February 16, 2022

Dr. Steven Cliff
Deputy Administrator
National Highway Traffic Safety Administration
1200 New Jersey Avenue, SE
Washington, DC 20590

Re: General Motors LLC Petition for Temporary Exemption from Provisions of Certain Federal Motor Vehicle Safety Standards

Dear Deputy Administrator Cliff,

Pursuant to 49 U.S.C. § 30113 of the National Traffic and Motor Vehicle Safety Act and 49 C.F.R. Part 555, General Motors LLC ("GM"), a Delaware limited liability company, with support from its majority-owned self-driving subsidiary, Cruise LLC ("Cruise"), respectfully submits this petition for temporary exemption from certain Federal Motor Vehicle Safety Standards.

GM and Cruise appreciate NHTSA's thoughtful and timely consideration of this petition. GM and Cruise remain willing and available to provide any further information necessary to support your review and expedition of this important request.

Sincerely,

Regina Carto
Vice President
Global Product Safety & Systems
General Motors LLC

Louise Zhang
Vice President
Safety and Systems
Cruise LLC

Attachment

Table of Contents

Origin 555 Petition

Pursuant to 49 U.S.C. § 30113 of the National Traffic and Motor Vehicle Safety Act ("Vehicle Safety Act") and 49 C.F.R. Part 555, General Motors LLC ("GM"), a Delaware limited liability company, with support from its majority-owned self-driving subsidiary, Cruise LLC ("Cruise"), respectfully submits this petition to the National Highway Traffic Safety Administration ("NHTSA") for temporary exemption ("Petition") from certain Federal Motor Vehicle Safety Standards ("FMVSS" or "Standards"). For purposes of this Petition, GM's address is:

General Motors LLC
25 Massachusetts Ave NW, Suite 400
Washington, DC 20001

I. EXECUTIVE SUMMARY

The Cruise Origin is the first American-made vehicle purpose-built for fleet-controlled autonomous rideshare and delivery. It is designed to improve overall road safety by not only meeting existing safety standards or their equivalent, but also through Cruise's managed fleet, which provides a unique ability to control, adapt, and improve vehicle function, ensuring it operates as intended.

GM and Cruise respectfully request temporary exemptions consistent with the Vehicle Safety Act, NHTSA guidance, and applicable law for certain requirements of nine FMVSS, all of which were developed for human-driven operations.[1] Those requirements are not necessary for safety as applied to the Origin's design and performance because their purpose is achieved through alternative means that, in each case, provide an equivalent level of safety. The Origin will operate at an overall safety level at least equal to that of nonexempt vehicles. Moreover, because the Origin is being deployed in a captive fleet, every Origin will incorporate the same continuous learnings and improvements across the fleet, instantaneously. The Origin is also a zero-emission, electric vehicle that does not unreasonably lower the overall safety level from that of a nonexempt vehicle.[2]

GM and Cruise seek these exemptions pursuant to both the "equivalent overall safety" and "evaluation of a low emission vehicle" provisions established by Congress in 49 U.S.C. § 30113(b)(3). In doing so, we draw on NHTSA's analysis in *Nuro*, which evaluated similar features (interior and exterior mirrors, back-up cameras, field of view, and the absence of manual controls) in the context of a zero-emission, low-speed, autonomous delivery vehicle.

[1] Through this Petition, GM seeks exemptions from certain portions of FMVSS 102, 104, 108, 111, 201, 203, 204, 207, and 208. *See* Tables 1 and 2, and Section III, below.

[2] In February 2020, NHTSA exercised its discretion to exempt from certain FMVSS an autonomous low-speed vehicle without any traditional human operating controls upon finding that *Nuro*'s vehicle met both the "equivalent overall safety" and "evaluation of a low emission vehicle" exemption bases. *See* NHTSA, *Nuro, Inc., Grant of Temporary Exemption for a Low-Speed Vehicle with an Automated Driving System*, 85 Fed. Reg. 7826, 7826-27 (Feb. 11, 2020) (hereinafter "*Nuro*"). This Petition builds upon the *Nuro* precedent. It seeks NHTSA's approval to allow GM and Cruise to further advance safety and low-emission technology by introducing into commerce this unique, zero-emission rideshare vehicle that can also be used to deliver goods—the Origin.

GM and Cruise are also guided by the Department's public interest objective to deploy new technology not merely to promote innovation, but also to advance societal goals and American values.[3] In addition to furthering the Safety Act's objectives, the Origin has been designed to advance other vital public interests: advancing environmental sustainability, ensuring U.S. leadership in advancing autonomous technology and artificial intelligence ("AI"), promoting accessibility, and supporting the American workforce. Every Origin will be a zero-emission, shared,[4] electric vehicle—helping to reduce the nation's reliance on oil, as well as helping to reduce emissions that disproportionately burden historically underserved communities. The Origin will help expand mobility options for seniors, people who are blind or have low vision, and other communities that have traditionally had lower access to reliable transportation. The Origin will be manufactured at GM's Michigan Factory ZERO, supporting and creating American jobs, promoting economic growth, and advancing the long-term success of the U.S. manufacturing sector and America's automotive industry.

The Origin's operations were developed with all of these interests in mind. The Origin will build on our six years designing, developing, testing and refining our advanced automated driving system ("ADS"), which has logged over three million miles of on-road autonomous driving with no incidents involving serious injury or death. Achieving the safety objectives set forth in the Vehicle Safety Act and related regulations has been an essential element of that work. The nine exemptions sought in this petition all relate to standards designed for a conventional human-operated vehicle, but are not required to accomplish the same objectives for an ADS operator.[5]

This exemption request for the Origin satisfies each of the requirements under the Equivalent Overall Safety Level ("EOS") and Low Emission Vehicle ("LEV") bases, as well as the objectives of the Safety Act and the public interest. Therefore, the Agency may grant this Petition under either of the statutory bases, and we respectfully request approval.

A. How We Got Here: Cruise AV

At GM and Cruise, safety is our mission. Despite significant advancements in vehicle technology, far too many Americans are injured or lose their lives on U.S. roads every year, and fatal crashes caused by speeding, impairment, and distraction—overwhelmingly due to human error—remain high. To further our vision of a world with zero crashes, zero emissions, and zero congestion, GM and Cruise joined forces in 2016[6] to design, develop,

[3] *See* Pete Buttigieg, U.S. Secretary of Transportation, Secretary Buttigieg remarks at the Consumer Electronics Show on the future of transportation innovation, Las Vegas, Nevada (Jan. 6, 2022), https://www.transportation.gov/briefing-room/secretary-buttigieg-gives-remarks-consumer-electronics-show-future-transportation.

[4] A "shared" or rideshare vehicle is one where passengers may be paired with other passengers along the course of their route. One example is a scenario in which Passenger 1 orders an Origin to go from City Hall to the library. At the same time, Passenger 2, orders a ride to go from City Hall to a restaurant one mile past the library. If both Passengers 1 and 2 elect to share a ride, they will both share the same Origin rather than each hailing their own vehicle and riding separately.

[5] Under the Society of Automotive Engineers International ("SAE") *Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles*, J3016_202104 (hereinafter "SAE J3016"), the Origin is a Level 4 Automated Driving System-Dedicated Vehicle ("ADS-DV"). *Id.* § 3.32.3, pg. 23.

[6] GM acquired Cruise on March 10, 2016, and Cruise remains a majority-owned and controlled subsidiary of GM.

and domestically manufacture the world's most advanced, zero-emission, purpose-built autonomous vehicles to help reduce motor vehicle crashes, emissions, and congestion.

We began this journey with Chevrolet Bolt EVs ("Bolt EVs") modified with an early ADS[7] and piloted by specially trained (human) Autonomous Vehicle Test Operators ("AVTOs"). With the ultimate goal being to remove the human driver from performing the Dynamic Driving Task ("DDT")[8] while maintaining safe operation, GM and Cruise started an extensive research, development, and testing program in 2016. In early 2017, using the Bolt EV as a starting point, we manufactured the first of several generations of purpose-built, zero-emission, autonomous vehicles—the "Cruise AV."[9] Using the modified Bolt EVs, and then Cruise AVs, over the course of this program GM and Cruise have continuously improved the functionality and safety of the ADS, related technology, sensors, and integration with vehicle systems.

The Cruise AV served as the foundational platform for testing and iterating the functionality and safety of the ADS before embarking on the journey to the Origin. Initial testing of the Cruise AV[10] included AVTOs seated behind the steering wheel ready to take active physical control of the Cruise AV if needed. This testing was focused on two specific operational design domains ("ODD"): the city and county of San Francisco and Scottsdale, Arizona. Cruise AVs are still tested in this manner in these ODDs.

Over the years, GM and Cruise have fine-tuned the ADS technology and vehicle systems in real-world environments with safety as the overriding metric. Today, the Cruise AV and its ADS execute the DDT consistently, effectively, and proficiently within a defined ODD, allowing GM and Cruise to successfully provide driverless rides to members of the public in accordance with California state permitting.[11] It is this same ADS, informed and continuously improving by years of ongoing development and millions of hours of real-world and simulated testing, that will direct the autonomous functionality of the Origin. With this Petition, GM and Cruise seek permission to deploy the groundbreaking Origin.

B. Where We Are Going: Cruise Origin

The Origin is the next step in the journey toward GM's future vision of a world with zero crashes, zero emissions, and zero congestion. It is GM and Cruise's next generation AV and is a zero-emission shared vehicle that represents the pinnacle of GM's leadership in automation, electrification, and mobility. The Origin will not be equipped with manually operated driving controls because it will not be operated by a human driver; the Origin will

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[7] *See* SAE J3016 § 3.2, pg. 6.

[8] *Id.* § 3.10, pg. 9.

[9] The current Cruise AV is an FMVSS-compliant ADS-DV based on the Chevrolet Bolt. While the Cruise AV retains all conventional vehicle controls and the AVTO can engage/disengage the ADS and perform the Dynamic Driving Task, it is *capable* of dedicated fully driverless operation at SAE "Level 4 - High Driving Automation" as defined in SAE J3016. *Id.* § 5.5, pg. 31-32.

[10] *See id.*, § 3.21, pg. 17.

[11] Cruise co-founder Kyle Vogt recorded his ride in a driverless Cruise AV on November 3, 2021 (Cruise, My first fully driverless pickup! (Nov. 3, 2021), https://www.youtube.com/watch?v=dmvZBiWYkFQ). Mary Barra, GM's CEO, also recently took her first driverless ride in a Cruise AV in San Francisco (Cruise, GM CEO Mary Barra takes her first driverless ride (Jan. 27, 2022), https://www.youtube.com/watch?v=2j2eLEHE-Dc).

be operated exclusively by its ADS, which has benefitted from the extensive Cruise AV development program.[12]

If this Petition is granted, GM and Cruise intend to deploy a dedicated, captive fleet of fully autonomous, electric ridesharing Origin vehicles—a significant step towards preventing vehicle crashes and related injuries, as well as reducing vehicle emissions and traffic congestion.[13]

C. Applicable Legal Standards

NHTSA may issue an FMVSS exemption upon a finding that the exemption(s) sought: (i) meets the requirements of at least one of the statutory exemption bases set forth in 49 U.S.C. § 30113(b)(3)(B) and related implementing regulations (e.g., 49 C.F.R. § 555.6); (ii) is consistent with the objectives of the Vehicle Safety Act and; and (iii) is consistent with the objectives of the Vehicle Safety Act.

1. Relevant Statutory Bases

- Under 49 U.S.C. § 30113(b)(3)(B)(iv), NHTSA may issue an FMVSS exemption where it finds that "compliance with the standard would prevent the manufacturer from selling a motor vehicle with an overall safety level at least equal to the overall safety level of nonexempt vehicles." Throughout this Petition, this statutory exemption basis will be referred to as the "Equivalent Overall Safety Level" or "EOS" basis.

- Alternatively, NHTSA may issue an FMVSS exemption pursuant to 49 U.S.C. § 30113(b)(3)(B)(iii) where "the exemption would make the development or field evaluation of a low-emission motor vehicle easier and would not unreasonably lower the safety level of that vehicle." Throughout this Petition, this statutory exemption basis will be referred to as the "Low Emission Vehicle" or "LEV" basis.

As set forth below, GM's exemption request for the Origin satisfies each of the requirements under the EOS and LEV bases, as well as the objectives of the Safety Act and the public interest. Therefore, the Agency may grant this Petition under either of the statutory bases.

[12] The Origin's ADS is the same ADS used in the Cruise AV, which incorporates years and millions of miles worth of learnings and experience. Both vehicles use the same core hardware, firmware, and software and the same software testing and release processes. In parallel with the on-road testing, simulated driving using advanced modeling and testing of Cruise's self-driving technology in virtual environments has accounted for over 1.2 million hours of additional driving experience, allowing GM and Cruise to test and validate against edge cases that are difficult or potentially dangerous to recreate in on-road scenarios. As outlined in Section II.I, this wealth of experience ensures that the Origin consistently, effectively, and proficiently operate in its ODD.

[13] Cruise will own and operate Origins along with Cruise AVs as part of its captive fleet of commercial rideshare and goods-delivery AVs.

2. FMVSS Background: Performance Standards

In 1966, Congress enacted the Vehicle Safety Act "to reduce traffic accidents and deaths and injuries resulting from traffic accidents."[14] To accomplish this purpose, the Vehicle Safety Act authorizes NHTSA to establish FMVSS that set performance requirements for motor vehicles and motor vehicle equipment.[15] Congress "expected" that FMVSS "be performance standards, specifying the required minimum safe performance of vehicles but not the manner in which the manufacturer is to achieve the specified performance."[16] Congress squarely rejected the notion that FMVSS are, or were to be, design standards: "the Secretary is not to become directly involved with questions of design,"[17] and the performance standards should not "stifle innovation in automotive design."[18] Instead, Congress intended that FMVSS "be analogous to a building code which specifies the minimum load-carrying characteristics of the structural members of a building wall, but leaves the builder free to choose [their] own materials and design."[19]

As NHTSA has explained, the FMVSS "were drafted at a time when it was reasonable to assume that all motor vehicles would have a steering wheel, accelerator pedal, and brake pedal, almost always located at the front left seating position, and that all vehicles would be operated by a human driver."[20] Thus, NHTSA has stated that "it is possible" that various FMVSS provisions "as written [are] not necessary for safety as applied to" a particular design.[21] As such, GM's safety-equivalency approach to the FMVSS that are the subject of this Petition has focused on the performance requirements of the applicable standard, considering the language of the applicable standard as a whole, with a particular focus on NHTSA's stated purpose and intent for that standard. This approach is consistent with NHTSA guidance related to other advanced technologies not envisioned at the time a particular standard was issued.[22]

3. Exemptions Sought

With this context, GM and Cruise now seek temporary exemptions consistent with the Vehicle Safety Act, NHTSA guidance, and applicable law from certain requirements of nine FMVSS. Again, these certain requirements are either not necessary for safety as

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[14] 49 U.S.C. § 30101 (2017).

[15] *Id*. at §§ 30101(1), 30111; 49 C.F.R. Part 571 (2016). The Secretary has delegated this authority to NHTSA.

[16] S. REP. NO. 89-1301, at 6 (1966), as reprinted in 1966 U.S.C.C.A.N. 2709, 2714.

[17] H.R. REP. No. 89-1919, at 15 (1966). *See also* 89 CONG. REC. H19, 628 (Aug. 17, 1966) (statement of Rep. Staggers) ("we do not want to set the design, we want to require the Secretary to set performance standards"); 89 CONG. REC. S14, 222 (1966) (statement of Sen. Magnuson) ("the committee is not empowering the secretary to take over the design and manufacturing function of private industry").

[18] H.R. REP. No. 89-1919, at 15 (1966).

[19] S. REP. NO. 89-1301, at 6 (1966), as reprinted in 1966 U.S.C.C.A.N. 2709, 2714.

[20] NHTSA Letter of Interpretation to Chris Urmson, Google, Inc. (Feb. 4, 2016) (hereinafter "Google Interpretation").

[21] *Id*.

[22] *See*, *e.g.*, NHTSA Letter of Interpretation to Samuel Campbell, BMW of North America, LLC (Jan. 4, 2016) (analyzing purpose and history of Section 5.3 of FMVSS 114 in the context of new remote controlled parking system); NHTSA Letter of Interpretation to Yaichi Oishi, Toyota Technical Center, USA, Inc. (Sept. 29, 1999) (explaining "we bear in mind the purpose underlying the provision that we have been asked to interpret" in assessing applicability of Section 3.1.3 of FMVSS 102 in the context of hybrid electric vehicles); NHTSA Interpretation to William R. Willen, American Honda Motor Co., Inc. (Jan. 17, 2001) (also construing Section 3.1.3 of FMVSS 102 in the context of idle stop technology).

applied to the Origin's design and performance, or their purpose and intent continue to be met through innovative, alternative means that each provide an equivalent level of safety, and together provide an overall safety level at least equal to the overall safety of nonexempt vehicles and would not unreasonably lower the safety of the vehicle.

In summary, GM and Cruise seek an exemption from the specific requirements associated with the FMVSS outlined below in Table 1.[23] Table 2 then summarizes the specific sections of each FMVSS from which GM and Cruise seek an exemption and summarizes how the Origin provides an equivalent level of safety. A more detailed equivalent safety analysis for each FMVSS exemption sought is provided in Section III.A.

100 Series: Crash Avoidance	200 Series: Crashworthiness
FMVSS 102 Transmission Shift Lever Sequence, Starter Interlock, and Transmission Braking Effect **Gears not displayed "in relation to each other"**	**FMVSS 201** Occupant Protection in Interior Impact **No sun visor**
FMVSS 104 Windshield Wiping and Washing Systems **No windshield washing/wiping system**	**FMVSS 203** Impact Protection for the Driver from the Steering Control System **No steering wheel**
FMVSS 108 Lamps, Reflective Devices, and Associated Equipment • **Turn signal self-cancellation (no steering wheel)** • **High/low beams (no manual switch)** • **Hazard lights (not independent of ignition switch)**	**FMVSS 204** Steering Control Rearward Displacement **No steering wheel**
	FMVSS 207 Seating Systems **No driver's seating position**
FMVSS 111 Rear Visibility **"Linger time" not met and no mirrors**	**FMVSS 208** Occupant Crash Protection **Telltale and chime timing due to boot up**

Table 1: FMVSS Exemptions

[23] To the extent the Final Rule with respect to Occupant Protection for Automated Driving Systems is finalized and published while this Petition is pending, and that Final Rule impacts the applicability of FMVSS 203, 204, or 207 to the Origin or modifies the requirements of those Standards as applied to the Origin, GM and Cruise reserve the right to amend this Petition to address those new Standards, including to remove them from the Petition.

FMVSS	Section	Requirement	Issue	How Origin Provides Equivalent Safety
102	S3.1.4.1	"[I]dentification of shift positions, including ***the positions in relation to each other*** and the position selected, shall be displayed in view of the driver whenever the ignition is in a position in which the engine is capable of operation."	**Gear selection display**: The Origin does not have a hand-operated control for shifting the transmission and will not display shift positions "in relation to each other."	The Origin's shift strategy meets the purpose and intent of the Standard's shift position and display requirements. While the Origin does not visibly display the transmission shift position selected in relation to the other positions, that requirement is not necessary for safety as applied to the Origin's particular design, which provides an equivalent level of safety compared to a traditional vehicle. The Origin's ADS will electronically command all gear shifts. It is programmed to always select the correct shift position and the ADS always knows which position it is selecting. There is no additional safety purpose to be served by displaying the shift positions in relation to each other. Because the ADS is programmed to select the correct gear, this shifting logic provides an equivalent level of safety as compared with a vehicle equipped with a manually operated shift lever with the shift positions displayed on the lever and in view of the human driver. The Origin meets all other requirements of FMVSS 102. GM designed the Origin without a hand-operated shift lever because the Origin has no need for human vehicle controls and to eliminate any potential risk of passengers interfering with the shift lever and, by extension, the safe operation of the Origin. The Origin will display the current transmission state (e.g., Park, Drive, and Reverse) on at least one of the in-cabin display screens so passengers are aware of the current transmission state.
104	S4.1 and S4.2	S4.1: "*Windshield wiping system.* Each vehicle shall have a power-driven windshield wiping system that meets the requirements of S4.1.1." S4.2: "*Windshield washing system* . . . Each multipurpose passenger vehicle . . . shall have a windshield washing system that meets the requirements of SAE Recommended Practice J942 . . . ."	**No windshield wiping or washing system**: The Origin is not equipped with a windshield wiping or washing system because the windshield is not used for driver visibility.	The purpose and intent of a traditional windshield wiping and washing system is obviated by the Origin, which uses an advanced sensor system to ensure that the ADS maintains full visibility of its surroundings. FMVSS 104 is focused on ensuring a human driver's ability to maintain sufficient visibility through the windshield of the roadway ahead in the case of inclement weather or debris or dirt build-up on the windshield. Unlike a human driver that relies exclusively on the windshield for forward visibility, the Origin "sees" through its vast array of exterior-mounted sensors. Visibility via the windshield is not required for these sensors to operate as they are all mounted exterior to the windshield. As a result, the Origin does not need a windshield wiping or washing system for driver visibility. The Origin does have an automated washing and drying system for its exterior-mounted sensors to help keep the sensors clean of debris. This system provides an equivalent level of safety as compared with a vehicle equipped with a compliant windshield wiping/washing system.
108	S9.1.1	"The turn signal operating unit installed on . . . multipurpose passenger vehicles . . . must be self-canceling ***by steering wheel rotation*** and capable of cancellation by	**Turn signal self-cancellation not dependent on steering wheel**: The Origin does not have a steering wheel. Turn signals are self-cancelled electronically by the ADS.	The Origin is equipped with all the lamps, reflective devices and other lighting equipment required by FMVSS 108 for a multi-purpose passenger vehicle ("MPV"). The Origin's ADS will exclusively control all aspects of vehicle lighting that meet the functional performance requirements, the purpose, and the intent of FMVSS 108. Thus, the FMVSS 108 exemptions that GM seeks relate to lighting requirements linked to the provision of human-operated controls which, here, are not necessary for safety as applied to the Origin's particular design.

FMVSS	Section	Requirement	Issue	How Origin Provides Equivalent Safety
		a ***manually operated control***."		As to S9.1.1, the Origin's ADS controls steering (electronically)—there is no human driver and therefore no need for a steering wheel. As a result, and to eliminate any potential safety risk with passengers interfering with the safe operation of the vehicle, the Origin was designed without a steering wheel. The ADS electronically cancels the turn signal after the turn or lane-change maneuver is complete, which meets the intent and purpose of S9.1.1. See Appendix A for further details regarding turn signal operation.
	S9.4	"*Headlamp beam switching device*. Each vehicle must have a means of switching between lower and upper beams designed and located so that it may be operated conveniently by a simple movement of the ***driver's hand or foot***."	**No manual high-beam switch**: The Origin is not equipped with manual controls for switching between high and low headlamp beams. All lamps are electronically activated by the Origin's ADS.	As to S9.4, the Origin does not need high beams to operate. The Origin's sensors, particularly LiDAR, can "see" the road at night without the need to activate high beams. The Origin is equipped with high beams, but they will only be activated in very rare situations that require Cruise Remote Assistance to intervene. In those situations, Cruise Remote Assistance may initiate activation of the high beams electronically and only when it is safe to do so based on the driving environment. The Origin was designed without a manual switch for high and low headlamp beams to eliminate any potential safety risk to oncoming traffic due to passengers interfering with the operation of the vehicle.
	S9.6.2	"*Operating unit switch*. The unit must operate ***independently of the ignition or equivalent switch***."	**Hazard lights require ADS to be "on"**: The hazard lights are not operable until the Origin is initially powered on. Once the Origin is powered "on," the hazard lights can operate independently of the main power in the event of a crash that causes a power loss.	As to S9.6.2, unlike a traditional vehicle, the Origin is designed to always be "on" when operating on public streets. Once the Origin is booted up, the hazard lights will always be operable and will be activated when appropriate. The Origin was designed with sufficient redundancy to ensure that hazard lights will be activated for any scenario in which hazard lights may be necessary. In the event of a crash, the ADS will automatically activate the hazard lights and those lights will stay on even in the event the Origin loses power. Additionally, either upon its own assessment of a situation or at the request of a passenger, law enforcement, or other emergency providers, Cruise Remote Assistance can also activate the hazard lights.
111	S6.1	"Each multipurpose passenger vehicle . . . shall have either - (a) Mirrors that conform to the requirements of S5; or (b) Outside mirrors of unit magnification . . . ."	**No outside or inside rearview mirrors:** The Origin does not need physical mirrors because it maintains constant 360-degree visibility outside and around the vehicle through a state-of-the-art sensor suite.	As to S6.1, during a backing event or lane changing event, the vast array of sensors provides the ADS with a constant, 360-degree field of view that is superior to that provided by the mirrors required by this standard.[24] The Origin is operated exclusively by the ADS, and the ADS does not need or use mirrors for driving visibility. Therefore, there is no operational safety need for outside or inside rearview mirrors. In addition, the design of the Origin provides additional safety in terms of constant vision that is at least equal to the safety intent provided by the required mirrors.
	S6.2.4	"*Linger time*. The rearview image meeting the requirements of	**Linger time**: The rearview image information is constantly transmitted to the ADS and always	The Origin's rear visibility system, which is provided by a state-of-the-art sensor system that provides always-on, 360-degree visibility, is superior to that provided by conventional vehicles that comply with FMVSS111. For that

[24] In addition, as explained in more detail in Section III.A.1.d.(ii), eliminating the physical rearview mirrors does not reduce the level of safety afforded passengers exiting the Origin. First, once the Origin stops in an appropriate drop-off location, the passenger exiting must press the "Open Door" button to open the doors and exit the vehicle—the doors do not open automatically once the Origin is stopped in the drop-off location. In addition, the Origin will provide a visual and audible warning to passengers reminding them to use caution and look for oncoming traffic when exiting the vehicle. Finally, the design of the Origin's doors, which slide open against the side of the vehicle and not outwards, precludes the doors from striking—or "dooring"—passing vehicles or pedestrians.

FMVSS	Section	Requirement	Issue	How Origin Provides Equivalent Safety
		S6.2.1 and S6.2.2 shall ***not be displayed after the backing event has ended***."	"on" while the vehicle is operating. Rearview image information is always being processed by the ADS and continues to display for the ADS following the end of the backing event.	reason and those outlined in Section III, the Origin's rear-visibility system provides an equivalent level of safety, and it satisfies the purpose and intent of this standard. As to S6.2.4, the sensor information is provided to the ADS constantly, such that the vehicle does not meet the Standard's "Linger Time" requirement. Because the ADS is not a human driver, the ongoing display of the rearview image information to the ADS is not a source of distraction. Rather, the ongoing display of that information ensures the ADS receives the necessary image data to perform the dynamic driving task consistently, effectively, and proficiently. Compliance with the linger time requirement in this case would actually reduce overall safety by limiting the sensor data provided to the ADS.
201	S5.4	"S5.4.1. A sun visor that is constructed of or covered with energy-absorbing material shall be provided for each front outboard designated seating position. S5.4.2. Each sun visor mounting shall present no rigid material edge radius of less than 3.2 mm that is statically contactable by a spherical 165 mm diameter head form."	**No sun visor**: The Origin is not equipped with any sun visors because it is not operated by human drivers.	NHTSA has recognized that installation of a sun visor in locations without a traditional forward facing designated seating position is not required. The Origin is not configured with any front forward-facing outboard seating positions. Accordingly, sun visors are not necessary for safety as applied to the particular design of the Origin. The Origin will otherwise meet all other requirements of FMVSS 201. The Origin is not operated by a human driver—the driver is the ADS and the ADS does not use the windshield for visibility. As such, no sun visors with energy absorption are needed or installed at the outboard front seating positions. Thus, there is no risk of injury to the passengers from coming into contact with a sharp or hard surface of a sun visor.
203	S5, et seq.	"[T]he steering control system of any vehicle to which this standard applies shall be impacted in accordance with . . . ." "The steering control system shall be so constructed . . . ."	**No "impact protection" for nonexistent steering control system:** There is no steering wheel and therefore no need for impact protection required by this standard.	FMVSS 203 and 204 presume the presence of a steering control system that is not necessary for safety as applied to the particular design of the Origin. Indeed, NHTSA recently stated in a 2020 Notice of Proposed Rulemaking that these Standards should "not apply to vehicles without steering control systems."[25] The Origin does not have a manual steering control system or a steering wheel because it is operated exclusively by the ADS. Since the Origin will not have a human driver, the absence of the steering wheel meets the safety purpose of this standard, which is to minimize the risk of chest, neck, and facial injuries to the driver due to the steering control system.
204	S4.2	"[T]he upper end of the steering column and shaft in the vehicle shall not be displaced more than 127	**No rearward displacement of nonexistent steering controls**: There is no steering wheel and therefore no need to limit rearward	See equivalent safety rationale for FMVSS 203, above.

[25] *See* NHTSA, *Notice of Proposed Rulemaking, Occupant Protection for Automated Driving Systems*, 85 Fed. Reg. 17624, 17629 (Mar. 30, 2020) (hereinafter "*Occupant Protection for ADS NPRM*"); *see id.* at 17625 ("[A]n occupant should not need protection from a steering control system if none exists in that vehicle.").

FMVSS	Section	Requirement	Issue	How Origin Provides Equivalent Safety
		mm in a horizontal rearward direction parallel to the longitudinal axis of the vehicle."	displacement of the steering control required by this standard.	
207	S4.1	"Each vehicle shall have an occupant seat for the driver."	**No driver's seat**: The Origin does not have a traditional driver's seat because it is not operated by a human driver.	S4.1 requires "each vehicle shall have an occupant seat for the driver." The Origin will have six occupant seating positions, but it will not have a traditional driver's seat because there is no human driver. NHTSA may grant an exemption from S4.1 here because without the required presence of a human driver to operate, the Origin has been designed without a traditional "driver's seat," and thus the requirements and safety intent of the Standard are neither applicable nor necessary for safety as applied to the particular design of the Origin. Indeed, NHTSA recently noted in a 2020 Notice of Proposed Rulemaking that requiring the installation of a driver's seat in a Level 4 AV may not be necessary and, as such, has proposed modifying FMVSS 207 to update the language at S4.1 to specify that a driver's seat is only necessary in vehicles that include manual controls. The Origin's seats otherwise meet or exceed the performance requirements for seating system strength and protection per FMVSS 207.
208	S7.3(b)	"A seat belt assembly provided at the driver's seating position shall be equipped with a warning system that . . . activates . . . ***beginning when the vehicle ignition switch is moved to the "on" or the "start" position*** . . . ."	**Timing of visual seat belt warning and chime is not based on the status of the ignition switch**: The Origin is always "on" when in operation, and there will not be any occupants in the vehicle when it is first powered on. Accordingly, the timing of the Origin's visual and audible seat belt reminders is triggered by occupants pressing the "Start/Stop" button (not the power-on switch), located both in-vehicle and in the mobile application.	The Origin's design and performance meets the purpose and intent of S7.3. Specifically, the Origin's innovative "Buckle to Ride" seat belt usage and reinforcement strategy provides an equivalent level of safety. S7.3 specifies requirements for a seat belt warning system at the driver's designated seating position that will alert the driver if their seat belt is not fastened. The Standard requires the warnings be activated for not less than 60 seconds beginning when the vehicle ignition switch is moved to the "on" or "start" position. The purpose and intent of the seat belt reminder provision is to reemphasize the need for and increase the use of seat belts. The Origin will feature a seat belt warning system, which will give both visual and audible reminders for passengers in any of its six occupant seating positions prior to a ride starting. The Origin is a fleet-managed vehicle and the power will be first turned on each day with no occupants in the vehicle. The Origin will also use the novel Buckle to Ride feature to provide passengers the required visual and audible seat belt warnings when passengers request the ride to start (by pressing the "Start/Stop" button). The Origin's Buckle to Ride feature is grounded in a simple philosophy—all passengers must be buckled before a ride can start. The Origin's seat belt warning system thus meets the intent and purpose of this standard when occupants are in the vehicle.

Table 2: FMVSS Exemption Details

D. Roadmap of the Petition

With this analytical framing, GM provides in the sections that follow an overview of the Origin in **Section II**, including: (1) the vehicular structure and electric propulsion; (2) the interior cabin and the information provided to passengers; and (3) GM's robust occupant protection design and the first-of-its-kind "Buckle to Ride" technology. Section II also describes the design and operation of the Origin ADS including: (a) the Origin's state-of-the-art, 360-degree sensing technology; (b) a description of the Origin's ADS and its fusion of environmental data and vehicle information to execute the Origin's driving function; (c) the Origin's operational design domain; (d) the Origin's ability to respond to faults and achieve minimal risk conditions; (e) the Origin's communication with other road users; and (f) the Origin's cybersecurity protections.

Section III details how the Origin's design meets the statutory requirements of the EOS and LEV exemption bases. This will include a standard-by-standard description of how the Origin achieves the safety purpose of each FMVSS requirement from which it is seeking an exemption. This section also explains how the Origin's design renders certain historical FMVSS features predicated on a human driver unnecessary (e.g., no steering wheel) and, in some cases, conformance with such standards could create unintended safety risks for the Origin and its occupants. Finally, Section III will explain how granting this Petition will facilitate the development and field evaluation of a low-emission vehicle.

Lastly, **Sections IV and V** address how and why granting the exemptions requested would be consistent with the Vehicle Safety Act and the public interest, including enhancing roadway safety, increasing mobility options, supporting domestic job creation, bolstering the United States' position as a global technology leader, and generating critical safety and operational data on autonomous vehicles ("AV") collected through GM and Cruise's AV program. This data can be harnessed as part of a growing body of information that will enable the Agency to better understand the safety implications of autonomous technologies and hopefully help support AV-centric rulemaking.[26]

II. ORIGIN OVERVIEW

A. The Origin's Exterior Design

The Origin is roughly the size of a modern SUV,[27] but it fundamentally innovates on vehicle design. As can be seen in Figure 1 - Figure 6, the exterior of the Origin is unlike a typical SUV. From the sensor pods gracing the four corners of the roof to the dual sliding

[26] As noted in NHTSA's December 3, 2020 Advanced Notice of Proposed Rulemaking (ANPRM) on a Framework for Automated Driving System (ADS) Safety, "[a]ny regulatory approach must have well-founded supporting data indicating safety needs." *See* NHTSA, *Advance Notice of Proposed Rulemaking, Framework for Automated Driving System Safety*, 85 Fed. Reg. 78058, 78062 (Dec. 3, 2020) (hereinafter "*Framework for ADS Safety ANPRM*"). Thus, the analysis of the Origin's on-road, real-world data could be very helpful to any future regulatory proposals relating to AV safety. *See id*. In response to this ANPRM, many commenters noted that rulemaking now would be premature given the lack of on-road ADS data, and noted the need for NHTSA to collect such data to inform potential rulemaking. *See, e.g.*, Alliance for Automotive Innovation, Comment on ANPRM on Framework for Automated Driving System Safety, Docket No. NHTSA–2020–0106 (Apr. 1, 2021).

[27] The Origin is classified as a Multipurpose Vehicle (MPV) with a curb weight of 3,084 kg and a GVWR of 3,640 kg.

subway-style doors, the Origin seeks to rethink what a shared vehicle should be from the exterior to the interior (described below).

Figure 1: Left Side View

Figure 2: Front View

Figure 3: Front & Left Side Perspective View

Figure 4: Rear View

Figure 5: Rear and Left Side Perspective View

Figure 6: Right Side View (Subway Style Door Open)

The Origin will be powered by GM's third-generation global EV platform with its state-of-the-art Ultium battery system and drive motors. The Ultium battery is based on a newly developed chemistry for the lithium-ion cells that increases the efficiency and performance of the battery.

The entire dynamic driving task (e.g., vehicle acceleration, braking, turning, signaling) is performed by the Cruise ADS, the centerpiece of which is the computer system housed near the rear of the vehicle as indicated in Figure 7. As such, the Origin does not need, and is not equipped with, a steering wheel, accelerator or brake pedals, a driver-facing instrument panel, manual turn signal controls, mirrors, or a traditional driver cockpit. In addition to the safety benefits of eliminating a human driver, removing manual controls dramatically frees up passenger and cargo space beyond what its exterior dimensions would otherwise allow in a conventional vehicle.

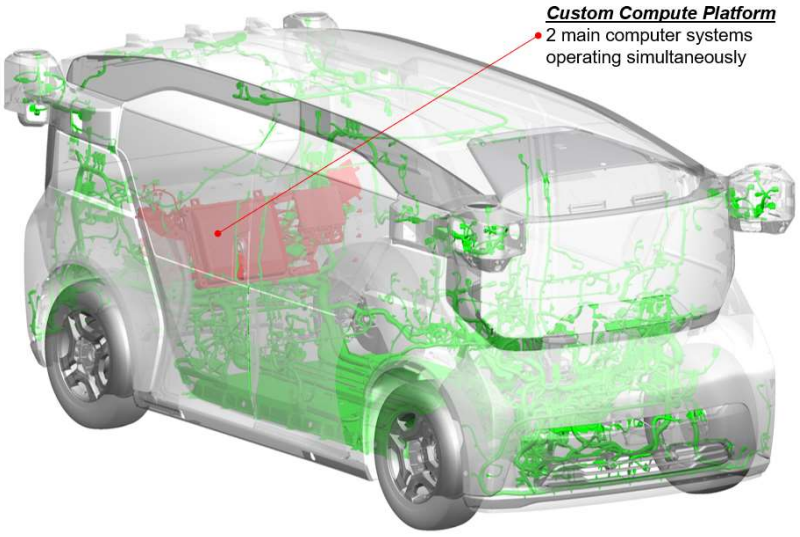

Figure 7: Compute Platform Component Schematic

B. The Origin's Interior Cabin

The Origin is purpose-built as a rideshare vehicle.[28] Therefore, as illustrated in Figure 8 and Figure 9, the Origin's interior cabin contains two rows of seats facing each other. Each row contains seating capacity and seat belts for three passengers. This seating configuration optimizes passenger space and enables easier ingress and egress through the subway-style doors.

[28] The Origin is a rideshare vehicle that also is capable of delivering goods and operating as an occupant-less delivery vehicle.

Figure 8: The Origin Interior Cabin, Right Side (Doors Omitted)

Figure 9: The Origin Interior Cabin, Angled Right Side (Doors Omitted)

C. Start and Stop Ride Button

Upon entering the vehicle through the subway-style split sliding doors, passengers can start the ride by buckling their 3-point seat belts and pressing the "Start/Stop" button.[29] The "Start/Stop" button is accessible through the physical button in the passenger cabin shown below in Figure 10 and Figure 11.[30] During a ride, passengers can request that the Origin end the ride at any time prior to reaching their destination by pressing the

[29] Pressing the "Start/Stop" button will start the ride or stop it (if the ride has already begun). For purposes of this document, we refer to this "Start/Stop" button as the "Start Ride" or "Stop Ride" button depending on the context.

[30] Each passenger requesting a ride will have downloaded the Cruise mobile application before entering the Origin. Passengers can also start and stop the ride through the mobile application.

"Start/Stop" button.[31] If this occurs, the Origin will identify the closest appropriate pull-over location, navigate to it, and stop.

Figure 10: Start/Stop Button

Figure 11: Start/Stop Button

D. Information Displays

The Origin is equipped with multiple in-vehicle information displays to provide a safe and informed experience for its passengers. As illustrated below in Figure 12, the Origin has six in-vehicle displays that can provide information about the vehicle, the ride, important safety messages (including seat belt warnings), and FMVSS-mandated telltales.[32] Specifically, one or more of these screens will provide passengers with information such as

[31] In addition to start and stop ride functions being accessed through the Cruise mobile application (see Section II.F), passengers also may reach out to Cruise Customer Support through the mobile application or through the in-vehicle call button to start the ride or to stop a ride before reaching their destination.

[32] The telltales displayed on the End zone screens include the turn signal, high beam, hazard flasher, brake malfunction, ESC malfunction, TPMS low tire pressure warning, fasten seat belt, airbag readiness indicator, and driving gear active.

directions, ingress/egress instructions, safety checks and reminders (e.g., fasten seat belt), maps, individual passengers' ETAs, and a series of telltales to communicate the status of certain vehicle functions to the passengers. The six information screens include four "Personal screens" (identified in Figure 12 by the number "1") and two "End zone screens" (identified in Figure 12 by the number "2"). Both the End zone and Personal screens are 12.6-inch screens, measuring approximately 11 inches wide and 6.2 inches in height.

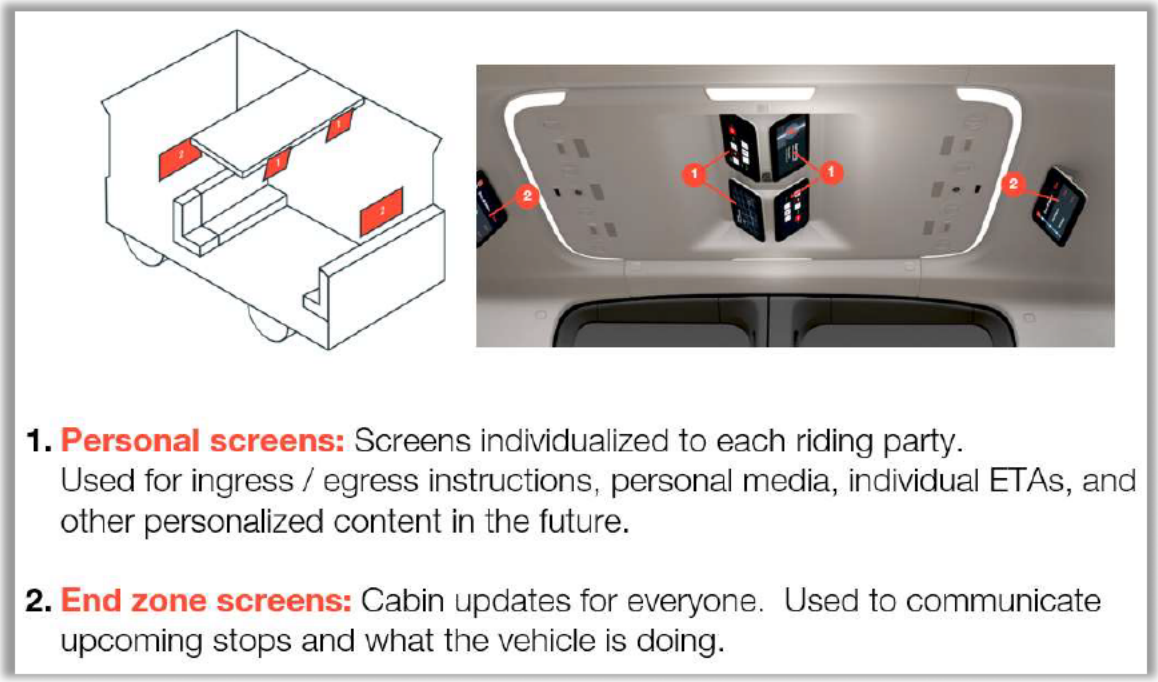

Figure 12: Information Displays

The FMVSS-required telltales will display dynamically on the End zone screens when active.[33] The Personal screens will also provide a seat belt warning system, including information, reminders, and seat belt warnings related to proper seat belt use before and during the ride, as detailed in Appendix B.

E. Call Button

The Origin also has various means to contact Cruise Customer Support ("Customer Support") from within the vehicle (i.e., via single button press). Passengers can call Customer Support and talk with a Customer Support representative for any reason.[34] Calls can be initiated through the mobile application or by using the in-vehicle call button illustrated below in Figure 13.

[33] For each of these telltales, the Origin uses the symbol provided in Table 1 of FMVSS 101 and meets any applicable color requirement.

[34] Cruise provides various live customer support options to passengers, which are discussed in more detail in Appendix F.

Figure 13: Call Button

F. The Origin's Mobile Application

Prior to their first ride, passengers will gain access to the Cruise mobile application ("mobile app"). The mobile app will guide passengers on how to properly hail, identify, confirm, and enter the Origin, as well as offer instructions on how to interact with vehicle features such as how to contact Customer Support or call for assistance. When passengers request an Origin, the mobile app will provide an estimated wait time.

Passengers will be able to hail an Origin through a mobile app that is compatible with iOS Voiceover. Voiceover provides blind and low vision users with auditory feedback even if they cannot see the mobile app screen. Passengers who use iOS Voiceover to hail the Origin will be able to receive wait time information audibly, allowing them to anticipate the Origin's arrival even if they cannot visually track its movements in the mobile app.

Once the Origin arrives, passengers will be able to locate the Origin through the mobile app's audio- and visual-based navigation systems. The mobile app will also provide passengers reminders to check doors and buckle seat belts after entering the Origin.

During a ride, passengers will be able to change their destination using the mobile app. Passengers also will be able to request to end the ride prior to reaching their destination through the mobile app. As noted above and illustrated in Figure 14 below, at any time during a ride, passengers will also be able to contact Customer Support through the mobile app using its live chat or phone support function. In addition, passengers may send a written message to Customer Support through the mobile app at any time before, after or during a ride.

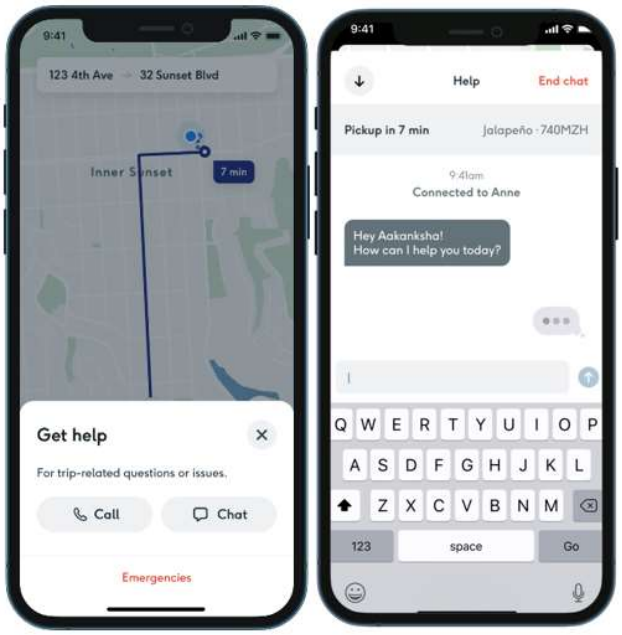

Figure 14: Example Interface for In-app Customer Support

When the Origin is approaching its destination, the mobile app also will provide a notification informing the passenger of the end of ride, with a reminder to exit safely and with consideration for other road users.

G. Occupant Protection Systems

The Origin's innovative interior design and unique seating configuration consists of one row of seats facing rearward and one row of seats facing forward. In designing the Origin, GM adapted the same occupant crash protection requirements and specifications that it applies to its conventional vehicles, including developmental load cases for structure, occupant performance targets for various passenger sizes, and high-voltage safety requirements. GM also extensively used Computer-Aided Engineering ("CAE") tools and advanced materials so that the Origin also is safe from a crashworthiness and occupant protection perspective.

1. Seat Belts and Child Restraint Accommodations

Proper and continuous seat belt use is fundamental to the safety strategy and design of the Origin. The Origin is equipped with three-point seat belts in all six designated seating positions. All six seating positions have retractors, dual pretensioners, and load limiters, designed to help provide effective restraint for a range of occupant sizes. The seat belt buckles include a dynamic locking tongue feature that helps to control lower torso excursion during high-braking events and crashes. The dual pretensioners are designed to deploy in appropriate frontal, side, rear, and rollover crashes. To help maximize proper seat belt use, the vehicle is equipped with a new seat belt reminder feature, called "Buckle to Ride"

(discussed in detail in Section 5, below), which is designed to enforce proper seat belt usage prior to and during a ride.[35]

The Origin also includes child restraint accommodations for the front-facing seats. The second row contains two full sets of Lower Anchors and Tethers for Children ("LATCH") and 3 top tether anchorages. Automatic locking retractors ("ALRs") are also provided in this row for child restraints. The Origin does not support child restraint installation in the first row (rear-facing) based on child-restraint manufacturers' recommendation that the child restraints only be used in forward-facing seating. The mobile app will provide passengers with information regarding permitted locations to install child restraints. The two LATCH locations and three top tether anchors are permanently and conspicuously marked as required by FMVSS 225.

2. Seats

The Origin is equipped with seats that are specifically designed for this unique vehicle environment—namely, integral in their design are crash-protection considerations for both frontal and rear impacts. Each seating position is equipped with head restraints, seat backs, seat cushions, and seat pans that are designed, along with the restraints, to provide the desired levels of occupant protection. Seat backs and head restraints are designed to help control upper body and head loading in front and rear crashes, and to control kinematics of primary occupant body structures such as the pelvis, shoulders, and head while providing localized compliance that limits forces and accelerations.[36] Similarly, the seat cushions and seat pans are designed to help control pelvis kinematics, limit pelvic loading, and to mitigate the risk of submarining. To help maximize proper seat belt use in the absence of a traditional "operator," the vehicle is equipped with a new seat belt reminder system, called "Buckle to Ride" (detailed below in Section 5 and Appendix B), which is designed to enforce proper seat belt usage prior to and during a ride.

3. Airbags

The Origin is equipped with head-curtain and seat-mounted side-impact airbags, depicted in their deployed state in Figure 15 and Figure 16, below. They are designed to deploy during certain side impact or rollover events and will also deploy in certain severe frontal or rear impacts. The head-curtain side-impact airbags are FMVSS 226-compliant roof rail airbags with coverage from roof to belt line, which help provide occupant containment and mitigate the risk of occupant injuries in certain side-impact crashes. The side impact airbags work in concert with the vehicle structure to help mitigate the risk of occupant injuries in certain side-impact crashes. Additionally, these airbags have been designed to meet the side airbag out-of-position requirements specified by the Technical Working Group Joint Agreement (2003).

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[35] Seat belt and airbag status information is communicated to passengers through the information displays as described in Section II.D, above, and in Sections II.G.5 and III.A.1.a, below.

[36] In the event of a crash, the seats are designed with energy absorbing elements at the upper seat back and lower legs to help control both occupant deceleration and forces from impacts that are directionally from the rear of the passengers. The head restraints are adjustable to accommodate a wide range of occupant sizes, from 5th percentile female to 95th percentile male.

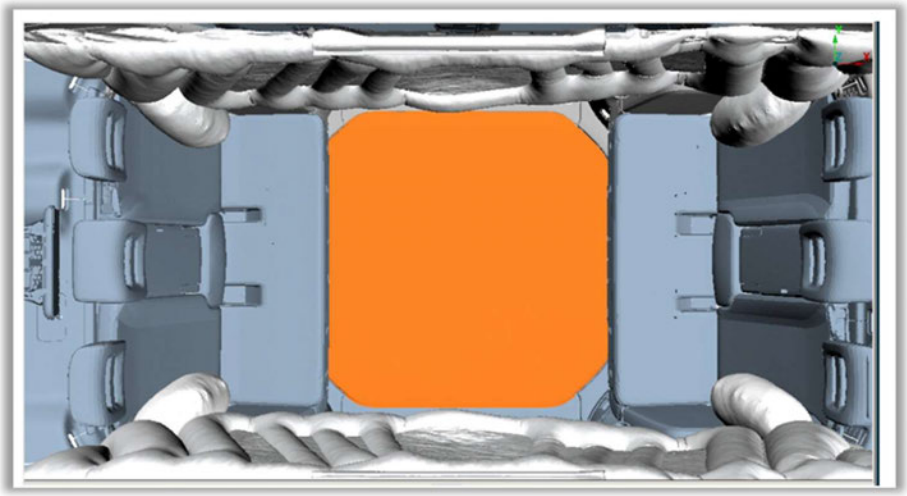

Figure 15: Origin Airbag Configuration, Top View

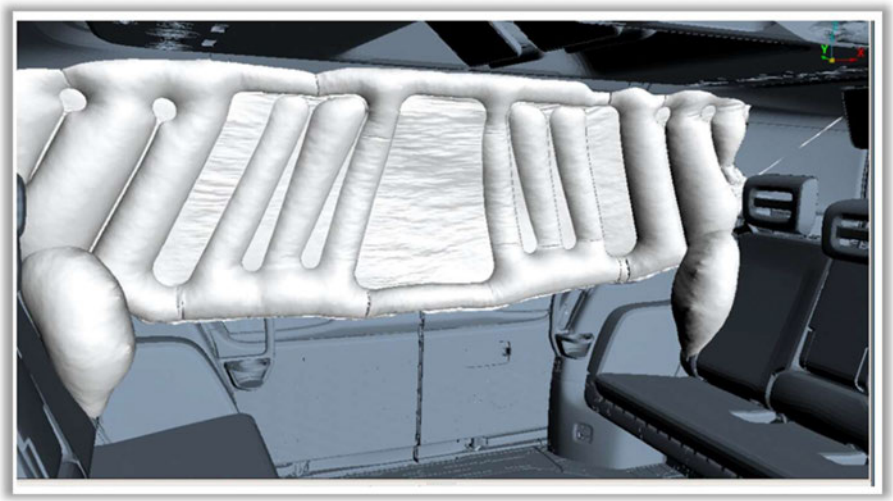

Figure 16: Origin Airbags, Angled Side Interior View

4. Crashworthiness and Occupant Protection

Similar to conventional vehicles, GM used a combination of simulation tools and physical crash tests to optimize the Origin's crashworthiness. CAE analysis included full-vehicle finite element analysis models, with over 15 million elements, as well as sled models to assess in detail the Origin's overall structure, interior components, restraint systems, electrical modules, and the behavior of various advanced materials in order to optimize vehicle and occupant performance, and post-crash electrical integrity. GM studied dozens of frontal, side, and rear impact crash scenarios during the development cycle of the Origin, generating over several thousand computer simulations on its high-performance computing system.[37]

GM evaluated an array of possible occupant injury mechanisms during the development of the Origin. Some examples include thoracic response in rearward impacts,

[37] These simulation applications were programmed to account for the Origin's novel seating arrangement.

submarining biomechanical assessments, side impact airbag loading and interactions, leg swing kinematics in frontal impacts for passengers seated in the forward-facing seating positions (i.e., second row), and lower leg loading to the front edge of the seat in rearward impacts.

To assess occupant protection in rear-impacts, GM used Hybrid III adult dummies for a number of reasons, including the fact that the neck is biofidelic in both forward flexion and rearward extension.[38] GM used the Hybrid III small female along with the mid-size and large males in these assessments. By using dummies of various sizes, GM was able to assess occupant protection across a wide range of the adult population. GM also used the Global Human Body Model as a cross-reference meant to verify and examine the occupant protection performance in various crash scenarios.[39] Data from these studies were used to iterate and optimize the restraints, seat design, and support structure.

The Origin is classified as a multi-purpose passenger vehicle ("MPV").[40] MPVs in this weight classification are not subject to the frontal airbag requirements of FMVSS 208, Paragraph S14, or the frontal dynamic barrier crash test requirements (belted and unbelted). Nonetheless, GM elected to design the Origin to meet FMVSS 208 performance criteria for belted occupants of both the first and second row seats. In fact, the occupant protection strategy for the Origin considers a broad range of real-world crash conditions, with occupant performance assessments for a range of occupant sizes and seating locations.[41]

Based on physical testing and CAE analysis, the Origin also complies with the FMVSS 214 side-pole impact requirements for the rearward-facing passenger bench seat in the first row, including for outboard 50th percentile male and 5th percentile female, as required by FMVSS 214. In addition, while not required by FMVSS 214, GM also has designed the Origin to meet the performance criteria in the forward-facing passenger bench seat in the second row. As a further safety measure, GM also designed the Origin to meet the side-impact moving deformable barrier performance criteria of FMVSS 214, even though this is not required given the Origin's Gross Vehicle Weight Rating ("GVWR").

5. Buckle to Ride

Using and fastening one's seat belt is one of the most important actions a vehicle passenger can take to mitigate the risk of injury or death in the event of a crash.[42] The Origin features three-point seat belts as its primary passenger restraint mechanism in all

[38] In addition, with its cylindrical shape, the Hybrid III neck has a more robust response at oblique angles, which might be induced by seatback twist. The Hybrid III has ribs and shoulders suitable for belt restraints and loading into the seatback. The Hybrid III is durable in higher severity rear impacts. It is repeatable and reproducible, and it can be instrumented to measure forces and moments in the upper and lower neck, lower thoracic spine, and lumber. See A. Kim et al., *A Comparison of the BioRID II, Hybrid III, and RID2 in Low-Severity Rear Impacts*, Rear Impact Dummy Evaluation Task Group of the Occupant Safety Research Partnership/USCAR, Paper Number 05-0225 (2005).

[39] By using the Global Human Body Model, the analysis was not limited to the capabilities of existing physical test dummies.

[40] As referenced earlier, the Origin's GVWR is 3,640 kg (8,024 pounds); its curb weight is 3,084 kg (6,799 pounds).

[41] The results from physical sled and barrier crash testing, as well as full-vehicle model CAE test results, are provided in Appendix B.

[42] *See, e.g.*, NHTSA, *Advance Notice of Proposed Rulemaking, Federal Motor Vehicle Safety Standards; Occupant Crash Protection*, 84 Fed. Reg. 51076, 51077 (Sept. 27, 2019).

seating positions. GM and Cruise have taken additional steps to encourage belt use by developing an innovative feature called Buckle to Ride. Our policy is simple: all passengers must buckle their seat belt prior to the start of their autonomous ride. The Buckle to Ride feature goes beyond the standard seat belt warning system requirements of FMVSS 208, Section S7.3, in that the Origin will not begin the ride until the seat belts of occupied seats are buckled. In addition, Buckle to Ride will give passengers a warning if their seat belt is detected as misrouted before the ride begins. Override mechanisms are provided to allow exceptions to seat belt buckling such as special medical conditions.

During the ride, the Buckle to Ride feature continuously monitors seat belt buckle status and certain seat belt misrouting conditions. Upon detecting that a passenger has unbuckled their seat belt, or has misrouted their seat belt during the ride, the Buckle to Ride feature provides visual and audible warnings to encourage passengers to properly fasten their seat belt.

The Buckle to Ride feature has four important functions:

1. Remind passengers to buckle their seat belts before the ride and remain buckled during the ride.
2. Alert passengers if their seat belts are improperly routed.
3. Enable the passenger to start the ride ***only after*** safety checks (including seat belt buckling) have passed.
4. Provide override mechanisms to allow exceptions if necessary.

The Buckle to Ride feature achieves these functions using three sensors and a GM-proprietary time-based algorithm to assess both general seat belt usage and certain seat belt misrouting conditions.

Each seating position includes the following three sensors:

1. Seat occupancy sensor.
2. Seat belt buckle sensor.
3. Seat belt payout sensor.[43]

The Buckle to Ride feature is able to identify certain instances of improper seat belt routing and advise passengers to properly position their seat belt. This is important because the efficacy of a seat belt depends on its proper use. The Buckle to Ride feature can detect improper seat belt routing in certain conditions including those shown in Figure 16:

[43] More detail regarding this feature and its sensors is provided in Appendix B.

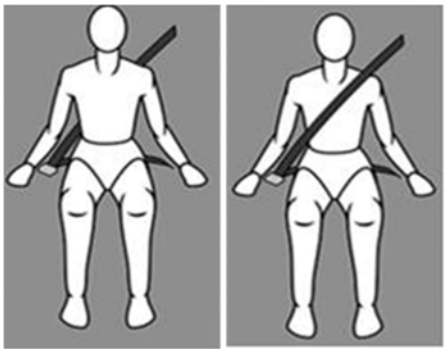

Figure 16: Examples of Improper Seat Belt Routing Conditions[44]

6. High Voltage Integrity, Post-Crash Response, and Emergency Exit Features

In addition to occupant protection, the Origin includes countermeasures to protect the high voltage electrical system in the event of a crash and will comply with FMVSS 305. The high voltage battery and other high voltage components are protected by a reinforced vehicle structure around these key components. In addition, GM evaluated and tested all safety-critical electrical modules, sensors, and wires in various crash scenarios to assess and design safeguards to mitigate functional damage and address residual energy and the potential for thermal propagation. The crash sensing system also mitigates the risk of thermal events in a crash by automatically shutting down the high voltage system when a severe crash is detected. This also mitigates the risk of injury to occupants and first responders.

In the post-crash environment, the Origin has a comprehensive suite of electrical integrity functions for safety-critical systems designed to ensure these systems remain active and allow Cruise to assess the situation in real-time. Once a crash is detected and the vehicle comes to a stop, the Origin automatically unlocks the doors, activates the hazard flashers and interior lights, and deactivates the HVAC blower. The Origin's telecommunications module also is protected. It is hardened to ensure it remains active during and after a crash to ensure Cruise Customer Support (part of a series of teams that constitute the Cruise Back Office, which also includes Remote Assistance and Field Support, which are described more fully in Appendix F) are able to continuously monitor the situation and provide an almost instantaneous voice connection to the vehicle and involve OnStar® emergency response services when needed.[45]

Emergency exit scenarios are also incorporated into the Origin's design. All doors can be manually opened in the case of electrical power loss. Passenger emergency exit

[44] GM refers to these two improper routing conditions as "Belted and Sat-On" (left image) and "Shoulder Belt Only" (right image).

[45] The design and architecture of the Origin's post-crash protocols could present valuable areas for collaboration with DOT and other agencies, particularly as emergency medical service best practices around autonomous driving are developed. DOT's broader vision for safer post-crash care as a key feature of its Safe System Approach was highlighted in the 2022 National Roadway Safety Strategy. *See* U.S. Department of Transportation, National Roadway Safety Strategy (Jan. 2022), https://www.transportation.gov/sites/dot.gov/files/2022-01/USDOT_National_Roadway_Safety_Strategy_0.pdf (hereinafter "2022 National Roadway Safety Strategy").

handles are clearly labeled with instructions, ISO symbols, and high-contrast colors as shown below in Figure 17 and Figure 18.

Figure 17: Emergency Exit Door Handle

Figure 18: Emergency Exit Lever

H. The Origin's Sensing Technology for Autonomous Driving

GM and Cruise have incorporated state-of-the-art sensors into the Origin's design that allow for robust sensing, perception, and motion tracking. These sensors are arranged to provide persistent long-range and short-range coverage of the environment around the Origin from the fascia of the vehicle up to distances of 200 meters.[46] In total, the Origin is equipped with over eighty (80) sensors that provide overlapping, 360-degree fields of view with no blind spots. This vast sensor array includes nineteen (19) cameras, three (3) long-wave infrared sensors, four (4) microphone arrays, eight (8) near-field LiDAR sensors, four (4) spinning LiDAR sensors, six (6) high-resolution radar sensors, twenty-two (22) near-field

[46] For reference, two hundred meters is the equivalent of over two football fields, or more than the length of Seattle's Space Needle. At 55 mph, it takes roughly 8 seconds to cover two hundred meters.

ultrasonic sensors, and sixteen (16) impact sensors.[47] These sensors are illustrated and described in Appendix C. The Origin's ADS receives a constant flow of rich sensor data, refreshed continuously by the millisecond, from this vast array of sensors to perceive a broad view of the surrounding road conditions and environment that informs the Origin's vehicle path planning and vehicle maneuvers.

Most of these sensors are configured and mounted in pods at the four corners of the roof (see Appendix C). Situating this equipment on or near the roof optimizes lines of sight and field of view, maximizing performance, and minimizing interference from road debris and other potential sources of interference. For example, placing the Origin's sensors on or near the top of the vehicle reduces the risk of them being damaged in the event of a collision, and avoids the potential for contact with cyclists, pedestrians, and other vulnerable road users during daily driving in urban environments. In addition to the roof-mounted pods, a roof top module provides further sensing capacity such that, at any given point in time, at least two different sensor types are surveying the Origin's near-field, mid-range and long-range path and surroundings to provide system redundancy.

I. The Origin's Automated Driving System ("ADS")

The Origin's ADS is a combination of multiple subsystems working together in concert to operate the vehicle consistently, effectively, and proficiently in a complex and dynamic environment, incorporating data from multiple sensors and making real-time decisions based on vehicle perception, prediction, planning, and controls.

The Origin will leverage the ADS used in the Cruise AVs. While the Origin's vehicle design is a first of its kind, the Origin benefits from the years of experience and developmental maturity of the ADS in the Cruise AV. This ADS has accumulated over three million miles of rich, on-road data in a variety of driving environments. This ADS is already engaged and approved in California for driverless rides with members of the public. The Origin and the Cruise AV use the same core software and have the same testing and release process for ADS software, hardware, and firmware. Test data from the Cruise AV fleet has also been used to design additional closed course and simulation tests for the Origin.

The Origin's ADS begins by rapidly synthesizing information collected from its preloaded, in-vehicle 3D maps. These maps, which are proprietary to Cruise, are high-fidelity, high-definition and highly detailed, including centimeter-level accuracy down to the level of each semantic road feature, such as lane markings, road signs, traffic lights, crosswalks, parking zones, and bike and bus lanes. The Origin map also evolves to reflect any modifications to permissible streets and other road use changes as part of Cruise's continuous mapping process. The ADS then uses the data collected by the sensor suite described above to inform the Origin's driving behavior through the mapped area.

The ADS uses all of this information to understand the surrounding environment (perception), evaluate the safest possible path for the vehicle given the environment

[47] In future versions of the Origin, technological advances may result in design modifications to the current sensor array configuration.

(prediction and planning), and then execute the corresponding driving maneuvers to move the vehicle along that path (controls).

J. Operational Design Domain

The Operational Design Domain ("ODD") refers to the environment, including location, weather, time of day, and speeds, in which an AV is designed to operate. The Origin's ODD will be controlled by Cruise as the operator of the Origin fleet, and safety is the gating metric. The Origin is designed to operate only within its defined ODD. As noted above, Cruise has developed high-fidelity, high-definition 3D maps that aid in vehicle localization and operation. The Origin ADS will only navigate through routes that fall entirely within the mapped area in any applicable ODD, which will include urban, suburban, and highway environments. Its advanced sensors enable operation in adverse weather such as rain, fog, and light snow, but, unlike some human drivers, the Origin will never operate outside of its performance limitations. It will not attempt to drive in dangerous weather conditions and it will not operate on roads that have not been mapped and are not a part of its ODD. It can avoid roadway types it has not been validated to operate in, and it will not operate through emergencies such as natural disasters (e.g., earthquake, hurricane, fires). Appendix E provides additional detail regarding the Origin's ODD.

When the Origin detects rapid or abnormal changes in weather conditions, the Origin will adjust how it operates (via perception, planning, prediction, and control) to accommodate both such environmental shifts and how other road users are behaving, such as when traffic slows during heavy rain. At all times, each Origin in the fleet can and will communicate with a centralized fleet operations center. This centralized fleet operations center will help the broader fleet proactively respond to—and in some cases avoid—certain geographies, conditions, or road segments that are temporarily less safe. This might occur, for example, if a falling rock or crane has created a roadway impediment; police or fire personnel have shut down an area due to an emergency; or there is an unexpected street closure. The centralized fleet operations center can monitor every Origin in a market and will have the capability to set dispatch and routing commands across the entire fleet, accounting for scenarios that even a single vehicle might encounter. Appendix F provides additional detail regarding the Cruise Back Office, including its centralized fleet operations center.

K. Minimal Risk Situations

Within the taxonomy of the Society of Automotive Engineers, the Origin is a level 4 "High Driving Automation" system.[48] The Origin's ADS will handle all driving tasks including vehicle motion controls, object and event detection and response, and achieving a minimal risk condition when appropriate. By way of example, if the Origin experiences a performance-related fault, it is designed to achieve a minimal risk condition.[49] The maneuver performed to achieve a minimal risk condition will depend on a number of factors, including the severity of the issue and the residual AV performance, resulting in

[48] SAE J3016 § 5.5, pg. 31-32.

[49] Other situations that may require minimal risk maneuvers include exiting the ODD or encountering an unanticipated change in the operating environment. *See* Appendix G for more details.

either the Origin pulling over at the nearest available safe stopping location, or executing a controlled stop in lane.

The Origin also is designed to achieve a minimal risk condition on detection of single or multi-point failures in its hardware and software systems if they are classified as hazardous. Internal diagnostics are integrated into hardware and software systems that are designed to initiate an appropriate dynamic driving task fallback maneuver ("DDT-F") that will bring the Origin to a minimal risk condition upon detection of a failure. Additionally, the Origin hosts redundant hardware and software systems to maximize its ability to achieve a minimal risk condition in the presence of a system failure.[50]

If the Origin must achieve a minimal risk condition, the vehicle will inform vehicle occupants that a situation that prevents ride completion has been detected and alternative transportation may be dispatched. A service call from the Cruise Customer Support team also will be initiated to explain the situation to the Origin's passengers, respond to any questions, and contact necessary support services or local authorities as needed.

L. Communication with Other Road Users

The Origin will communicate its intended navigation path to other road users through traditional methods used by human drivers, such as a turn signal to indicate an approaching turn, brake lights to signal a stop, hazard signals, and a horn to be used sparingly in emergency situations. The Origin also will house an external speaker capable of communicating with first responders and third parties in real-time in the event of a collision. When the Origin is stopped and in the park position, the external speaker will be used to communicate with humans controlling traffic and/or gated access areas. The Origin will also provide a pedestrian alert sound in compliance with FMVSS 141.

M. Mitigating Cybersecurity Risks

Cybersecurity is fundamental to the Origin and has been integrated into all aspects of the vehicle's design. To ensure the safety of the Origin from external threat vectors, GM and Cruise have dedicated cross-functional security personnel from both companies spanning Cruise and GM engineering, supplier sourcing, and security engineering teams (the "Security Team"). GM and Cruise have developed numerous vehicle security controls, which are listed in Appendix H, including those recommended by NHTSA's Cybersecurity Best Practices guidelines.[51]

Additionally, the Security Team has implemented measures beyond the NHTSA published guidelines to help ensure vehicle security. Such measures include unique technologies, such as host-based anomaly detection/prevention software. These are systems that monitor, alert, and react in real-time to potential cyber-related threats in the

[50] *See* Appendix G for more detail regarding the Origin's redundant systems, its internal diagnostics, and its fallback maneuver capabilities in the event of a fault.

[51] *See* NHTSA, *Cybersecurity Best Practices for the Safety of Modern Vehicles* (Draft 2020 Update), https://www.nhtsa.gov/sites/nhtsa.gov/files/documents/vehicle_cybersecurity_best_practices_01072021.pdf; NHTSA, *Request for Comments, Cybersecurity Best Practices for the Safety of Modern Vehicles*, 86 Fed. Reg. 2481 (Jan. 12, 2021).

main vehicle computer and base vehicle system. More detail regarding the Origin's cybersecurity protections is provided in Appendix H.

III. PETITION FOR EXEMPTION

The Vehicle Safety Act provides the Secretary of Transportation authority to exempt motor vehicles from an FMVSS on a temporary basis, under specified circumstances, and on terms the Secretary deems appropriate.[52] The Secretary has delegated that authority to NHTSA.

NHTSA, in exercising this delegated authority, "must look comprehensively at the request for exemption" and determine if the petition meets the three statutory requirements set forth in the Vehicle Safety Act.[53]

As noted above, GM and Cruise in this Petition seek temporary exemptions for certain requirements of nine FMVSS. The particular requirements for which GM and Cruise seek exemption are unnecessary given the Origin's design and functionality, and their purpose and intent is met through the Origin's overall safety level, which is at least equal to the overall safety level of nonexempt vehicles. As such, and at a minimum, granting these temporary exemptions would not unreasonably lower the Origin's safety. Thus, GM and Cruise seek an exemption from NHTSA that is premised on one or both of the two following statutory bases:

First, under 49 U.S.C. § 30113(b)(3)(B)(iv), NHTSA may issue an FMVSS exemption under the equivalent overall safety level ("EOS") basis

> on finding that—(A) an exemption is consistent with the public interest and [the Vehicle Safety Act] (as applicable); and (B)…compliance with the standard would prevent the manufacturer from selling a motor vehicle with an overall safety level at least equal to the overall safety level of nonexempt vehicles.

Second, and alternatively, under 49 U.S.C. § 30113(b)(3)(B)(iii), NHTSA may issue an FMVSS exemption under the low-emission vehicle ("LEV") basis[54]

> on finding that—(A) an exemption is consistent with the public interest and [the Vehicle Safety Act] this chapter or chapter 325 of this title (as applicable); and (B)…the exemption would make the development or field evaluation of a low-emission motor vehicle easier and would not unreasonably lower the safety level of that vehicle.

[52] *See*, *e.g.*, 49 U.S.C. § 30113(b).

[53] *Nuro*, 85 Fed. Reg. at 7828.

[54] NHTSA has recognized that granting an application under the LEV basis would allow for the deployment of a vehicle that provides a lower level of safety, as long as doing so does not unreasonably lower the safety level. *Id.* at 7832. In this case, the Origin does not decrease the overall level of safety compared to a nonexempt vehicle.

NHTSA may grant this Petition based upon either of these two bases.

A. EOS: The Origin Provides an Equivalent Overall Safety Level

The Origin provides an overall safety level at least equal to the overall safety level of nonexempt vehicles for the reasons detailed in the Origin Overview in Section II, above, and for the reasons explained in this Section. The Origin meets the EOS requirements when reviewed vis-à-vis the individual FMVSS for which exemption is sought, but also when considering the Origin's overall safety performance more holistically. NHTSA may consider both aspects in analyzing the Origin's level of safety.[55] Indeed, NHTSA recently recognized that the "broader considerations of safety that may not be captured at the individual standard level" are nonetheless an appropriate basis for consideration in an EOS analysis.[56]

Additional technical data demonstrating equivalent safety for each individual FMVSS for which an exemption is sought is provided in Appendix A. Except where the need for FMVSS exemptions has been noted in this Petition, the Origin will comply with applicable FMVSS. The Origin has been evaluated extensively for how it meets or exceeds the safety level of each pertinent Standard.

The Origin uses a state-of-the-art vehicle architecture that is purpose-built to meet the specific needs of an autonomous vehicle in a ridesharing application. With innovative technology, systems, and construction that enable optimal operation at all times without a human driver, the vehicle meets the full intent and purpose of each of the applicable FMVSS, but in some instances because of its novel designs and technology, does not meet the literal requirements of the Standards. The Standards were drafted with the assumption that the "driver" will always be a human being. In light of today's technological developments, this assumption no longer holds true. Indeed, in 2016, NHTSA interpreted "driver" to mean a motor vehicle's ADS.[57] As relevant to this Petition, the Origin fulfills the underlying purposes and safety objectives of the Standards, despite their assumption of a human driver and a vehicle with traditional manual controls.

1. 100 Series FMVSS Safety Analysis: The Origin Provides an Equivalent Level of Safety for Each FMVSS for Which an Exemption Is Sought

a. <u>FMVSS 102, Gear Selection Display (S3.1.4.1)</u>

GM and Cruise respectfully seek an exemption from that portion of FMVSS 102 requiring that the transmission shift sequence be identified "in relation to each other."[58] The purpose and intent of FMVSS 102 is satisfied because the shift positions are transmitted electronically to the ADS, which is the Origin's driver. The ADS, unlike a human driver, is not susceptible to confusion as to which shift position the vehicle is in or which position it needs to move to next during operation. Instead, under the Origin's transmission-shift strategy,

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[55] *See id.*

[56] *Id.*

[57] *See* Google Interpretation at p. 7 ("[B]ecause we are interpreting 'driver' and 'operator' in this instance to refer to the SDS [Self-Driving System], we agree that the information required by the provisions of FMVSS No. 111 that must be provided to the 'driver' or 'operator' may be provided to the SDS.").

[58] 49 C.F.R.§ 571.102, S3.1.4.1.

the purpose and intent of the Standard's shift position and display requirement is met; is not necessary for safety as applied to the Origin's particular design; and provides an equivalent level of safety as compared to a traditional vehicle. The Origin meets all other requirements of FMVSS 102.

The relevant portion of the Standard states:

> S3.1.4.1 Except as specified in S3.1.4.3, if the transmission shift position sequence includes a park position, identification of shift positions, **including the positions in relation to each other and the position selected**, shall be displayed in view of the driver whenever any of the following conditions exist:
>
> *(a)* The ignition is in a position where the transmission can be shifted; or
>
> *(b)* The transmission is not in park.

The purpose of this portion of FMVSS 102 is to "reduce the likelihood of shifting errors" by the driver.[59] While the Standard was written with an assumption that a human driver would always shift a manually operated shift lever (a valid assumption at the time), in this instance, in a vehicle that is fully operated by the ADS, there is no potential for transmission shifting errors resulting from confusion over which gear the vehicle is in or the physical position of the shift lever.

In the Origin, the ADS is the "driver"—it alone operates the vehicle, commanding the required shift positions electronically and it is always aware of the current shift position. The shift positions are electronically presented to the Origin's ADS without need for a visible display. NHTSA determined that the ADS is the "driver" for purposes of this requirement in its original, February 4, 2016 response to Google's request for interpretation.[60] Consistent with that determination, identification of shift positions is displayed in view of the "driver" (i.e., the ADS) in the Origin, consistent with the requirements of S3.1.4.1 of the Standard.

The Origin does not have a physical transmission shift lever—all gear shifts will be electronically commanded by the ADS. Indeed, including a manual shift lever when the gear shift operation is controlled completely by the ADS could introduce potential safety issues by presenting an opportunity for passengers to interfere with the transmission shift process and the safe operation of the vehicle.[61]

The Origin is programmed to know the shift position and select the gear without referring to a physical shift position display. There is no additional safety purpose to be served by displaying the shift positions in relation to each other. This shifting logic provides

[59] *Id*. at S1.

[60] *See* Google Interpretation at 10 (NHTSA, addressing FMVSS 102, S3.1.4.1, stated: "We agree that the SDS is the driver for purposes of this paragraph.").

[61] GM specifically designed the Origin without a manually operated gear selector to eliminate any potential for passenger interference with the safe operation of the Origin.

an equivalent level of safety as compared with a vehicle equipped with a manually operated shift level with the shift positions displayed on the lever and in view of the human driver.

Even though the Origin will not have a manually operated shift lever, the vehicle will display the current shift position (e.g., Park, Drive, Reverse) on End zone screens so that all passengers are always aware of the current shift position of the vehicle. The Origin's display of the shift position also updates automatically as the Origin moves from one position to the next so that the shift position is communicated to passengers in real time. While the shift position is not provided to the passengers on the display screen relative to other shift positions or to the position selected, there is no need for such a display in the Origin because the passengers cannot operate or alter the shifting process.

Figure 19, below, provides an example of the Origin's End zone screens, demonstrating from the passengers' perspective, how the Origin will communicate the current shift position.[62] The red arrows were added for purposes of this document to highlight the shift position display.

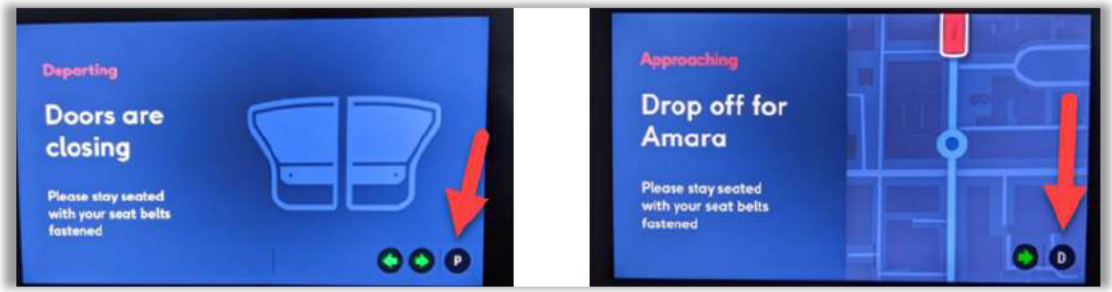

Figure 19: End zone screen Views

b. FMVSS 104, Windshield Wiping/Washing System

The purpose and intent of a traditional windshield wiping and washing system is obviated by the Origin, which uses an advanced system to ensure that the ADS maintains full visibility of its surroundings. FMVSS 104 is focused on ensuring a human driver's ability to maintain sufficient visibility through the windshield of the roadway ahead in the case of inclement weather or debris or dirt build up on the windshield.

Unlike a human driver that relies exclusively on the windshield for forward visibility, the Origin uses a vast array of exterior sensors to "see" the road and its surroundings.[63] The Origin's vision system does not rely on, and is completely independent from, the windshield. As such, the Origin is not equipped with and does not need windshield wipers or washers as required by FMVSS 104.

Instead, the Origin uses an alternate means to maintain the ADS' vision which provides an equivalent level of safety. The Origin's exterior optical sensors (i.e., LiDAR and

[62] This is an illustration of what the display screens in the production-level Origin will look like. The exact colors, text, and layout of these screens are subject to change.

[63] *See* Appendix C for additional detail on the Origin's sensor and vision system. In addition, as explained in Appendix E, the Origin will not operate in severe weather conditions, including heavy rain, hail, sleet, and snow. In fact, the Origin's current ODD excludes heavy rain, heavy smoke, heavy fog, hail, sleet, and snow.

cameras) have integrated cleaning systems that keep the outer lens surface of the sensors clean by removing moisture and dirt. A schematic block diagram describing the sensor cleaning system is provided in Figure 20: Sensor Cleaning System Diagram, below.

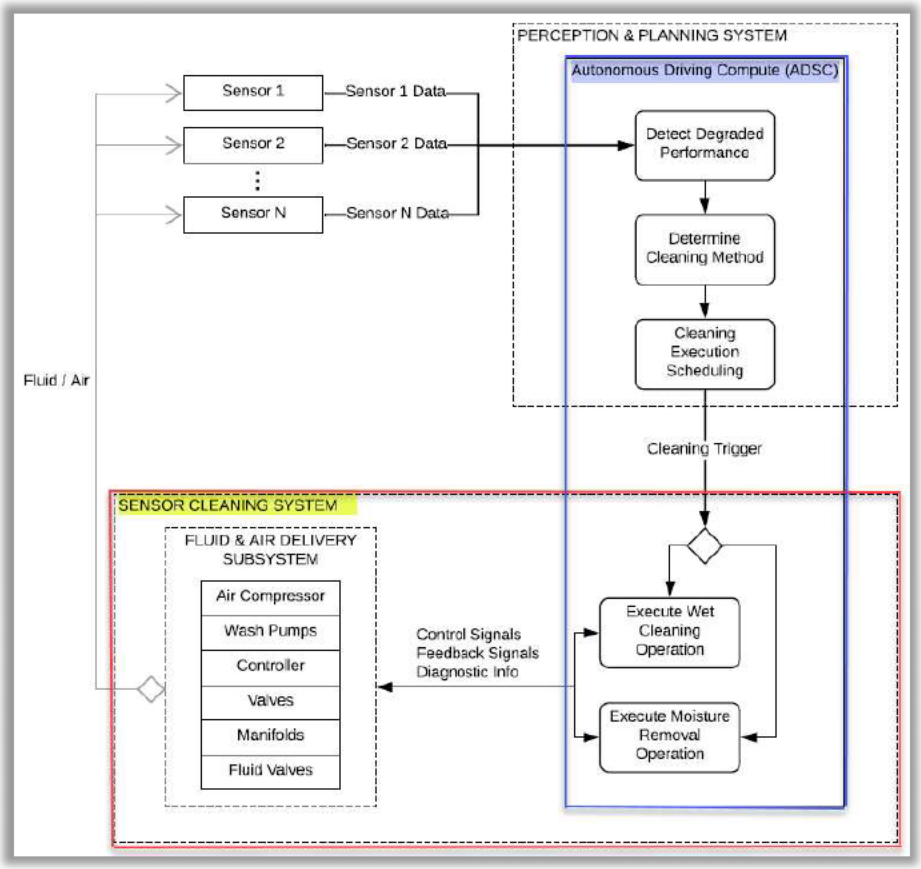

Figure 20: Sensor Cleaning System Diagram

As shown above in Figure 20, the sensor cleaning system (red block) consists of an air compressor, wash pumps, a controller, valves, manifolds, and fluid valves. The ADS (represented by the blue block) continuously monitors the performance of the optical sensors (i.e., sensor output). If the ADS determines that sensor cleaning is required (e.g., by detecting degraded performance of any optical sensor based on, for example, contrast, range, distortion, or occlusion), it sends an activation signal to the cleaning system and determines the appropriate cleaning method—air only (e.g., to remove rain) or with washer fluid first (to remove dirt and debris), followed by air to clear the fluid off. The washer fluid used is similar to traditional automotive windshield washer fluid. The ADS will monitor the quality of the sensor data given the current conditions (e.g., vehicle speed and roadway type) to understand if a sensor or plurality of sensors are impaired. If impairment is detected, the cleaning system will be triggered to remedy the situation. If the situation cannot be remedied, the Origin will execute a minimal risk condition maneuver and may determine the appropriate action is to pull over.[64]

[64] *See* Appendix G for additional detail regarding minimal risk (fallback) capabilities of the Origin.

An example of the Origin's sensor cleaning system used for its four roof-mounted sensor pods and the roof-top module is shown in Appendix A (e.g., Figure A-6). The Origin's sensor cleaning system is functionally equivalent to the traditional type of windshield wiping system required by this Standard and provides an equivalent level of safety at both an individual Standard level and at an overall vehicle level. More information, including illustrations, regarding the sensor cleaning system is provided in Appendix A.

c. <u>FMVSS 108, Turn Signal Self-Cancellation, High/Low Beam Switch, and Hazard Lights (S9.1.1, 9.4, and 9.6.2)</u>

The Origin is equipped with all the lamps, reflective devices and other lighting equipment required by FMVSS 108 for an MPV. Because a human driver is not required to operate the Origin, there is no need for manually operated lighting controls. The Origin's ADS will exclusively control all aspects of vehicle lighting, which will meet the functional performance requirements as well as the purpose and intent of FMVSS 108. Thus, the temporary exemptions that GM and Cruise seek relate to FMVSS 108 lighting requirements that are linked to the provision of human-operated controls that, as described herein, are not necessary for safety given the Origin's design and functionality.

Moreover, eliminating manual controls in the Origin was a deliberate decision premised on enhancing safety by eliminating the potential for passenger interference. Indeed, allowing passengers access to manual lighting controls could have the unintended consequence of creating safety issues, such as, for example, passengers turning on the high beams when there is oncoming traffic.

(i) In the Origin, the turn signal will cancel itself without regard to the position of the steering wheel or manual controls (S9.1.1)

Per FMVSS 108, S9.1.1: "The turn signal operating unit installed on…multipurpose passenger vehicles…must be self-canceling by steering wheel rotation and capable of cancellation by a manually operated control." The Origin meets the intent and safety purpose of this Standard through the ADS' electronic cancellation of a turn signal after the turn maneuver or lane change is complete, without regard to any rotation of a steering wheel. Specifically, the ADS will cancel the turn signal when it determines, based on multiple inputs from the AV's sensor systems, map data, and localization data that the Origin has successfully executed the intended maneuver and the vehicle is appropriately positioned in the lane. Once this determination has been made, the ADS automatically turns off the turn signal.[65] By automatically canceling turn signals upon completion of the turning maneuver or a lane change, the Origin will not forget to cancel them like a human driver could with a conventional turn stalk. The lack of conventional turn stalks also avoids the potential unintended consequence of passenger interference with the steering wheel's

[65] The Origin's ADS is programmed to ensure turn signal activation and cancellation is compliant with state law requirements applicable to its ODD. *See, e.g.*, Cal. Veh. Code § 22108 (requiring continuous use of a turn signal 100 feet prior to turning).

turn signal cancellation function and, by extension, the safe operation of the vehicle and its interactions and communications with other road users.[66]

(ii) The Origin automatically and electronically activates the high/low beam lamps; there is no manual switch (S9.4)

FMVSS 108, S9.4 requires a "headlamp beam switching device" that has "a means of switching between lower and upper beams designed and located so that it may be operated conveniently by a simple movement of the driver's hand or foot." The Origin's design and performance satisfies the purpose and intent of this language as well.

The Origin is equipped with fully compliant high beams that meet the performance requirements of the Standard. However, as previously noted, the Origin does not have a manual control for switching between lower and upper beams.

While the Origin is equipped with high beams, its sensors do not need them to "see" and operate at night. The Origin uses a series of sensors as its sole means of visibility, and these sensors—e.g., LiDAR, radar, and thermal imaging cameras (among other sensors—see Appendix C) are designed to operate, without external lighting, at night or in low light conditions. That is, the Origin's ADS does not rely on high beam activation to enhance its ability to operate at night.[67]

The Origin is equipped with daytime running lights and automatic headlights, such that when operating at night, the Origin's low beams are always active. While the Origin is equipped with a method for electronically switching between low and high beams, GM and Cruise do not anticipate that the ADS will ever need to command high beams during normal operation.[68]

(iii) The Origin's automated hazard warning lights are not independent of an ignition switch (S9.6.2)

Under FMVSS 108, S9.6.2:

> The [hazard warning signal operating] unit must operate independently of the ignition or equivalent switch. If the actuation of the hazard function requires the operation of more than one switch, a means must be provided for actuating all switches simultaneously by a single driver action.

[66] Appendix A provides additional technical details regarding the Origin's electronic control of the turn signals. Appendix A also provides real-world turn-signal data from the Cruise AV that demonstrates that the ADS ensures the turn signals are properly activated and deactivated during turning maneuvers. *See* Table A-1, below.

[67] In the roughly three million on-road miles that the Cruise AV has operated, it has never needed to activate the high beams to operate safely at night.

[68] Appendix A provides additional technical details regarding the electronic activation of headlamps. The only situation in which the high beam lamps may be activated would be in the event of a malfunction requiring the vehicle to perform a minimal risk maneuver and come to a stop at night. From a stopped location, if Cruise's Remote Assistance personnel needed to connect with the vehicle to see the road ahead through the Origin's front-facing cameras, the Remote Assistance Advisor may need to activate the high beam lamps.

The purpose and intent of the requirement at S9.6.2 for the hazard warning lights to operate independently of the vehicle's ignition is that, with conventional, manually operated personal vehicles, there may be situations when a human driver needs to activate the hazard lights when the vehicle is stopped with the ignition off. In this circumstance and in a traditional vehicle, the hazard lamps require an independent power source.

The Origin, however, is quite different. The Origin is equipped with hazard warning lights that are compliant with FMVSS 108's performance requirements with the one exception: that the hazard lights do not operate independent of the ignition switch. Rather, the Origin's hazard lights will not operate until the vehicle is first started (booted up) by trained Cruise personnel. After this initial boot up, the Origin's hazard warning lights function consistent with the Standard while in operation on public roads. The ADS will electronically activate the hazard warning lights in appropriate circumstances as explained below.

Short of a severe incident (discussed below), there is no reasonably foreseeable situation where the Origin will ever operate on public roads and be stopped without power, which is the equivalent of the ignition switch being "off." Once an Origin is initially powered up by Cruise trained personnel at the start of service, the Origin remains powered "on" at all times thereafter. This includes all travel on the public roads and during minimal risk maneuvers.[69]

Importantly, all Origins will be part of a centrally commanded and professionally managed fleet. Each Origin will be booted up at the start of service and only by trained Cruise personnel. In order for the Origin to start its service, it must be powered on. Similar to boot up, only trained Cruise personnel can power off an Origin—and this happens only during shutdown. This means that anytime the Origin leaves a dispatch site, the vehicle is powered "on" and the hazard lamps will be capable of being activated. Per operational requirements, the Origin will never be in a hazardous location or situation where the hazard warning lights could be needed prior to being powered on. Once the Origin is powered "on," it will remain "on" and will always command the hazard lights to activate when they are needed, even if the vehicle is disabled. Therefore, the requirement in S9.6.2 that the hazard warning lamp operating unit operate independent of the vehicle ignition has no impact on the ability to activate the hazard warning lamps once the vehicle is initially powered on.

Moreover, the Origin is designed with sufficient redundancy to ensure that hazard lights will be activated for any scenario in which hazard lights may be necessary. In the unlikely event of a severe incident (e.g., a severe crash) that results in an unintentional loss of power, the Origin will automatically command the hazard lights to activate prior to the loss of power and the hazard lights will remain activated through a backup 12-volt power supply.

[69] Passengers cannot turn the Origin's power on or off. Power to the Origin is controlled exclusively by Cruise. There is no mechanism in the vehicle (e.g., an ignition switch) that passengers can access and use to control power to the Origin. The primary means of turning the Origin's power on and off is remotely by the Cruise Back Office. There is a physical power switch on the Origin, located behind a locked panel, but it is used as a backup only and is accessible only by authorized Cruise personnel.

d. FMVSS 111, Rear Visibility (Linger Time) and Rearview Mirrors (S6.2.4 and 6.1)

The purpose and intent of FMVSS 111 is to reduce the potential for deaths and injuries when the "driver of a motor vehicle does not have a clear and reasonably unobstructed view to the rear."[70]

To that end, FMVSS 111 requires the installation of:

- Rearview mirrors on the outside of the vehicle.
- A rearview mirror on the inside of the vehicle.
- A rear visibility system that displays the area immediately behind, and which displays while the vehicle is engaged in a reverse maneuver.

Each of these systems and devices were expressly developed to meet performance requirements that are based on the premise that a human driver is manually controlling the rearward movement and operation of the vehicle. This section describes the ways in which the Origin's design and performance satisfies the purpose and intent of the Standard:

- The Origin's ADS relies on a series of sensors, including cameras, radars, and LiDAR, to provide a 360-degree, live image of the surrounding area.

- Information and images from these sensors are constantly provided to the Origin's ADS throughout vehicle operation. The Origin's ADS cannot be distracted or look away during its dynamic driving task—it is designed to operate by means of receiving and processing *all* sensor inputs simultaneously, and all the time.

- Multiple sensors are able to simultaneously and completely "see" the areas that FMVSS 111 S6.2.1 and S6.2.2 require the traditional rear vision system to see, as explained below.

(i) Technical Overview of the Origin Rear Visibility System

The Origin has a 360-degree view with no blind spots. This is enabled by a state-of-the-art sensing system that is comprised of over eighty (80) sensors, including cameras, LiDAR, and radar,[71] which provides the Origin with constant access to a live image of the vehicle's full surroundings, as detailed in Appendix C.

More specifically, the Origin's rear visibility system uses a combination of 10 rear-facing sensors:

- 4 cameras
    - 2 Surround View

[70] 49 C.F.R. § 571.111, S2.

[71] *See* Appendix C.

    - 2 Medium Range, Medium Resolution ("Medium Distance")[72]
- 4 LiDAR sensors
    - 2 Near-Field
    - 2 Spinning
- 2 radar sensors

Figure 21, below, illustrates the location of all 10 devices that comprise the Origin's comprehensive rear sensor system.

[redacted]

Figure 21: Origin's Rear Sensor System[73]

FMVSS 111, S6.1(a) require that a vehicle's side-mounted rearview mirrors be able to see a view of a level road surface that is 8 ft wide, extends to the horizon, and starts 35 ft behind the location of the driver's eyes. Since the Origin does not have a human driver, we expand the area that FMVSS 111, S5.2.1 requires to be visible to include all hypothetical locations a human driver could possibly occupy in any vehicle. We therefore consider two 8 ft-wide areas that must be seen by the sensor system: one that starts 35 ft from the frontmost point of the Origin, extending to the horizon, and one that starts 35 ft from the rearmost point of the Origin, extending to the horizon. This is depicted in Figure 22, which shows (for reference) the left-hand mirror required areas. In this figure, the area that starts 35 ft back from the frontmost point of the vehicle is depicted in light orange, and the area that starts 35 ft back from the rearmost point of the vehicle is depicted in darker orange. Collectively, the light and orange bands represent all possible areas that S5.2.1 of FMVSS 111 requires a rearview side mirror system to be able to see.

[72] For purposes of this document and the Figures below, we refer to the Medium Range (Medium Resolution) cameras as "Medium Distance" cameras. More detail regarding the Origin's cameras is provided in Appendix C.

[73] Figure 21 also illustrates the location of the rear-facing external microphones, the impact sensors, and the near-field ultrasonic sensors that contribute to the Origin's ability to detect and react to objects behind and around the vehicle.

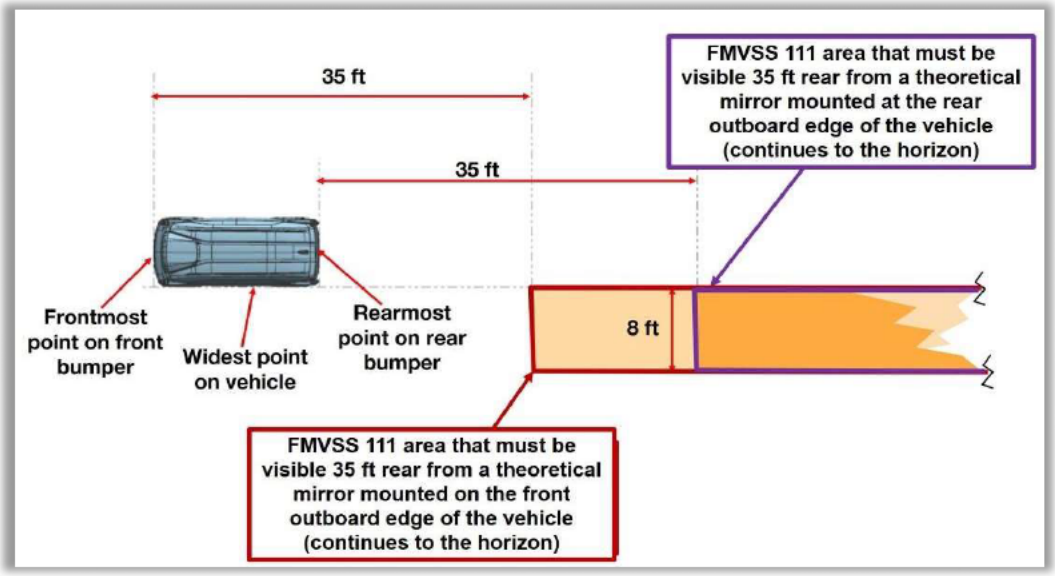

Figure 22: Areas that S6.1(a)(S5.2.1) Requires to be Visible by the Outside Mirrors

FMVSS 111, S6.2.1 also requires that the backup rear vision system be able to see an array of seven cylindrical test objects. In the following figures we show that multiple rear-looking sensors fully see both the side mirror required areas of coverage and the backup rear vision system-required test objects.

[ ]

Figure 23: Origin Camera Coverage (FOV) Provided by 4 Rear Cameras: 2 Surround View (Yellow) and 2 Medium Distance (Orange), Represented by Ground Intercepts[74]

[74] Note that these illustrations do not represent the sensors' full range or field of view ("FOV"). For ease of reference, these figures illustrate what the Origin's rear-looking sensors can see by providing the ground intercepts of the sensors' three-dimensional FOV. The ground intercepts represent the intersection of the three-dimensional area the sensors can see with the ground. In these ground-intercept illustrations, the truncation of these ground-intercept shapes at a given radial distance from the sensor does not imply that the sensor cannot see beyond these illustrated limits.

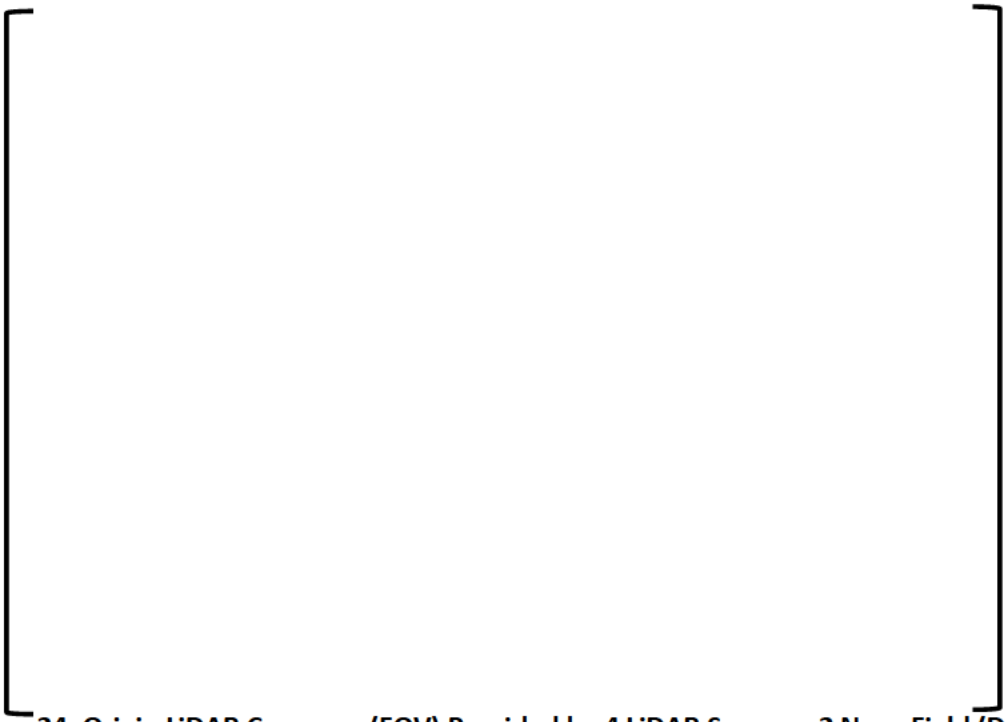

Figure 24: Origin LiDAR Coverage (FOV) Provided by 4 LiDAR Sensors: 2 Near-Field (Dark Blue) and 2 Spinning (Light Blue), Represented by Ground Intercepts

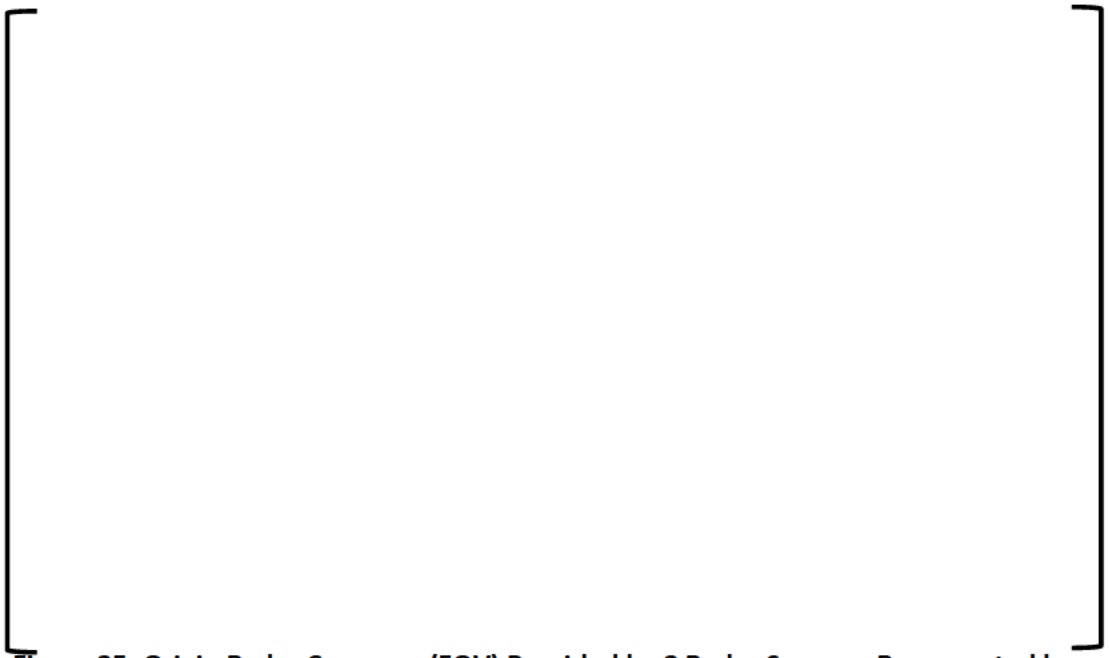

Figure 25: Origin Radar Coverage (FOV) Provided by 2 Radar Sensors, Represented by Ground Intercepts

The illustrations above (Figures 23, 24, and 25) demonstrate that the Origin's collective sensor modalities cover both the areas required to be visible by the side rear view mirrors, and the backup rear vision system.

(ii) Rearview Mirrors (S6.1)

Traditional MPVs are required to have a series of physical mirrors mounted on both the interior and exterior of the vehicle.[75] These mirrors are configured based on the driver's line of sight and are required to provide a minimum field of view at the rear of the vehicle. The Origin's LiDAR and mounted cameras are designed to work in tandem and provide a FOV that well exceeds the area that S6.1(a) requires to be visible to the driver via rearview mirrors.

While each of the Origin's sensor modalities cover the required areas of coverage at the rear of the vehicle as illustrated above, GM conducted tests at its Milford Proving Grounds to confirm that the FOVs provided by the rear-facing cameras meet and exceed the areas of coverage required by S6.1(a). The figures below show images captured from each of the Origin's rear-facing cameras (right and left). Additional snapshots and camera specifications are provided in Appendix C.

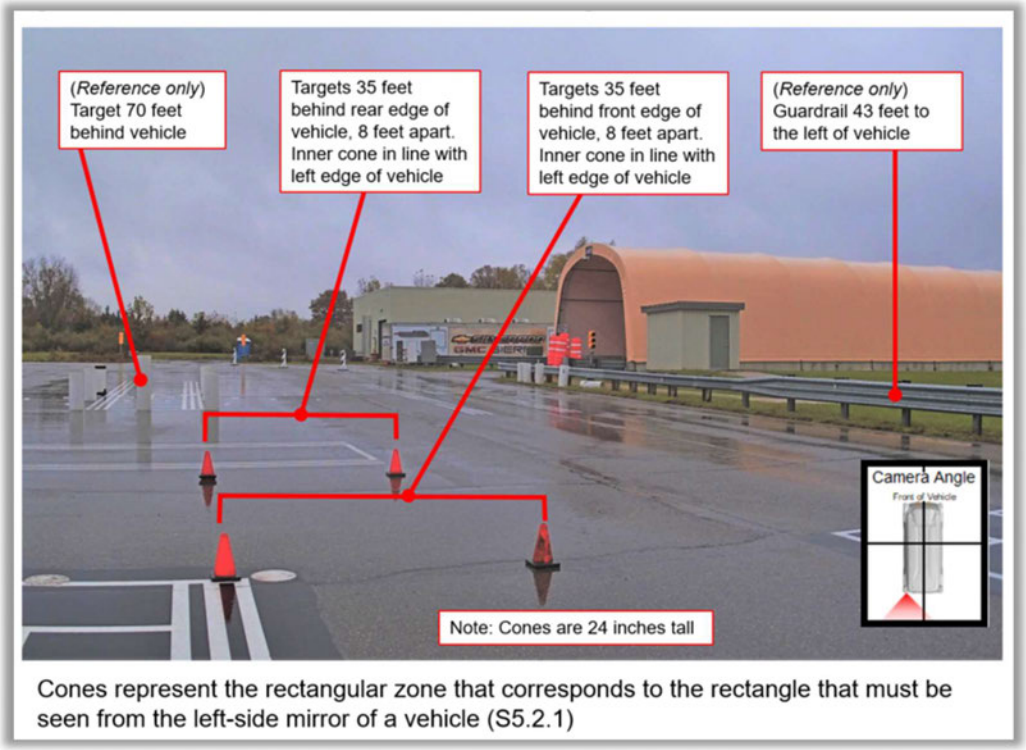

Figure 26: Origin Left Rear Medium Distance Camera Showing FMVSS 111, S5.2.1 Left Side Mirror Zone

[75] *See* 49 C.F.R. § 571.111, S6.1.

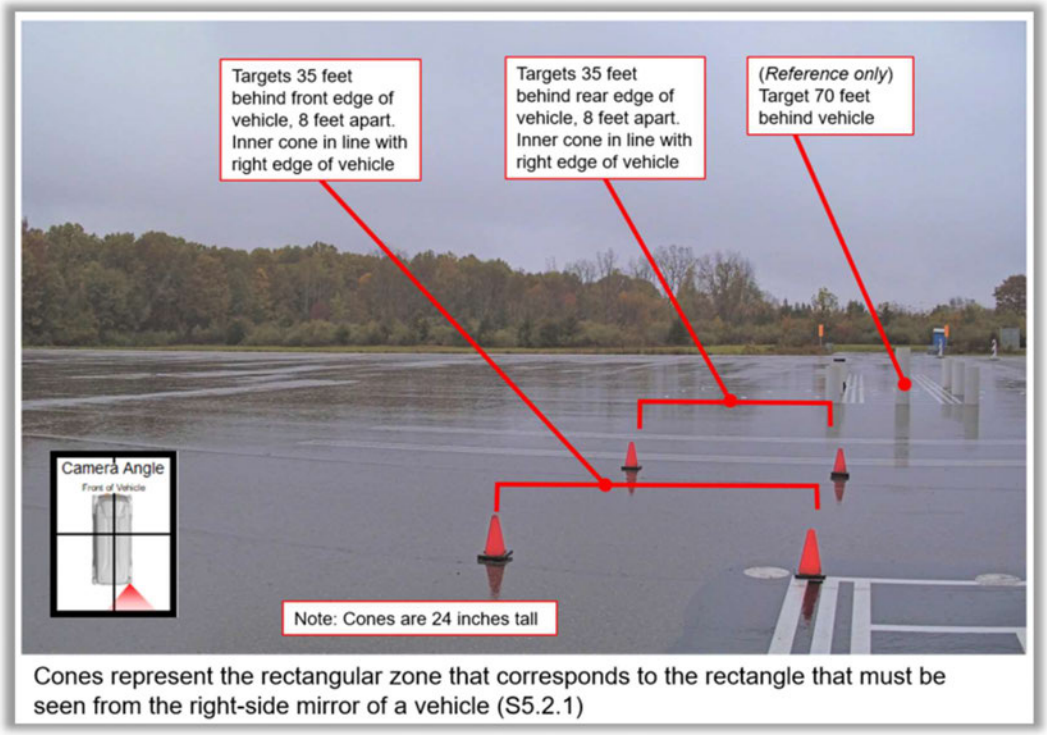

Figure 27: Origin Right Rear Medium Distance Camera Showing FMVSS 111, S5.2.1 Right Side Mirror Zone

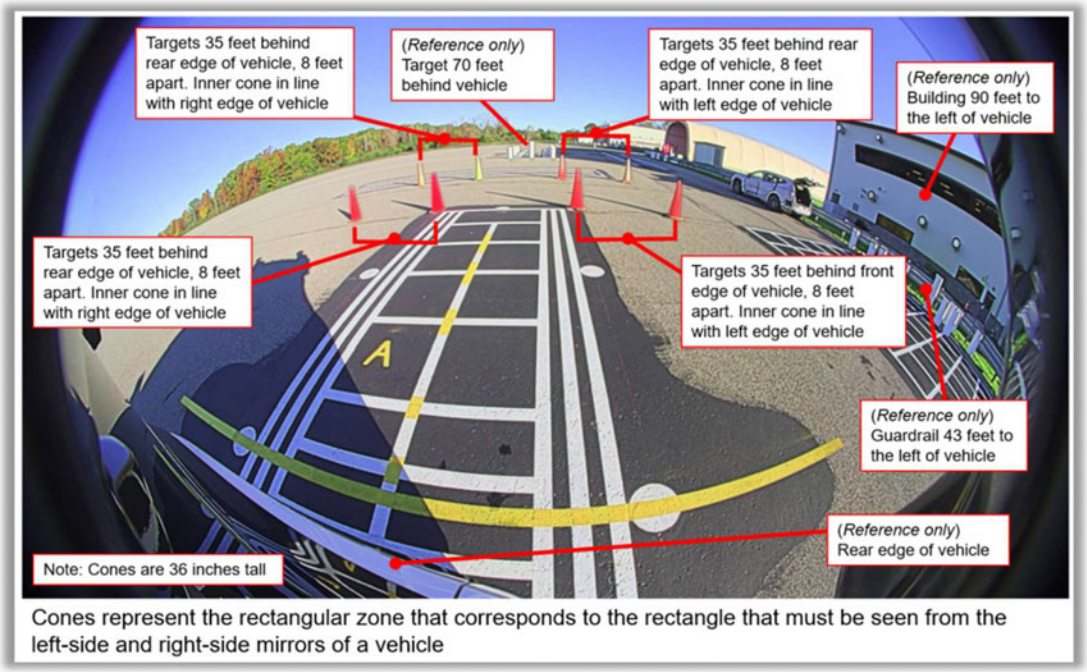

Figure 28: Origin Left Rear Surround Camera Showing FMVSS 111, S5.2.1 Both Mirror Zones

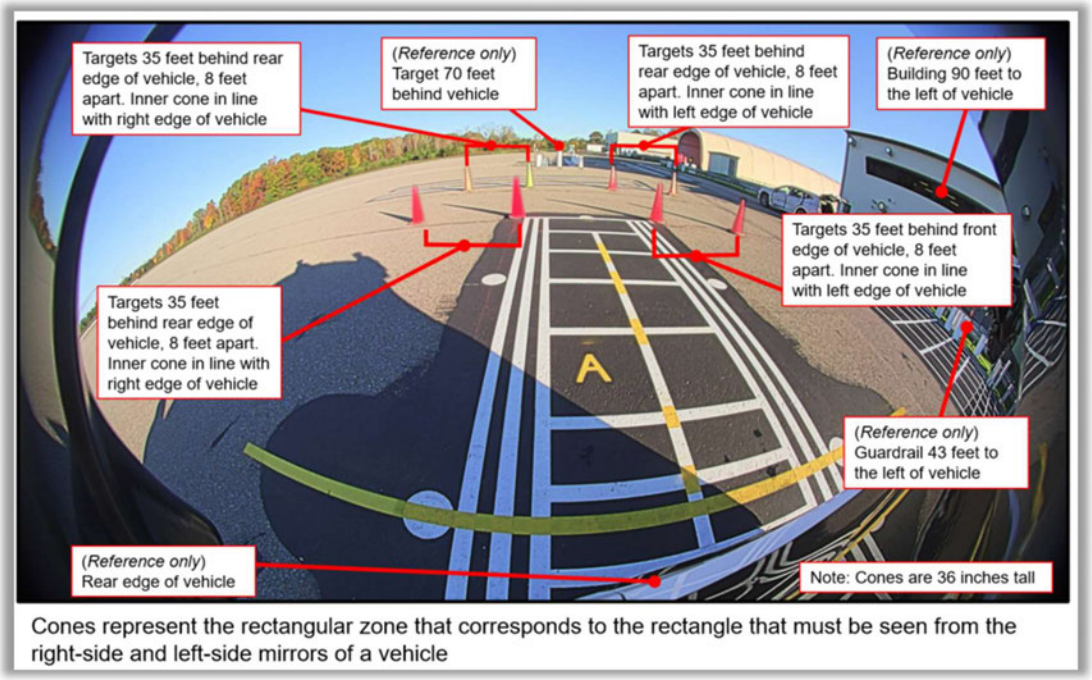

Figure 29: Origin Right Rear Surround Camera Showing FMVSS 111, S5.2.1 Both Mirror Zones

(iii) The Origin's Rear Visibility System Complies with All Aspects of S6.2 With One Exception—Linger Time (S6.2.4)

FMVSS 111, S6.2(b) requires each MPV to "display a rearview image meeting the requirements of S6.2.1 through S6.2.7." A rearview image is further defined as a "visual image, detected by means of a single source, of the area directly behind a vehicle that is provided in a single location to the vehicle operator and by means of indirect vision."[76] The Origin's rear visibility system produces a "rearview image" that meets the requirements of S6.2, and constantly provides this compliant rearview image to the Origin's vehicle operator—the ADS.[77]

The Agency has also recognized that in the context of a driverless vehicle, an in-vehicle rearview image display screen is not necessary. In *Nuro,* NHTSA explained that "[w]hile most conventional vehicles with human drivers comply with this requirement through the use of a screen on which the rearview image is displayed, the R2X does not have such a screen because, since it cannot be operated by a human driver, such a screen is unnecessary."[78] The same principle applies to the Origin's driverless system.

[76] 49 C.F.R. 571.111, S4.

[77] Again, the Agency has recognized through interpretation that the ADS is the driver in the context of an autonomous driving system. Google Interpretation at p. 7.

[78] *Nuro*, 85 Fed. Reg. at 7835 n.62.

As illustrated below in Figure 30 and Figure 31, GM has confirmed the Origin's rear cameras provide an FOV that meets and exceeds the requirements of S6.2.[79]

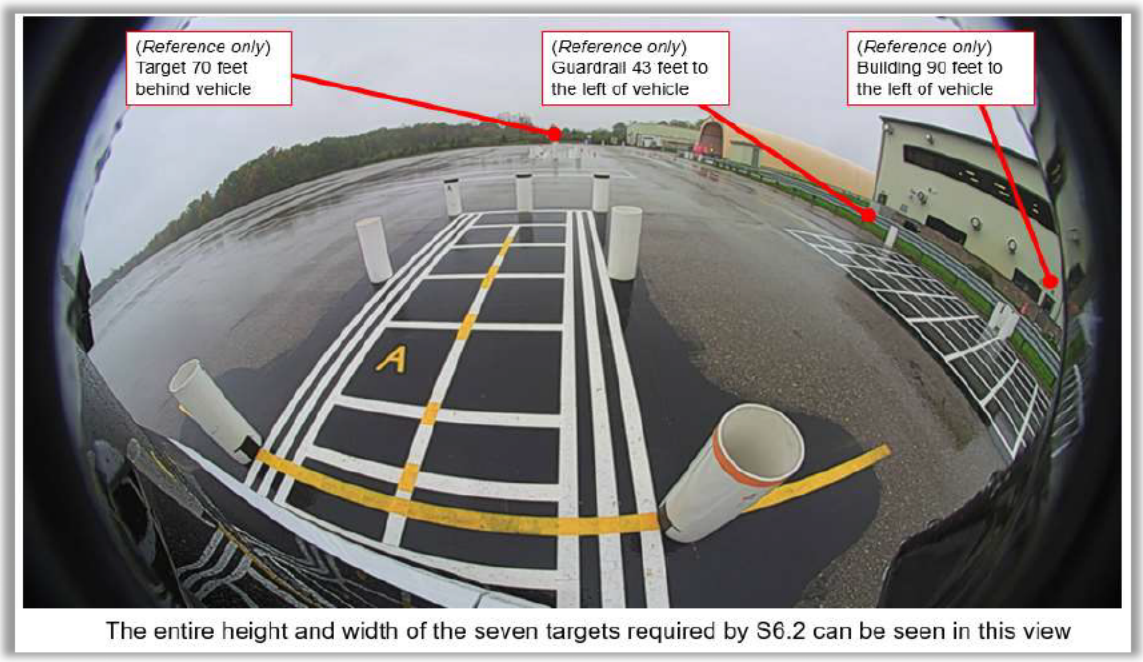

Figure 30: Origin's Left Rear Surround Camera Showing FMVSS 111, S6.2 Rear Vision Grid

[79] GM placed the requisite test objects in the locations specified in FMVSS 111, and then captured the images provided to the ADS from the left and right rear surround cameras. As both Figures illustrate, each camera provides the field of view required by S6.2. These images are constantly provided to the ADS (they are never deactivated) and therefore each camera meets the "Response Time," "Default View," and "Deactivation" requirements of S6.2. However, since the images are constantly provided to the ADS, the Linger time requirement in S6.2 is not met (*see* Section III.A.1.d.iv below). Because these images are also used by the ADS at all times to "see" and to operate the vehicle, an always-on vision system that includes rear-facing sensors is an essential part of the Origin's driving task, and is not a driver distraction risk while the vehicle is moving in a forward direction.

Figure 31: Origin's Right Rear Surround Camera Showing FMVSS 111, S6.2 Rear Vision Grid

(iv) Linger Time (S6.2.4)

FMVSS 111, S6.2.4 requires that the rearview image cease being displayed at the conclusion of the backing event.[80] The rationale for this requirement is to avoid distracting the driver by continuing to display the rearview image after the backing event has ended and the vehicle has resumed forward movement. However, the Origin's vast array of overlapping sensors are always "on" when the vehicle is operating, and their information is continually provided to the perception system. As a result, the rearview image continues to be electronically displayed without interruption to the driver, the ADS, even after the end of the backing event. The same risk of distraction that the linger time provision was intended to address in a traditional vehicle with a human operator does not exist in the Origin's driverless system.

In fact, modifying the Origin's rear visibility system to operate consistently with the linger time provision would diminish the performance and the safety of the system because the Origin uses its rearview sensors even during forward motion, to gain a comprehensive understanding of its environment and avoid collisions with vehicles or objects approaching from the rear. Deactivating these rearview would significantly decrease the vehicle's ability to identify and react to potential other road users and potential obstacles located at the rear of the vehicle. Retaining the ADS's access to these rearview images is functionally analogous to a human driver glancing at the interior rearview mirror to observe traffic behind the vehicle while driving forward.

[80] "*Backing event* means an amount of time which starts when the vehicle's direction selector is placed in reverse, and ends at the manufacturer's choosing, when the vehicle forward motion reaches: (a) a speed of 10 mph, (b) a distance of 10 meters traveled, or (c) a continuous duration of 10 seconds." 49 C.F.R. 571.111, S4.

Because the risk of distraction with the ADS is not present, exempting the Origin from the linger time provision does not diminish—and in fact enhances—its level of safety.

(v) Summary of FMVSS 111

In summary, the Origin relies on a series of sensors, including cameras, radars, and LiDAR, to produce a 360-degree, live image of the surrounding area. These sensors remain on and functional throughout the ADS's driving task, and the Origin maintains full FOVs in all directions without looking away or becoming distracted the way a human driver might.

NHTSA has also recognized that passengers sometimes use rearview mirrors to gain situational awareness prior to exiting vehicles. The Origin is designed to encourage passengers to exercise caution by providing visual and audio warnings to look for oncoming traffic prior to exiting the vehicle, allowing the Origin to eliminate physical mirrors from its design without reducing the level of safety afforded to passengers. A passenger exiting an Origin without exterior rearview mirrors is no different than a passenger exiting the rear seat of a traditional motor vehicle where rearview mirrors are not available. In each case, the passenger will need to be aware of their surroundings and use caution and common sense before exiting the vehicle. The Origin's doors also slide open against the side of the vehicle, not outwards like a traditional motor vehicle, which prevents the Origin's doors from inadvertently striking passing cyclists or obstructions such as parked vehicles at the time of passenger exit.

Finally, external mirrors may introduce a safety hazard as protruding objects for cyclists and fellow road users. The Origin's streamlined exterior design allows it to reduce these safety hazards while maintaining the full 360-degree view of its surroundings that exceed the areas required to be covered by rearview mirrors and a rear backup vision system.

2. 200 Series FMVSS Safety Analysis: The Origin Provides an Equivalent Level of Safety for Each FMVSS for Which an Exemption Is Sought

Turning now to the crashworthiness standards, NHTSA may likewise grant the requested exemptions because the applicable Standards are not necessary for safety given the design and functionality of the Origin. As such, the Origin is not equipped with the feature (e.g., a steering wheel) referenced in the Standard, or the Origin's design and functionality provides an equivalent level of occupant protection consistent with the purpose and intent of those Standards (e.g., Buckle to Ride feature).

a. FMVSS 201, Sun Visors (S5.4)

NHTSA has long recognized that installation of a sun visor in locations without a traditional forward facing designated seating position is not required.[81] The Origin is not configured with any front forward-facing outboard seating positions and, as such, the Origin

[81] *See* NHTSA, *Final Rule, Occupant Protection in Interior Impact; Impact Protection for the Driver From the Steering Control System; Steering Control Rearward Displacement*, 44 Fed. Reg. 68470, 68474 (Nov. 29, 1979) ("[A commenter] pointed out that Standard No 201 currently requires two sun visors in a vehicle and requested that a second visor not be required if there is no front passenger seat. NHTSA agrees that such a change is appropriate and has made the necessary amendment to the standard.").

will not and need not be equipped with sun visors. Accordingly, GM and Cruise respectfully seek a temporary exemption from the sun visor requirements of FMVSS 201, S5.4 because those requirements are not necessary for safety in light of the Origin's design. The Origin will otherwise meet all other requirements of FMVSS 201.

The relevant portion of FMVSS 201 states:

> S5.4 Sun visors.
>
> S5.4.1 A sun visor that is constructed of or covered with energy-absorbing material shall be provided for each front outboard designated seating position.
>
> S5.4.2 Each sun visor mounting shall present no rigid material edge radius of less than 3.2 mm that is statically contactable by a spherical 165 mm diameter head form.

Originally, sun visors were installed to mitigate the risk of sun glare creating visual interference with the driving function. When FMVSS 201 was initially introduced decades ago, it was appropriate to assume that a vehicle would include sun visors as a standard feature at the front row-outboard seating positions. FMVSS 201 sought to protect occupants in the event of an impact with the sun visor by requiring they be covered in energy absorbing material.

With respect to the Origin, there is no risk of injury due to contact with a sun visor because the Origin is not equipped with—and does not need—any sun visors. The glare mitigation benefits of a sun visor are not needed in the Origin because (1) there will be no occupants seated in a traditionally configured forward-facing front row and (2) the driving task is handled exclusively by the ADS, which is designed, as part of its ODD, to operate in conditions involving high sunlight glare.[82]

Moreover, the Origin provides an equivalent level of occupant impact protection in the traditional locations for a sun visor. The Origin's roof and upper trim target points—where a sun visor would typically be installed—meet or exceed the performance requirements of FMVSS 201 S6.2(b)(1) and (2). The Origin also will meet all applicable FMVSS 201 requirements for upper components in Sections S6 through S10.

As the Origin is not configured with any front forward-facing outboard seating positions, and the Agency already has recognized that it is inappropriate to require installation of a sun visor in locations without a traditional forward facing designated seating position, GM and Cruise respectfully seek an exemption from the requirements of S5.4.

[82] The Origin's sensors and vision systems are designed to "see" and operate under all driving conditions faced in its ODD, including high sunlight glare. The Origin is also built with redundancy with LiDAR, radar, and other sensors to "see," as described above. Accordingly, there is no need for a sun visor to assist a non-existent human driver with forward visibility through the front windshield.

b. FMVSS 203 (S5) and FMVSS 204 (S4.2)

GM and Cruise respectfully seek an exemption from FMVSS 203 and 204 because they presume the presence of a steering control system that is not necessary for safety given the Origin's design. NHTSA recently proposed in a 2020 Notice of Proposed Rulemaking that these Standards should "not apply to vehicles without steering control systems."[83] But even if these Standards were applicable to the Origin—and they are not because the Origin is not equipped with a steering wheel or steering column[84]—the Origin should be exempted from FMVSS 203 and 204 because the Origin's design provides an overall level of safety to its occupants equivalent to that which would be provided to them in a nonexempt vehicle.

FMVSS 203 and 204 mitigate the risk of occupant injury that may occur from interaction with steering control systems during a crash. However, since the Origin is not equipped with a manual steering control system (including a steering wheel or steering column), its design eliminates the risk these two standards seek to mitigate: e.g., the risk of chest, neck, and facial injury caused by the steering wheel and column.

NHTSA has tentatively concluded that eliminating the applicability of FMVSS 203 and 204 to vehicles not equipped with steering systems is an appropriate means of modifying the Standard to account for vehicles without manual controls while at the same time maintaining the foundational level of occupant safety.[85] NHTSA has stated that the "proposed changes [to FMVSS 203 and 204] would not reduce vehicle safety because, if there is no steering control present at the seating position where the driver's seat would normally be located, that seating position would become a passenger seat that is still subject to the protection afforded by the requirements of FMVSS No. 201."[86]

Likewise, the Origin's absence of a steering wheel does not diminish the level of safety afforded the occupants because the Origin meets all of the occupant protection requirements of FMVSS 201 and the vehicle includes a comprehensive array of automatic crash protection features under FMVSS 208.[87] As such, GM and Cruise respectfully seek an exemption from FMVSS 203 and 204.

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[83] *Occupant Protection for ADS NPRM*, 85 Fed. Reg. at 17629; *id.* at 17625 ("[A]n occupant should not need protection from a steering control system if none exists in that vehicle.").

[84] NHTSA has noted that there is uncertainty in the industry over whether these two Standards should be interpreted as "if-equipped" Standards so that the Standards would not apply to vehicles manufactured without steering systems. *See id.* at 17640.

[85] Although NHTSA's view is related to vehicles without manual controls but with traditional vehicle interiors, the same rationale that the Agency expressed in the NPRM for modifying FMVSS 203 and 204 can equally be applied to this exemption request for a vehicle with an innovative interior design.

[86] *Occupant Protection for ADS NPRM*, 85 Fed. Reg. at 17640.

[87] GM has assessed reasonably foreseeable crash scenarios and the Origin meets GM's occupant protection performance requirements and mitigation measures in such scenarios. Furthermore, to ensure robust and equivalent occupant protection performance, GM has conducted applicable crash tests using both computer simulation and physical barrier tests on the Origin to confirm that the Origin provides equivalent occupant protection and injury mitigation as these standards. Appendix B describes the approach used to validate occupant impact mitigation in all seating positions in the Origin.

c. FMVSS 207, Driver's Seat (S4.1)

FMVSS 207, S4.1 requires "each vehicle shall have an occupant seat for the driver." NHTSA may grant an exemption from S4.1 here because the Origin is operated exclusively by its ADS and does not have a traditional "driver's seat," nor is one necessary for safety in light of the Origin's design.

The Origin's seats meet or exceed the performance requirements for seating system strength and protection per FMVSS 207. And as discussed above, NHTSA recently noted in a 2020 Notice of Proposed Rulemaking that requiring the installation of a driver's seat in a Level 4 AV may not be necessary and, as such, has proposed modifying FMVSS 207 to update the language at S4.1 to specify that a driver's seat is only necessary in vehicles that include manual controls.[88]

d. FMVSS 208, Timing of the Seat Belt Warnings (S7.3)

FMVSS 208, S7.3 specifies requirements for a seat belt warning system at the driver's designated seating position that alerts the driver if their seat belt is not fastened. The Standard requires the visual warning be activated for not less than 60 seconds and an audible chime be activated for a period of not less than 4 seconds and not more than 8 seconds beginning when the vehicle ignition switch is moved to the "on" or "start" position. The purpose and intent of the seat belt warning system is to underscore the importance of the use of seat belts. The Origin's design and performance meets the purpose and intent of S7.3 and, along with the Origin's unique Buckle to Ride feature, provides an equivalent level of safety.

The Origin otherwise meets all applicable requirements for the seat belt warning system with just two exceptions: the warning appears at all designated seating positions, instead of the driver's seating position; and the timing requirements for the warning are not linked to the status of the vehicle's ignition because the vehicle is always "on" when in operation, including anytime there is a passenger in the Origin.

The Origin is equipped with a robust seat belt warning system that reminds all passengers to buckle their seat belts. The seat belt warnings begin when the passenger enters the vehicle and presses the "Start Ride" button. While the seat belt reminder activates outside of the literal parameters of the requirements of S7.3, the seat belt reminder system provides an equivalent level of safety to the passengers of the Origin and continues to meet the purpose and intent of the seat belt reminder provision, which is to reemphasize the need for, and increase the use of, seat belts.

FMVSS 208, S7.3 states:

> (a) A seat belt assembly provided at the driver's seating position shall be equipped with a warning system that, at the option of the manufacturer, either -

[88] *Occupant Protection for ADS NPRM*, 85 Fed. Reg. at 17640.

> (1) Activates a continuous or intermittent audible signal for a period of not less than 4 seconds and not more than 8 seconds and that activates a continuous or flashing warning light visible to the driver displaying the identifying symbol for the seat belt telltale shown in Table 2 of FMVSS 101 or, at the option of the manufacturer if permitted by FMVSS 101, displaying the words "Fasten Seat Belts" or "Fasten Belts", for not less than 60 seconds (beginning when the vehicle ignition switch is moved to the "on" or the "start" position) when condition (b) exists simultaneously with condition (c), or that
>
> (2) Activates, for a period of not less than 4 seconds and not more than 8 seconds (beginning when the vehicle ignition switch is moved to the "on" or the "start" position), a continuous or flashing warning light visible to the driver, displaying the identifying symbol of the seat belt telltale shown in Table 2 of FMVSS 101 or, at the option of the manufacturer if permitted by FMVSS 101, displaying the words "Fasten Seat Belts" or "Fasten Belts", when condition (b) exists, and a continuous or intermittent audible signal when condition (b) exists simultaneously with condition (c).
>
> (b) The vehicle's ignition switch is moved to the "on" position or to the "start" position.
>
> (c) The driver's lap belt is not in use, as determined, at the option of the manufacturer, either by the belt latch mechanism not being fastened, or by the belt not being extended at least 4 inches from its stowed position.

The Origin will provide a seat belt warning system for unbuckled passengers in any of its six occupant seating positions, leveraging audible chimes and visual warnings on the information displays. Those chimes and warnings meet the content and activation timing requirements in FMVSS Section 7.3(a). GM and Cruise respectfully seek an exemption from the requirement that the seat belt warning system be activated based on the timing of ignition switch being moved to "on" or "start" position as stated in S7.3(b). Instead, these warnings will be triggered by the passenger pressing the "Start Ride" button illustrated above in Figure 10, which is the Origin's equivalent to the ignition switch being moved to the "on" or "start" position by a human driver.

The Origin's seat belt warning system is purposefully triggered from the "Start Ride" button instead of the ignition switch (or power source in this case) being turned to "on" or "start" to ensure that the seat belt warning system always operates when there are passengers in the vehicle. By tying the seat belt warning activation to the "Start Ride" button, each time a new passenger has entered the vehicle the seat belt warning system will be activated to remind them to buckle their seat belt before the ride begins.

As previously mentioned, at all times during operation, the Origin's ignition will always be "on" and timing the seat belt warning system to the initial powering up of the vehicle per the literal requirements of the Standard would frustrate the purpose of the seat belt reminder system: namely, to remind vehicle occupants to buckle their seat belts. The only time the Origin's power will be turned "on" will be when it is first booted up each day by trained Cruise personnel. This will occur well before the vehicle first accesses the public roads or has any passengers or occupants. Because there will be no passengers or occupants in the vehicle at the time of boot up, the Origin's seat belt warning system is designed to activate only when a passenger enters the vehicle and initiates a ride. By the time the Origin is deployed for ridesharing commercial operation, the Origin will always remain "on" and at that time will provide numerous seat belt warnings, including audible and visual warning as explained in detail above in Section II.G.5.

Moreover, the Origin will start a passenger ride only when a passenger is detected and the system recognizes that their seat belt is buckled, with limited exceptions. If the passenger presses the "Start Ride" button and their seat belt is not buckled, the Origin will immediately activate an intermittent, audible seat belt chime for a period of not less than 4 seconds and not more than 8 seconds. Concurrently with the audible seat belt chime, the Origin will also display the visual "Fasten seat belt" message shown in Figure 32, for a minimum of 60 seconds (assuming seat belt remains unfastened). Moreover, every riding party who enters the Origin will run through a safety checklist on their Personal screen before they are able to start the ride. This checklist will contain a "Fasten seat belt" reminder, as displayed in Figure 32 below. Additionally, if at any point the passenger takes their seat belt off, their Personal screen displays a full-screen seat belt reminder.

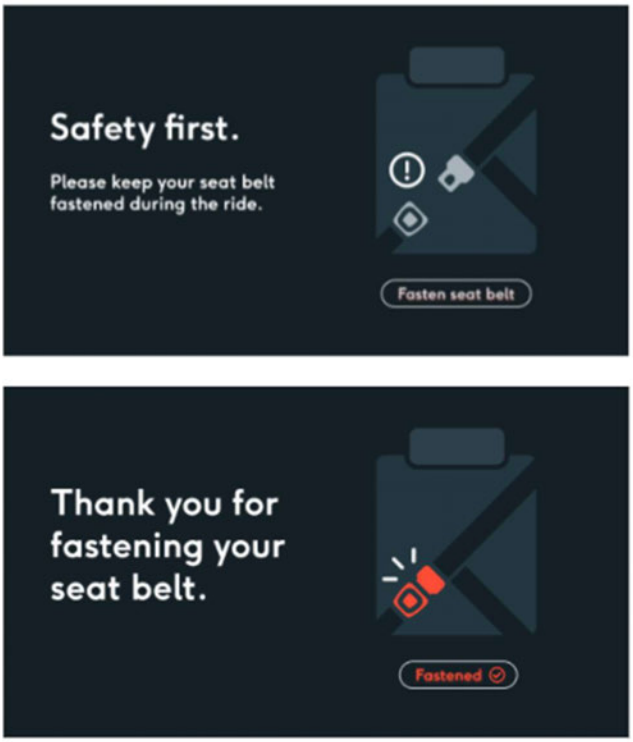

Figure 32: Fasten Seat Belt Warning[89]

3. The Origin Introduces and Advances Vehicle Safety Technologies Not Required by the FMVSS

The EOS basis for exemption allows NHTSA "to weigh broader considerations of safety that may not be captured at the individual standard level," and is an appropriate basis for consideration of "features [] intended to improve the safety of aspects of performance that are not regulated under" specific FMVSS.[90] Recognition of the safety potential inherent in AV technologies has been a consistent mainstay of the DOT's guidance on this developing technology.[91] As the DOT and NHTSA have recognized, an important promise of vehicles like the Origin is the ability to mitigate or prevent crashes that can be tied to human operator error, distraction, or impaired driving.[92]

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[89] This is an illustration of what the display screens in the production-level Origin will look like. The exact colors, text, and layout of these screens are subject to change.

[90] *Nuro*, 85 Fed. Reg. at 7832.

[91] *See, e.g.,* National Science & Technology Council & United States Department of Transportation, *Ensuring American Leadership in Automated Vehicle Technologies*: *Automated Vehicles 4.0* (Jan. 2020) ("AVs—if developed properly—also have the potential to make our roadways safer by reducing crashes caused by human error, including crashes involving impaired or distracted drivers.").

[92] The need for this exemption pathway remains acute. NHTSA data indicates that over 38,000 American lives were lost on U.S. roads in 2020. *See* Press Release, NHTSA, *2020 Fatality Data Show Increased Traffic Fatalities During Pandemic* (June 3, 2021), https://www.nhtsa.gov/press-releases/2020-fatality-data-show-increased-traffic-fatalities-during-pandemic. And estimates indicate traffic fatalities continued to rise at a record pace in the first nine months of 2021. *See* Press Release, NHTSA, *NHTSA Data Estimates Indicate Traffic Fatalities Continued to Rise at Record Pace in First Nine Months of 2021* (Feb. 1, 2022), https://www.nhtsa.gov/press-releases/traffic-fatalities-estimates-jan-sept-2021.

Additionally, every Origin is part of a fully connected captive fleet that is capable of communicating road hazards or travel-route information instantaneously. By way of example, such instantaneous information could redirect Origins from routing through known hazard areas where emergency responders are on scene, or avoid other types of unanticipated roadway hazards, like an emergency street closure or a public demonstration.

Alongside a robust set of cameras for imaging and video, the Origin is designed to use four spinning LiDAR and six radar sensors, and also uses thermal cameras that operate in the infrared spectrum. This hardware dramatically improves detection of pedestrians, cyclists, and animals when these objects may be otherwise occluded by ambient light or other visible spectrum obstructions. Moreover, the Origin offers technological advancements to help improve the safety of vulnerable road users. For example, the Origin has no blind spots. Sensors provide 360-degree coverage for detection of pedestrians and cyclists within the vicinity of the vehicle. The Origin's ADS includes a vehicle behavior design that maintains the California-mandated three feet passing distance between a vehicle and cyclist.[93] Furthermore, the Origin uses subway-style exterior doors to reduce the risk of "dooring" cyclists during passenger entry and exit and cautions passengers to be alert upon exiting.

The Origin's architecture also builds in redundancy and proactive diagnostics to help ensure that the vehicles are roadworthy at all times.[94] The Origin's proactive diagnostics capabilities will alert both the vehicle itself and central fleet operations of faults like low tire pressure, steering system faults, and broken tail lamps. Cruise personnel are trained to respond with the requisite maintenance and repairs.[95] Further, the Origin is designed with power and control redundancy for safe operations even in the event of an unforeseen mechanical or electrical fault. In addition, Cruise's central fleet operations personnel will regularly inspect and maintain all Origins. Using the inspections framework from the airline industry (MSG3), GM has performed a top-down analysis to identify inspection procedures and frequencies that ensure proper function of all systems. Such inspections include proactive review of airbag covers and seat belt webbing material to detect any tampering or misuse by occupants. Finally, GM and Cruise will also comply with all regulatory inspections required by the jurisdictions in which they operate, including the California Public Utilities Commission-mandated 19-point inspection at 50,000 mile intervals in California.[96] This ecosystem of proactive diagnostics, critical system redundancy, central fleet operations and regulatory compliance enables Cruise to maintain a continually roadworthy fleet.

Cruise's central fleet operations also provide unique benefits to Origin passengers, who will have the support of a continuously monitored connection between the vehicle and central fleet management. In the event a passenger requires assistance, they will be able to interact with emergency support staff in real time through interior cameras and

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[93] Cal. Veh. Code § 21760(c).

[94] *See* Appendix G.

[95] *Id.*

[96] *See* D. 18-05-043, *Decision Authorizing A Pilot Test Program for Autonomous Vehicle Passenger Service with Drivers and Addressing in Part Issues Raised in the Petitions for Modification of General Motors, LLC, Lyft, Inc., and Raiser-CA, LLC/UATC, LLC for Purpose of a Pilot Test Program for Driverless Autonomous Vehicle Passenger Service* (May 31, 2018), https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M215/K279/215279920.PDF

microphones; such staff are available to passengers 24/7. Passengers will be able to promptly contact Customer Support by pressing a hard button in the vehicle interior or by using their cell phone or other mobile device. In many circumstances, live support, including GM's OnStar, will be available and responsive within seconds of a collision, which includes personnel trained to communicate with first responders.[97]

As described more fully in Section II.G.5 above and in Appendix B, before starting a ride, each passenger must buckle their seat belt and is prompted to do so on the informational display. After buckling up, the Origin will only start moving once the passenger presses the "Start Ride" button, either in the vehicle or via the mobile app. During the ride, the informational screens in the interior of the Origin will provide updates on the passenger's estimated time of arrival, instructions for entering and exiting the vehicle, and seat belt reminders as needed. As its passenger service scales, Cruise and GM will also evaluate other ways to leverage these informational screens to provide targeted safety related messages to passengers.

The Origin is also equipped with technology to enable communication with local law enforcement or emergency personnel if the need arises. The Origin will detect the presence of nearby emergency vehicles and yield right-of-way so that emergency vehicles may safely pass without interference. In addition, the Origin includes the ability to detect the presence of law enforcement seeking to pull the vehicle over, and to adhere to a pull-over siren signal. The Origin also allows Cruise fleet-management personnel to remotely talk with law enforcement personnel standing outside the vehicle through onboard microphones and speakers.[98] Additional technology advantages the Origin has over a nonexempt, human-driven vehicle are provided in Appendix I.

B. LEV: The Origin Qualifies as a Low-Emission Motor Vehicle, and Granting This Petition Would Not Unreasonably Lower the Safety of the Origin

GM and Cruise further submit this application on the basis that the vehicle is a low-emission vehicle under the Safety Act and that granting the application would not "unreasonably degrade the safety or impact protection of the vehicle."[99] NHTSA, in the alternative, may grant an exemption under the LEV framework for three reasons:

First, the Origin squarely qualifies as a low-emission vehicle as defined by 49 U.S.C. § 30113(a). Section 30113(a) defines a "low-emission motor vehicle" as a vehicle "meeting the standards for new motor vehicles under Section 202 of the Clean Air Act when the vehicle is manufactured, and emitting an air pollutant in an amount significantly below one of those standards." The Origin is a fully electric, zero-emission vehicle, and it will not emit any of the air pollutants regulated under the Clean Air Act.

[97] Appendix F provides more detail regarding live support available to Origin passengers.

[98] Appendix D offers an overview and brief summary of the past, current, and ongoing work that GM and Cruise are undertaking with state and local law enforcement officials to ensure law enforcement has the understanding and education they desire in how to interact with our AV fleets.

[99] 49 C.F.R. § 555.6(c)(2).

Second, for all the reasons explained above, granting the Petition on the LEV basis would "not unreasonably degrade the safety or impact protection of the vehicle."[100] The Origin will provide a level of safety or occupant protection at least equivalent to the level of safety or occupant protection established in the standard from which an exemption is sought, as explained above in Section III.A above; and thus the safety or impact protection of the Origin will not be unreasonably degraded by granting this Petition.

Third, "a temporary exemption would facilitate the development or field evaluation of the vehicle" in multiple ways.[101] The deployment of the Origin on public roads will allow GM and Cruise to collect and analyze a significant amount of real-world operating data that can be used to develop a realistic data set. This includes, among other things, ADS-related data, information about the Origin's innovative safety systems, and vehicle design and human factors-based elements (e.g., the response and reaction of pedestrians, first responders and other road users to the Origin). This data in turn can be used to develop and refine future regulations for automated vehicles. In addition, deployment of the Origin would educate and familiarize the public to fully electric and shared vehicles. Granting the Petition would allow the public to evaluate the benefits of these vehicles as a viable and sustainable means of transportation with a minimal environmental impact.

C. Statement Regarding Compliance at the End of the Exemption Period

GM and Cruise respectfully request that NHTSA grant all exemptions sought in this Petition for a period of two years from the date of such grant. The Origin will not comply with the Standards identified in this Petition from which GM and Cruise are seeking exemption at the end of the two-year temporary exemption period unless the Standards are changed.

IV. GRANTING THIS PETITION IS CONSISTENT WITH THE VEHICLE SAFETY ACT

NHTSA is provided "broad authority and discretion" in determining whether granting the Petition is consistent with the public interest and the Vehicle Safety Act.[102] In exercising that broad discretion, NHTSA may consider "many diverse effects of the exemption, including:

- The overall safety of the transportation system beyond the analysis required in the safety determination;
- How an exemption will further technological innovation;
- Economic impacts, such as consumer benefits; and
- Environmental effects."[103]

The Origin is poised to generate benefits to the public related to on-road safety, transportation emissions reductions, economic development, accessibility, transportation

[100] *Id.* § 555.6(c)(2).

[101] *Id.* § 555.6(c)(3).

[102] *Nuro*, 85 Fed. Reg. at 7837.

[103] *Id*. at 7828.

equity, and long-term U.S. industrial competitiveness. Each of these factors, when applied to the Origin, are squarely consistent with both the public interest and the Safety Act.

Granting this exemption is consistent with the objectives of the Safety Act for, among other reasons:

- The Origin complies with the applicable FMVSS or, for the FMVSS identified above for which GM and Cruise are seeking an exemption, the Origin provides an equivalent level of safety (see Section III.A above).
- The Origin provides an overall level of safety equivalent to that of an FMVSS-compliant vehicle.[104]
- To the extent there is ever a safety-related defect requiring notice under 49 CFR 573, GM and Cruise are able to mitigate any risk by immediately taking action to address the risk, including, but not limited to grounding the fleet (depending on the severity and availability of a remedy) and ensuring that the defect will be remedied in a timely manner. Unlike conventional vehicles, as a captive fleet, GM and Cruise can also guarantee a 100 percent completion rate for any safety recall.

In addition, because every Origin vehicle will be part of a connected and captive fleet operated by Cruise, all diagnostic information will be immediately transmitted to Cruise in real-time, allowing Cruise to be aware of any potential quality, durability, or safety issues immediately. Importantly, this will allow GM and Cruise to promptly identify and investigate any potential safety issues and comply with their Safety Act reporting obligations.

V. GRANTING THIS PETITION IS CONSISTENT WITH THE PUBLIC INTEREST

A. Granting this Petition Will Enable Sharing of Substantive AV and ADS Information with NHTSA

Granting this Petition will facilitate future agency rulemaking and ensure that U.S. policy and regulations keep pace with technology. As noted in NHTSA's Advanced Notice of Proposed Rulemaking ("ANPRM") on a Framework for Automated Driving System ("ADS") Safety, more information is needed to begin evaluating the requirements and focus of future regulations for automated technology.[105] As was the case in *Nuro*, "granting this petition will provide the agency with valuable information that can facilitate its knowledge of ADS functionality to advance future policy and regulatory decisions."[106] The exemptions sought through this Petition thus will provide a channel by which GM and Cruise may share additional, Origin-based data with NHTSA. GM and Cruise expect that this sharing of information would be generally consistent with the terms of the *Nuro* petition grant, and information provided to the Agency could be designated confidential where appropriate.

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[104] *See* 49 U.S.C. § 30113.

[105] As stated in this ANPRM, "NHTSA has no desire to issue regulations that would needlessly prevent the deployment of any ADS-equipped vehicle, as this could inhibit the development of a promising technology that has the potential to result in an unprecedented increase in safety. Any regulatory approach must have well-founded supporting data indicating safety needs." *Framework for ADS Safety ANPRM*, 85 Fed. Reg. at 78062.

[106] *Nuro*, 85 Fed. Reg. at 7837.

GM and Cruise further anticipate that the data they will provide will include post-crash reporting encompassing field safety performance data associated with the Origin to enable NHTSA "to understand the cause of [a] crash (including any role the ADS may have played)."[107] GM and Cruise also anticipate other periodic reporting requirements detailing the operation of each Origin vehicle during a particular time period (including mileage accumulated, changes to the ODD, and descriptions of potential incidents involving violations of local or state traffic laws, among others), and understands that the Agency views this information as necessary "to facilitate improved safety oversight."[108]

B. Granting this Petition Will Help Promote Safety of the Transportation System by Advancing Autonomous Technology

NHTSA has recognized the importance of developing ADS technology "in real-world (non-simulated) environments, both to validate the safety of the current ADS technologies and to expose those technologies to new situations in which 'machine learning' capabilities can be used to improve performance."[109] The exemptions requested under this Petition would permit a controlled deployment of new technology while offering a scale large enough to generate meaningful learnings. This in turn will generate valuable data to facilitate continual improvements in the safety, accessibility, and functionality of the Origin's core technologies.

The Origin has the potential to help address some of the systemic challenges we face in trying to reduce motor vehicle deaths caused by human behavioral issues. As stated in the U.S. DOT's National Roadway Safety Strategy: "Dangerous behaviors like impaired driving and excessive speeding threaten the safety of all road users, not just individual drivers. The overwhelming majority of serious and fatal crashes involve at least one human behavioral issue as a contributing factor. People in motor vehicles not wearing seat belts, driving while impaired from alcohol, and speeding are the three most frequent and persistent factors."[110] The Origin will never drive drunk, it will never text behind the wheel, it will never be distracted, and as detailed in this petition, the Origin will promote safe travel through its innovative "Buckle to Ride" feature.

C. Granting this Petition Is an Important Step to Unlocking Potentially Significant Environmental Benefits

NHTSA and DOT have made clear that accelerating the development and deployment of zero-emission vehicles, including battery electric vehicles, is in the public interest. As Secretary of Transportation Buttigieg recently remarked, "At the Department of Transportation and the Federal Highway Administration, we know that electric vehicles and

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[107] *Id.* at 7840.

[108] *Id*. In this regard, GM and Cruise understand from their review of the *Nuro* petition grant that the Agency may seek additional information about the Origin program, including information regarding interaction with state and local safety officials (including incorporation of information related to the Origin's compliance with state and local traffic laws within its ODD), and assurances of Cruise's continuous ownership and control of the Origin. Appendix D offers a brief overview of GM and Cruise's interactions, permits, and approvals with state, local, and Native American tribal nation officials. GM and Cruise remain willing to coordinate with NHTSA on these and other related information requests.

[109] *Id.* at 7837.

[110] 2022 National Roadway Safety Strategy at 14.

the charging networks that fuel them are good for the planet and will help create good American jobs."[111] This sentiment was similarly reflected in NHTSA's 2020 granting of *Nuro*'s petition under Part 555, noting that its approval would "further[] the overarching goal of allowing more LEVs on the roads."[112] DOT also underscored this intrinsic link between climate change and roadway safety in January 2022 with its National Roadway Safety Strategy.[113] Electric vehicles can help reduce the nation's reliance on oil and reduce greenhouse gas and other emissions, including particulate emissions that present serious health safety risks, most acutely felt by historically underserved communities. Moreover, development of electric vehicles like the Origin contributes to the expansion of consumer choices. The Origin has been purpose-built to be a rideshare vehicle, and as such, it will be available to consumers on a per ride basis. Thus, for the great swath of consumers that cannot afford to purchase an electric vehicle but want to travel more sustainably, or that wish to purchase but may not have access to reliable charging infrastructure, or are otherwise reluctant to commit to an EV without ever having tried one, the Origin provides the ability to partake in the EV revolution at a pace, and a price, more befitting their needs.

Beyond being all-electric with zero emissions, the Origin is a shared AV and that brings the following additional benefits discussed below.

1. Shared

The Origin can be shared by up to six passengers at a time and a myriad of users over the course of a trip. The Origin's innovative design enhances the ability to transport more occupants in a single vehicle than in a personal EV. This in turn allows the vehicle's environmental benefits to be amplified because electrifying rideshare vehicles can greatly reduce emissions. The University of California at Davis has found that electrifying one rideshare vehicle has the same emissions impact as three private EVs due to travel intensity.[114] In this context, a shared vehicle can also serve a broader segment of the population than a single owner, and be used more efficiently than personal vehicles.[115]

2. Autonomous

The Origin can also deliver additional environmental gains through the benefits of autonomy. Through system-level coordination, the Origin will take advantage of efficiencies that would be nearly impossible to achieve through uncoordinated individual behavior, such as dynamic charging to address renewable curtailment or to support the grid. GM and

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[111] *See* Pete Buttigieg, U.S. Secretary of Transportation, Secretary Buttigieg remarks on the Future of Electric Vehicle Infrastructure, Washington, D.C. (Apr. 22, 2021), https://www.transportation.gov/briefing-room/secretary-buttigieg-remarks-future-electric-vehicle-infrastructure.

[112] *Nuro*, 85 Fed. Reg. at 7832.

[113] 2022 National Roadway Safety Strategy at 7-9.

[114] Alan Jenn, Emissions Benefits of Electric Vehicles in Uber and Lyft Services (National Center for Sustainable Transportation, Aug. 2019) at 12-13, https://escholarship.org/uc/item/15s1h1kn.

[115] Research from the University of Texas at Austin shows that a shared AV can replace up to 11 conventional, personally owned vehicles and still serve the needs of those passengers' travel patterns. Daniel Fagnant & Kara M. Kockelman, The Travel and Environmental Implications Of Shared AVs, Using Agent-based Model Scenarios (Transportation Research Part C. 2014) at 14, https://www.caee.utexas.edu/prof/kockelman/public_html/TRB14SAVenergy_emissions.pdf.

Cruise will also be able to more efficiently route customers through fleet-wide coordination and mapping, allowing for lower energy consumption.

3. Renewable Powered

Lastly, GM and Cruise have taken steps to integrate renewable energy in the production and operation of the Origin, promising to help dramatically reduce carbon emissions across both the manufacturing supply chain and throughout the vehicle's life. As part of its efforts to reduce its manufacturing carbon footprint, GM has committed to powering Factory ZERO—the home for the Origin's assembly—with fully renewable power by 2023.[116] Cruise has similarly committed via its own initiatives to power its California and Arizona fleets with renewable power. Cruise's California renewable program, called Farm to Fleet, sources renewable energy credits directly from family-owned farms in the Central Valley that have invested in on-site solar.[117] This creative approach to electrification—enabled by Cruise's centralized fleet management—ensures that not only is every Cruise mile zero emission, but now also generates revenue for local businesses in California's agricultural heartland. With the scale unlocked through the approval of this Petition, the impact of renewable initiatives like Farm to Fleet will dramatically grow as Cruise's charging needs expand.

D. Granting this Petition Could Advance Environmental Justice

GM and Cruise believe that the AV industry must be deliberate in addressing the impacts of environmental inequality. The costs of transportation pollution are not equally borne across communities, particularly among low-income communities and communities of color.[118] PM2.5 particulate exposure (including from transportation) disproportionately impacts black and Hispanic communities.[119] In Cruise's home state of California, which encompasses much of the Origin's current and future ODD, African American and Latino communities are exposed to PM2.5 pollution 43% and 39% higher than Caucasian communities, while those who have the least access to personal mobility often have the most exposure to pollution from gas-powered cars.[120] As a first of its kind zero-emission AV deployed at even limited scale, the Origin can also help reduce air pollution in frontline communities as a fully sustainable transportation alternative to gas-powered personal vehicles—both directly for local residents within its ODD, and in reducing overall emissions from other road users.

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[116] Press Release, General Motors, *GM Marks Progress Toward All-Electric Future with Unveiling of Factory ZERO* (Oct. 16, 2020), https://media.gm.com/media/us/en/gm/home.detail.html/content/Pages/news/us/en/2020/oct/1016-event.html.

[117] Robert Grant, *Farm to Fleet: How Cruise Powers Its Self-Driving Cars With Clean Energy From Family Farms*, Cruise (Aug. 25, 2021), https://www.getcruise.com/news/farm-to-fleet-how-cruise-powers-its-self-driving-cars-with-clean-energy.

[118] American Lung Association, *Disparities in the Impact of Air Pollution* (Apr. 21, 2020), https://www.lung.org/clean-air/outdoors/who-is-at-risk/disparities.

[119] Michelle L. Bell & Keita Ebisu, *Environmental Inequality in Exposures to Airborne Particulate Matter Components in the United States*, 120 Environmental Health Perspectives, no. 12 (Dec. 2012) at 1700-01, https://ehp.niehs.nih.gov/doi/pdf/10.1289/ehp.1205201.

[120] David Reichmuth, *Inequitable Exposure to Air Pollution from Vehicles in California*, Union of Concerned Scientists (Jan. 28, 2019), https://www.ucsusa.org/resources/inequitable-exposure-air-pollution-vehicles-california-2019.

GM and Cruise recognize the importance of engaging the communities which we hope to serve by earning trust today. Shared, autonomous, and electric vehicles like the Origin present many potential benefits for communities; we must be and are being deliberate in our approach in communities that have been most historically impacted by environmental injustice.

To begin a conversation on how the Origin can help serve as an asset for these communities, Cruise has launched a research partnership with EVNoire—a national award-winning minority-owned and -led organization working at the intersection of transportation, energy, and environmental health equity. Cruise and EVNoire jointly partnered to engage San Francisco residents in Districts 5 and 10, two frontline communities within the city, to: (1) engage local residents on their attitudes towards innovative transportation, (2) hear how shared, autonomous, and electric vehicles could fit into community needs to address and mitigate disparities in transportation access and public health, and (3) understand how developers can best integrate service to support community goals around cleaner, more inclusive transportation.[121] These findings will help inform how shared, electric, AVs can fit into a broader set of tools for how emerging mobility can serve community goals and serve the public interest.

E. Granting this Petition Will Help Advance Greater Transportation Accessibility for All Users

The Origin is an opportunity to begin resetting today's transportation system by promoting accessibility in mobility. Accordingly, GM and Cruise have engaged in numerous studies to inform user experience and product design goals for the Origin aimed at making it more accessible for all passengers, and helping to ensure inclusive product development.[122]

To operationalize this opportunity, Cruise's first external user experience study was done in 2021 in partnership with the National Federation of the Blind, American Council of the Blind, and the San Francisco Lighthouse for the Blind, engagements and partnerships that continue through the present day. GM and Cruise are also collaborating with stakeholders within the accessibility community to enable the Origin to carry people in wheelchairs. The wheelchair accessible Origin would be intended to operate within Cruise's fleet to provide truly accessible point-to-point transportation services, offering all passengers an opportunity for equal access to freedom of mobility.

GM and Cruise recognize that the public benefits of autonomy will not be fully achieved with a "one size fits all" solution. As Anthony Stephens of the American Council of the Blind stated when talking about the potential impact of AVs, "For the first time, people who are blind will be able to move freely over great distances without the assistance of other sighted individuals."[123] According to research from the Ruderman Family Foundation

[121] Prashanthi Raman, *AVs and a More Equitable Transportation Future*, Cruise (Feb. 3, 2022), https://www.getcruise.com/news/avs-and-a-more-equitable-transportation-future.

[122] *See* Sam Abuelsamid, *Cruise CEO Shows Off Locker Module And Wheelchair Accessible Origin Robotaxi*, Forbes (Oct. 6, 2021), https://www.forbes.com/sites/samabuelsamid/2021/10/06/cruise-ceo-shows-off-locker-module-and-wheelchair-accessible-origin-robotaxi/?sh=101016a01c78.

[123] Anthony Stephens, *Autonomous Vehicles Make Roads Safer for Drivers and Pedestrians*, Morning Consult (Sept. 20, 2018), https://morningconsult.com/opinions/autonomous-vehicles-make-roads-safer-for-drivers-and-pedestrians/.

and Securing America's Future Energy (SAFE), the mobility gains from access to AVs could enable employment opportunities for 2 million Americans with disabilities, while also saving $19 billion annually in healthcare expenses from missed appointments.[124]

To build a more inclusive transportation future that serves the public good, GM and Cruise recognize that they must do their part to also address the historic inequities and disparities inherent in our system today. These inequities have come at costs to public health and wellbeing, negatively impacting economic opportunity, inclusivity, and community empowerment—costs disproportionately borne by low income and disadvantaged communities.[125] Indeed, the intersection of road safety, equity, and climate are a core theme of the U.S. DOT's recent National Roadway Safety Strategy, which highlights the disproportionate burden of auto fatalities borne by communities of color and low-income households.[126] While the Origin will not be the only solution when deployed at scale, it is an opportunity to fundamentally reshape this landscape by providing an affordable, accessible, and sustainable alternative. While this Petition request is for a limited number of vehicles, its grant will offer a small, yet potentially meaningful, step in ensuring that AVs are addressing these concerns as they are deployed in larger numbers.

F. Granting this Petition Will Support US Jobs and Investment

Manufacturing the Origin will support economic growth and further catalyze General Motors' transition to fully electric vehicles. The Origin will be produced at GM's newly renovated and opened Factory ZERO located in Detroit-Hamtramck, Michigan, which is the Company's first assembly plant fully dedicated to EV and AV manufacturing. GM will be investing $2.2 billion to retrofit this plant for the production of autonomous and electric vehicles. Additionally, this facility will contribute to over 2,000 union manufacturing jobs—with the Origin serving as one of the first major production lines at the site.[127]

Additionally, the Origin has already generated US jobs. Cruise employs over 2,500 people at various locations throughout the United States dedicated solely to the design, development and testing of the Cruise AV and Origin self-driving software, hardware, firmware, and related technology. Through these jobs, American workers gain valuable skills and experience in a burgeoning high-technology field that is on the cutting edge of artificial intelligence, believed by many experts to be a defining pan-industry expertise of this century.[128] By granting this Petition, NHTSA will play a direct role in facilitating the continued development of these skills and technology in the United States.

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[124] Henry Claypool et al., *Self-Driving Cars: The Impact on People with Disabilities*, Ruderman Family Foundation and SAFE (Jan. 2017) at 16, https://rudermanfoundation.org/wp-content/uploads/2017/08/Self-Driving-Cars-The-Impact-on-People-with-Disabilities_FINAL.pdf.

[125] Hana Creger et al., *Mobility Equity Framework*, The Greenlining Institute (Mar. 2018), at 8, 19, http://greenlining.org/wp-content/uploads/2019/01/MobilityEquityFramework_8.5x11_v_GLI_Print_Endnotes-march-2018.pdf.

[126] 2022 National Roadway Safety Strategy at 7.

[127] Press Release, General Motors, *Detroit-Hamtramck to be GM's First Assembly Plant 100 Percent Devoted to Electric Vehicles* (Jan. 27, 2020), https://media.gm.com/media/us/en/gm/home.detail.html/content/Pages/news/us/en/2020/jan/0127-dham.html.

[128] James A. Lewis et al., *AI Strategies and Autonomous Vehicles Development*, Center for Strategic & International Studies (Apr. 2001) at 1-3, https://www.csis.org/analysis/ai-strategies-and-autonomous-vehicles-development.

GM and Cruise's investment in the Origin has a powerful downstream impact as well, driving additional investment by suppliers, competitors, and supporting industries. The efforts of GM and Cruise collectively create a market for suppliers, such as those creating powerful in-vehicle computers and new sensors to enable AVs, as well as those supporting related services and infrastructure, such as vehicle charging stations. The Origin also represents an opportunity to maintain vital U.S. industrial competitiveness on automotive technology, particularly in light of rising competitive and strategic pressures from European and Chinese producers.

Across the U.S. economy, the automotive industry supports 10.3 million jobs, representing 5.5% of total GDP.[129] The industry is responsible for $99 billion in U.S. exports annually, and invested over $46 billion in U.S. factories and facilities between 2010 and 2014. Self-driving technology will define the future of the automotive industry. The Origin represents an opportunity to spur this industry further, connecting Silicon Valley technology development with industrial heartland expertise as a roadmap for the future of U.S. manufacturing. And, as shown in research from the Center for Strategic and International Studies, there are clear synergies between marrying the development of software and hardware systems for electric, AVs like the Origin in advanced technology centers with American OEMs—the supply chain and manufacturing engine of the United States.[130] GM and Cruise believe this model, manifested in the Origin, can be a useful blueprint for the long-term success of the U.S. manufacturing sector in the 21st century.

G. Granting this Petition Will Enable the US to Shape AV Norms and Standards

The Origin could not only support U.S. leadership on AV manufacturing, but could serve as the vehicle through which the United States defines and shapes the global regulatory landscape for AVs. The Origin will be one of the first global commercial applications for machine learning, artificial intelligence, and advanced manufacturing capabilities inherent in a Level 4 ADS-DV. The Origin presents an opportunity for an American company to be first to market with a purpose-built zero-emission AV. Therefore, a Petition grant will position the US to have substantial influence in global norm and standard setting when it comes to autonomous transport. Granting this Petition will provide the US access to more data and real world understanding of the technology than any other country in the world. The Origin and the learnings, data, and experience NHTSA gains from a grant of the Petition will provide NHTSA with unparalleled access and understanding of this developing technology, and allow NHTSA to develop data driven regulations on AVs and ADS that will serve as a model to the world. Such leadership is critical, as US safety standards are central to the international automotive sector, serving as an enabler of American auto exports globally and supporting domestic job creation. It is vital the United States remains at the forefront of this field.

[129] Alliance for Automotive Innovation, *The Industry* (2021), *at* https://www.autosinnovate.org/initiatives/the-industry.

[130] Jack Caporal et al., *Bridging the Divide: Autonomous Vehicles and the Automobile Industry*, Center for Strategic & International Studies (Apr. 14, 2021) at 3-5, https://www.csis.org/analysis/bridging-divide-autonomous-vehicles-and-automobile-industry.

Indeed, the United States' ability to first set global norms and standards is critical—particularly in light of rising international AV and EV industrial pressures from competitors like China, as articulated by Securing America's Future Energy ("SAFE") in their work on the future of the transportation sector.[131] Chinese competitors have made impressive gains in recent years, with evidence pointing to strong regulatory alignment between Beijing and its domestic developers that put the United States' interests at a disadvantage. News reports point to financial support for Chinese AV developers from state-backed investment funds.[132] As summarized by SAFE in its September 2020 report *The Commanding Heights of Global Transportation:* "In the best case, this risk amounts to a significant loss of jobs as the United States cedes some advanced technology and automobile manufacturing to China. At worst, it amounts to a severe degradation of the U.S.-based innovation ecosystem—a system which catalyzes future economic growth and enables the United States to stay ahead in technological, industrial, and military competition."[133]

H. Granting this Petition Will Help Foster Public Acceptance of Autonomous and Electric Technologies

Lastly, NHTSA has previously noted the importance of "consumer acceptance" of ADS vehicles. [134] The Origin can be an ideal vehicle for educating the public about the benefits of both automated and electric vehicle technology. Indeed, public acceptance is critical for broad realization of the safety and mobility benefits of AVs. Through an Origin-based ride-sharing fleet, consumers—from the earliest adopters to those most reticent to experience AVs—will be able to experience the technology firsthand, without significant individual financial commitment.

VI. CONCLUSION

For all the foregoing reasons, GM and Cruise respectfully request that NHTSA grant this Petition. GM and Cruise welcome NHTSA's feedback on the Petition and look forward to working with the Agency through the Petition process.

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[131] Securing America's Future Energy, *The Commanding Heights of Global Transportation* (Sept. 2020) at 1-14 (hereinafter "*The Commanding Heights of Global Transportation*"), *at* https://secureenergy.org/commandingheights/.

[132] *China's Didi raises $300 million for autonomous driving unit*, Reuters (Jan. 28, 2021), *at* https://www.reuters.com/article/us-didi-chuxing-autonomous-idUSKBN29X0YO.

[133] *The Commanding Heights of Global Transportation* at 9.

[134] United States Department of Transportation, *Preparing for the Future of Transportation: Automated Vehicles 3.0* (Oct. 4, 2018), https://www.transportation.gov/sites/dot.gov/files/docs/policy-initiatives/automated-vehicles/320711/preparing-future-transportation-automated-vehicle-30.pdf.

Appendix A
Technical Data for Equivalent Safety

A. FMVSS 102 Support

1. Shift Transmission State

The below technical summary illustrates how the Origin's ADS electronically commands the correct transmission state (i.e., shift position or gear). The schematic below (Figure A-1) illustrates how the Origin's ADS performs transmission state shifts and which components/modules are involved in that process. When shifting transmission states, the Origin's ADS uses the information, like gear selected and the relation between the gear positions, that would otherwise be provided to a human driver in a visual gear shift display to accurately shift transmission states. Therefore, the Origin's electronic transmission control satisfies the intent of FMVSS 102 and provides equivalent safety.

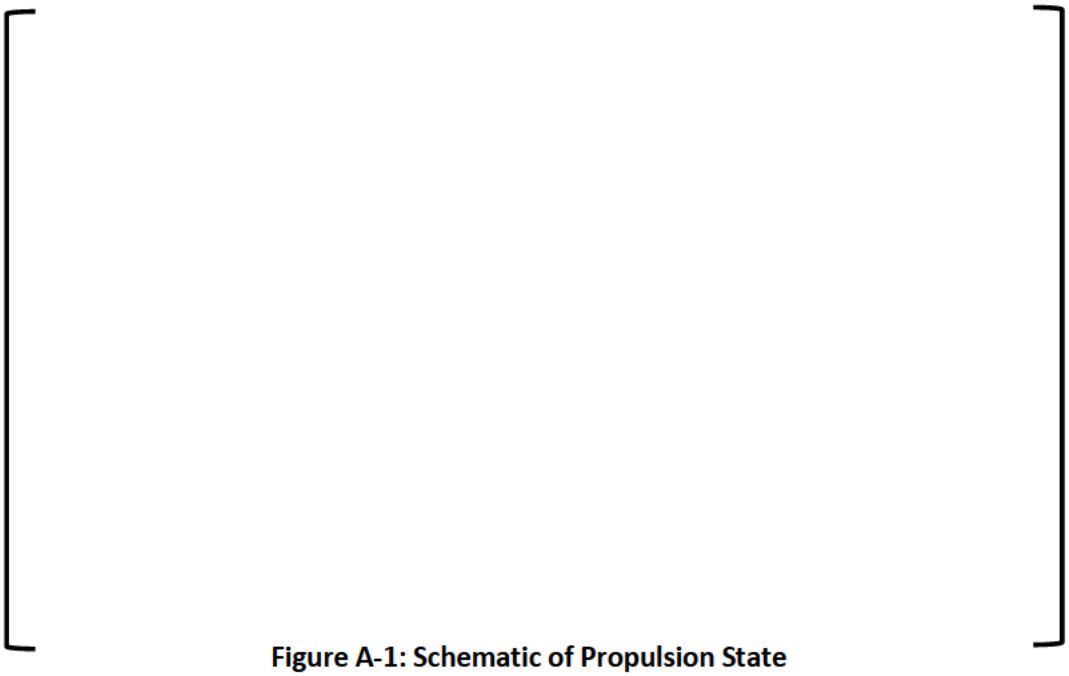

Figure A-1: Schematic of Propulsion State

2. State Change Process

The below steps further explain the schematic above and explain the steps the Origin takes to shift transmission state:

[redacted]

B. FMVSS 104 Support

The sensor cleaning system operates as outlined below and illustrated in Figure A-2 through Figure A-6. Each exterior-mounted optical sensor on the Origin has a dedicated sensor cleaning system. Each of those systems consists of two primary components: a fluid system and a pressurized air system with a condensation trap. These two components work together to ensure the sensors are clear of debris, dirt, and condensation. This provides the ADS with a clear 360-degree view of its surroundings at all times when operating within its ODD. The Origin will not operate outside of its ODD, including in inclement weather, as described in Appendix E.

[redacted]

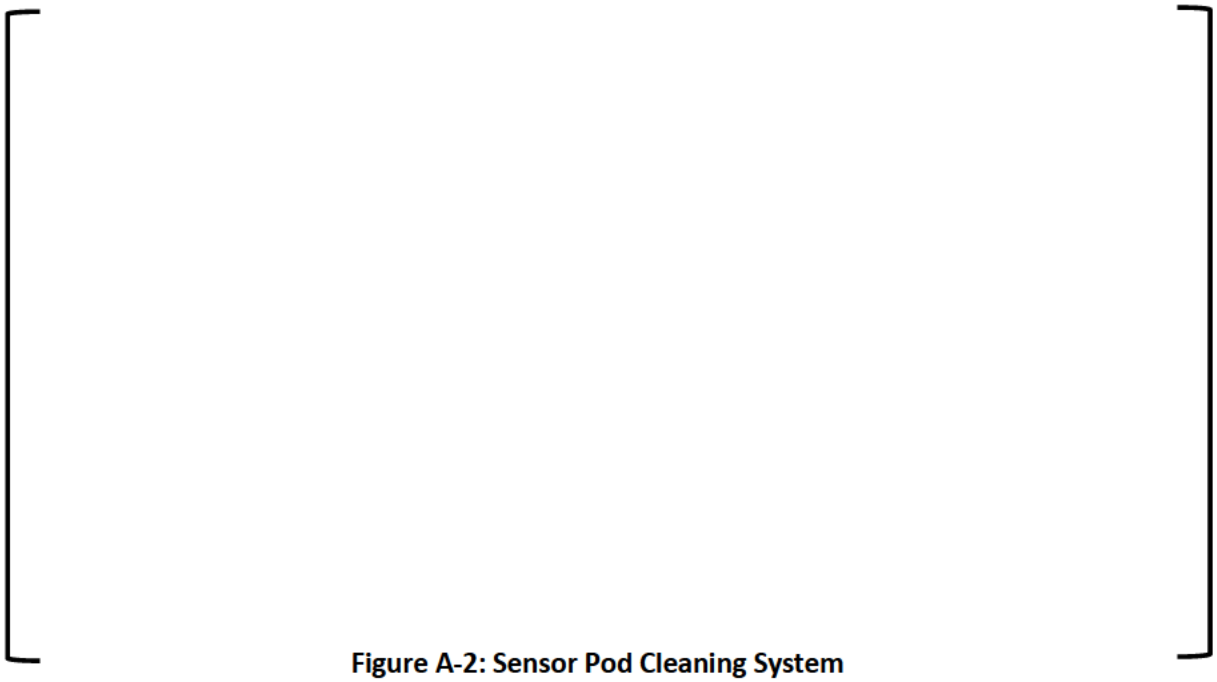

Figure A-2: Sensor Pod Cleaning System

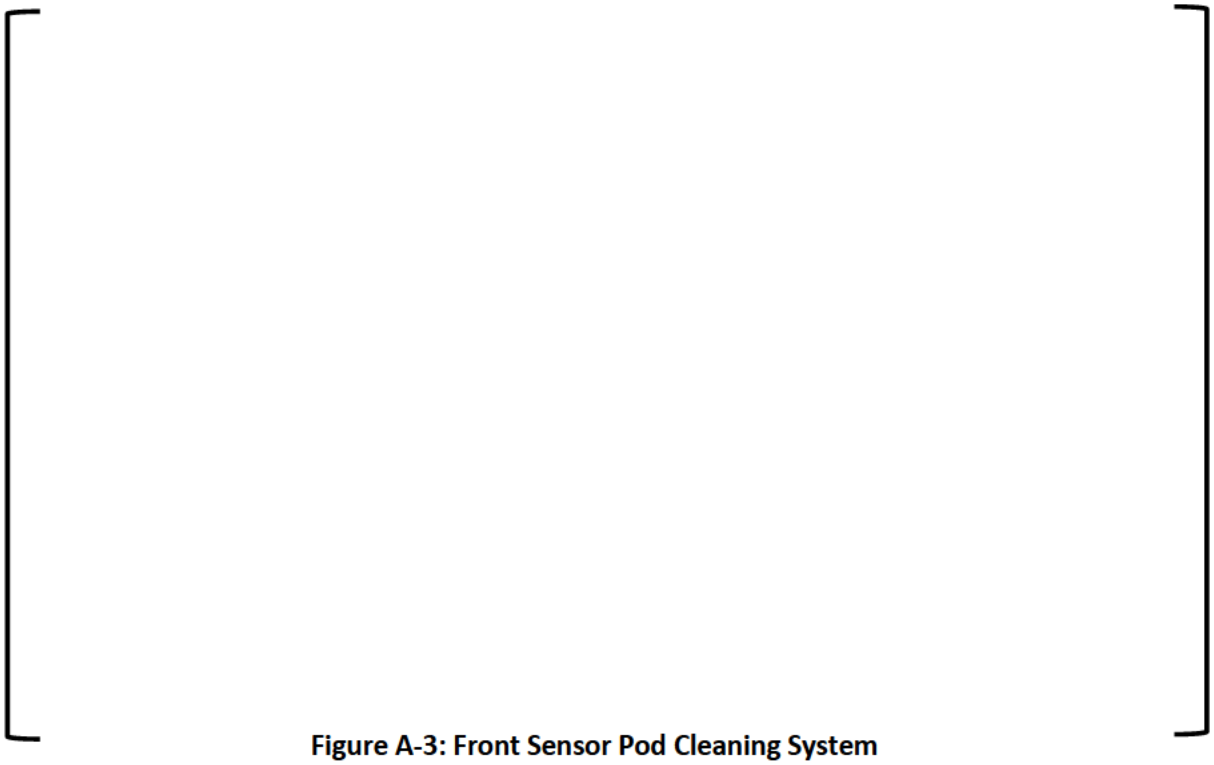

Figure A-3: Front Sensor Pod Cleaning System

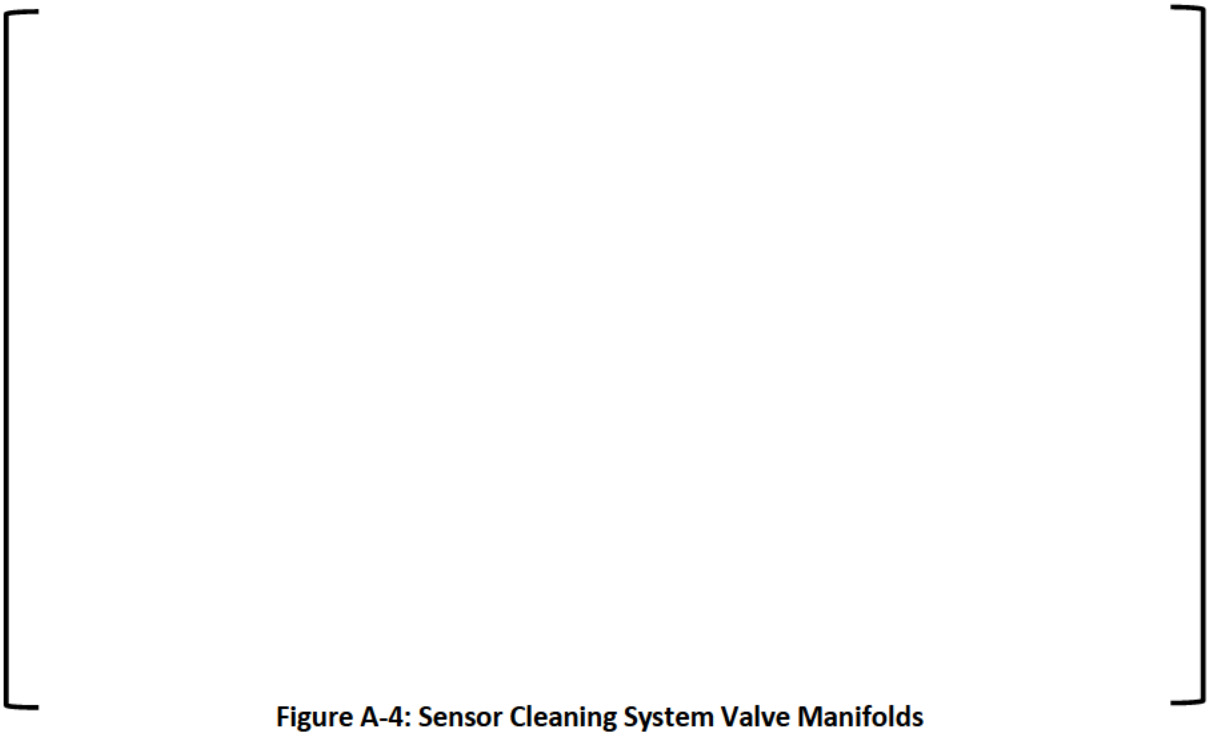

Figure A-4: Sensor Cleaning System Valve Manifolds

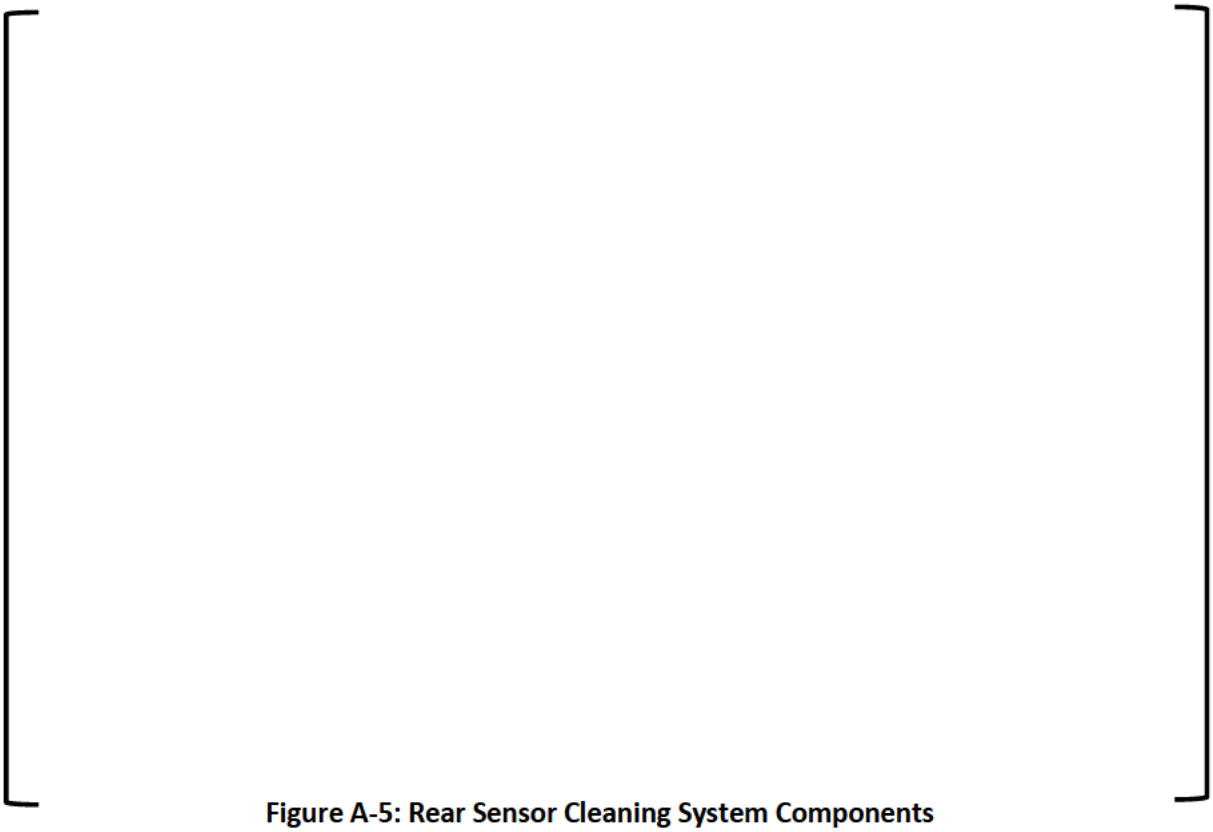

Figure A-5: Rear Sensor Cleaning System Components

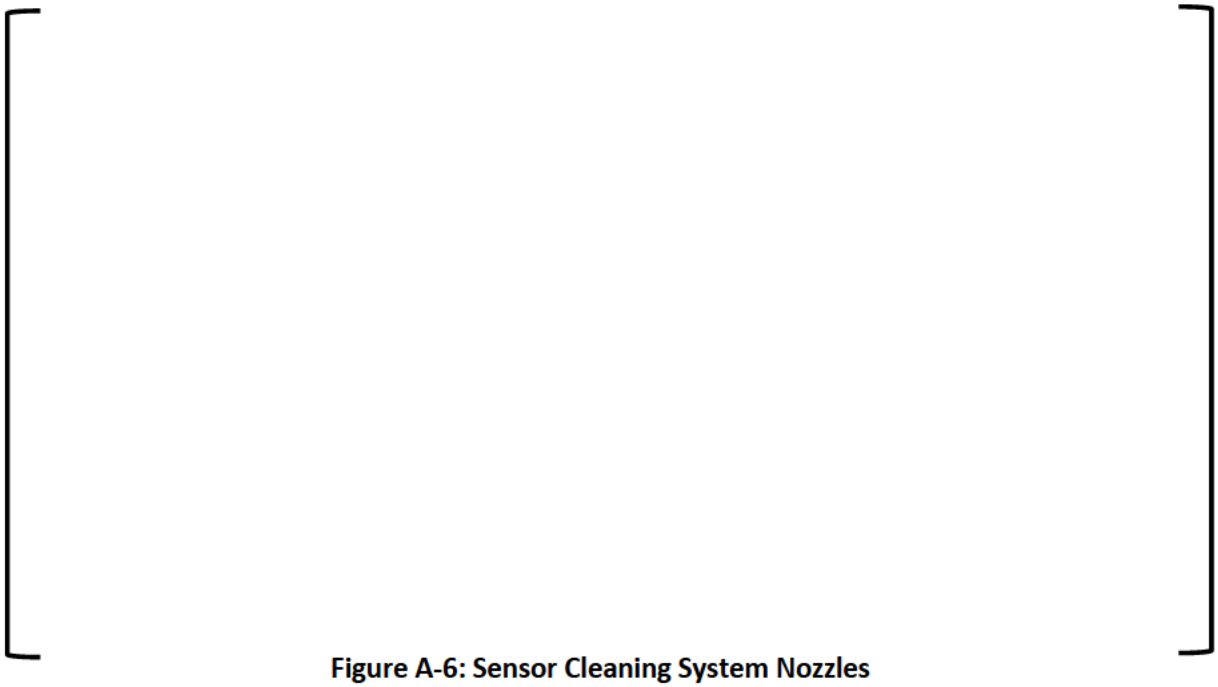

Figure A-6: Sensor Cleaning System Nozzles

Figure A-6, above, illustrates the air and liquid nozzles (blue and gray nozzles) of the sensor cleaning system. These nozzles provide specific spray patterns for optimal cleaning performance for various sensors and camera lenses on the Origin.

The Origin, both through its comprehensive sensor suite and its sensor cleaning system, provides an equivalent level of safety to a compliant vehicle by meeting the purposes and intent of FMVSS 104: that the driver, in this case the ADS, retains the ability to maintain sufficient visibility of the roadway ahead in the case of inclement weather, or debris or dirt build up on the windshield.

C. FMVSS 108 Support

1. Turn Signals

Paragraph S9.1.1 requires the turn signals to self-cancel by steering wheel rotation. The Origin does not have or need a steering wheel, and it does not have a manually operated turn signal control. The Origin's ADS controls turn signal activation and cancellation, and it does so consistently, effectively, proficiently, and in compliance with the laws of the state in which its ODD is located (e.g., the ADS timely activates the signals before initiating a turn or changing lanes).[135] Similarly, the ADS will timely cancel turn signals after the Origin successfully completes a lane change or a turn. A more detailed description of how and when the ADS activates and deactivates the turn signals is provided below.

- Turning maneuvers: The ADS activates the turn signal approximately 100 feet prior to making a turn on its programmed route and it automatically cancels the exterior

[135] The Origin's ADS is programmed to ensure turn signal activation and cancellation is compliant with applicable state law requirements applicable to its ODD. *See, e.g.*, Cal. Veh. Code § 22108 (requiring continuous use of a turn signal 100 feet prior to turning).

turn signal lamp when the turn is completed (when the mapped turn has been completed and the vehicle returns to a lane-centered position).

- Lane change maneuvers: The ADS activates the turn signal approximately 100 feet prior to the lane change and it automatically cancels the exterior turn signal lamp when the lane change is completed (when the vehicle confirms it is properly centered in the new lane).

- Maneuvering around road hazards: The ADS automatically activates the turn signal when maneuvering around road hazards, blocked traffic, a person directing traffic or other non-planned events.

The Origin's turn signal lighting system is illustrated in Figure A-7, below.

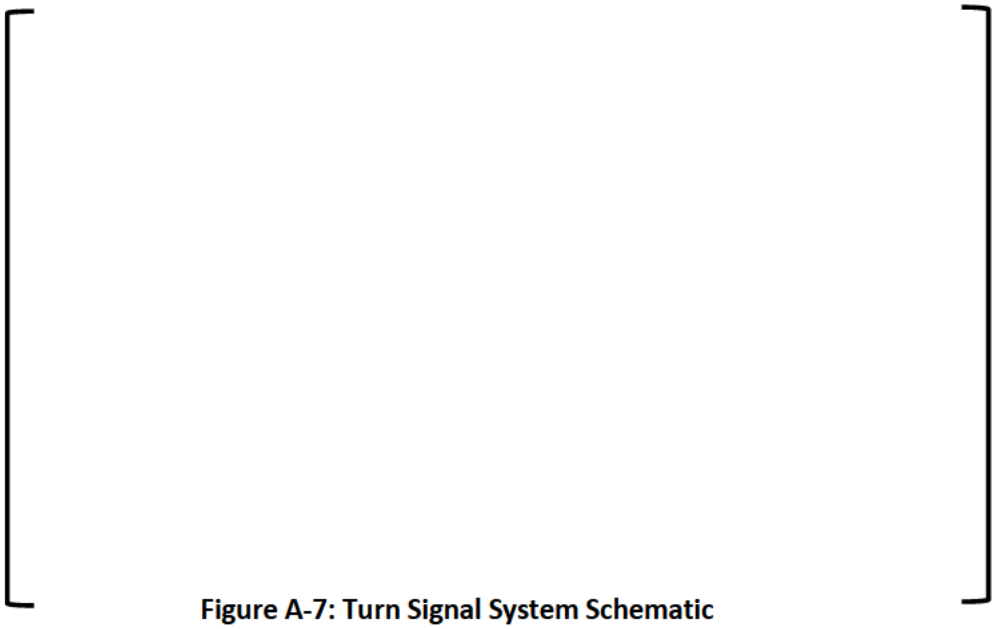

Figure A-7: Turn Signal System Schematic

Acronyms

- **ADS:** Automated Driving System
- **ADIM:** Automated Driving Integrated Module
- **BCM:** Body Control Module

The Origin and the currently deployed Cruise AV use the same turn signal logic to control the activation and deactivation of the turn signals. The data from deployed Cruise AVs was mined for 100 random turns to verify that the turn signals operate as intended. The results are shown below in the Table A-1. Column F shows the time when the turn signal activated prior to the turn. Column G shows the time after the turn that the turn signal was deactivated. As indicated by Column H, in all cases the turn signal operated properly—the turn signal activated prior to the turn and deactivated immediately after completion of the turn.

A	B	C	F	G	H
VIN (last 6 digit)	**Left or Right Turn**	**Left or Right Signal**	**Turn Signal ON Lead Time (sec)**	**Turn Signal OFF Trail Time (sec)**	**Did the turn signal operate properly?**
100118	left	left	69	1	**YES**
100069	left	left	7.09	1.29	**YES**
100037	right	right	7.46	1.44	**YES**
100037	right	right	7.87	1.48	**YES**
100046	right	right	8.12	1.42	**YES**
100068	left	left	5.47	2.16	**YES**
100085	left	left	5.7	2.09	**YES**
100068	right	right	5.66	0.75	**YES**
100068	right	right	4.74	0.5	**YES**
100068	left	left	4.84	0.17	**YES**
100069	right	right	5.11	0.8	**YES**
100037	left	left	5.66	0.3	**YES**
100118	left	left	5.33	0.7	**YES**
100118	left	left	5.9	0.7	**YES**
100085	left	left	6.24	0.88	**YES**
100037	right	right	5.17	0.93	**YES**
100037	left	left	4.19	0.24	**YES**
100037	left	left	4.54	0.56	**YES**

100037	right	right	0.87	0.8	YES
100037	left	left	0.49	0.21	YES
100046	right	right	4.61	1.05	YES
100069	left	left	38.36	0.79	YES
100046	right	right	4.89	1.15	YES
100069	right	right	4.75	0.87	YES
100046	left	left	7.55	1.57	YES
100029	right	right	7.45	2.1	YES
100037	left	left	8.22	1.43	YES
100118	right	right	93.52	1.74	YES
100046	right	right	7.41	1.29	YES
100085	left	left	4.51	1.36	YES
100068	right	right	6.61	1.29	YES
100068	right	right	6.61	0.66	YES
100029	right	right	6.05	1.43	YES
100118	right	right	6.58	1.63	YES
100037	left	left	8.15	1.89	YES
100068	left	left	8.2	1.75	YES
100085	right	right	8.24	1.38	YES
100118	left	left	8.28	1.21	YES
100046	right	right	8.29	1.35	YES
100046	left	left	8.31	2	YES
100069	left	left	8.34	1.69	YES
100046	left	left	8.34	5	YES
100037	right	right	8.36	1.81	YES
100069	left	left	8.39	1.84	YES
100085	right	right	8.4	1.77	YES
100118	right	right	8.43	1.69	YES
100085	left	left	8.43	1.41	YES
100029	right	right	8.44	1.57	YES
100069	left	left	8.5	1.49	YES
100029	left	left	8.54	1.66	YES
100118	left	left	9.54	1.12	YES
100068	left	left	8.55	1.74	YES
100118	left	left	8.56	1.49	YES
100029	left	left	10	1.87	YES
100029	right	right	8.6	1.78	YES
100068	right	right	8.6	1.66	YES
100046	right	right	10	1.79	YES
100068	left	left	8.67	1.66	YES
100046	right	right	8.72	1.75	YES
100069	left	left	8.75	1.63	YES
100069	right	right	8.79	1.6	YES
100069	right	right	8.79	1.7	YES
100029	left	left	8.79	1.59	YES
100085	right	right	8.82	1.74	YES
100118	right	right	8.83	1.95	YES
100085	left	left	8.83	1.83	YES
100037	right	right	8.84	1.48	YES
100068	left	left	8.85	1.68	YES
100085	right	right	8.86	1.91	YES
100068	right	right	8.87	1.59	YES
100068	right	right	8.89	1.51	YES
100069	right	right	20	1.92	YES

100046	left	left	9.02	1.71	YES
100029	left	left	9.03	1.75	YES
100068	right	right	9.07	1.65	YES
100118	left	left	9.1	1.19	YES
100029	right	right	9.13	1.75	YES
100069	left	left	9.27	1.91	YES
100029	left	left	11	1.8	YES
100046	left	left	13	1.78	YES
100085	left	left	12	1.28	YES
100029	left	left	11	1.25	YES
100118	left	left	13	1.32	YES
100085	right	right	9.54	1.7	YES
100046	left	left	9.55	1.56	YES
100085	right	right	9.59	1.76	YES
100029	right	right	9.81	1.74	YES
100046	right	right	9.9	1.83	YES
100029	right	right	9.98	1.62	YES
100118	left	left	10.04	1.95	YES
100046	left	left	10.21	1.87	YES
100085	left	left	10.22	1.76	YES
100118	left	left	10.89	1.86	YES
100029	left	left	11.04	1.48	YES
100068	right	right	11.68	1.88	YES
100085	right	right	12.35	1.69	YES
100037	left	left	13.28	1.72	YES
100118	left	left	15.5	1.69	YES
100085	right	right	15.91	1.71	YES
100037	right	right	16.93	1.36	YES

Table A-1: Turn Signal Operation Analysis

2. Hazard Warning Lights

The technical summary below describes how the Origin will activate the hazard lights.

Acronyms

- **ADIM:** Automated Driving Integrated Module
- **BCM:** Body Control Module
- **SDM:** Sensing and Diagnostic Module

[ ]

The Origin has sufficient design redundancy to ensure that hazards will be triggered for any scenario in which hazard lights may be necessary.

- Ignition in this context shall be interpreted when the Origin is booted up and powered on.
- Per operational intent, the vehicle will not be in a hazardous location prior to vehicle ignition.
- Once asserted, ignition signals for the ADS shall latch on (function shall be maintained even if ignition signal is lost).
- In the event of an unintended loss of primary power, including loss of power to the ADS components, the hazard flasher system is designed to remain enabled/active through the power provided by a backup 12v battery system.

In the event of a crash, the ADS will command the hazard lights to activate, and the hazard lights will remain on even if the ignition signal is lost.

3. Headlight Beam Switching

This section describes how the Origin can switch between high and low beams. That process is illustrated in Figure A-8 and described more fully below. However, as noted, the Origin will never need the upper beams (i.e., "high beams") to "see" to operate the vehicle consistently, effectively, and proficiently day or night. In other words, the Origin's ADS does not rely upon high beam activation to operate at night.[136] The Origin is equipped with daytime running lights and automatic headlights, such that when operating at night, the Origin's low beams are always active. While the Origin is equipped with high beams and a method for electronically switching between low and high beams, GM and Cruise do not anticipate that the ADS will need to command high beams while operating within its ODD.

[136] In the roughly 3 million on-road miles that the Cruise AV has operated, it has never needed to activate the high beams to operate safely at night.

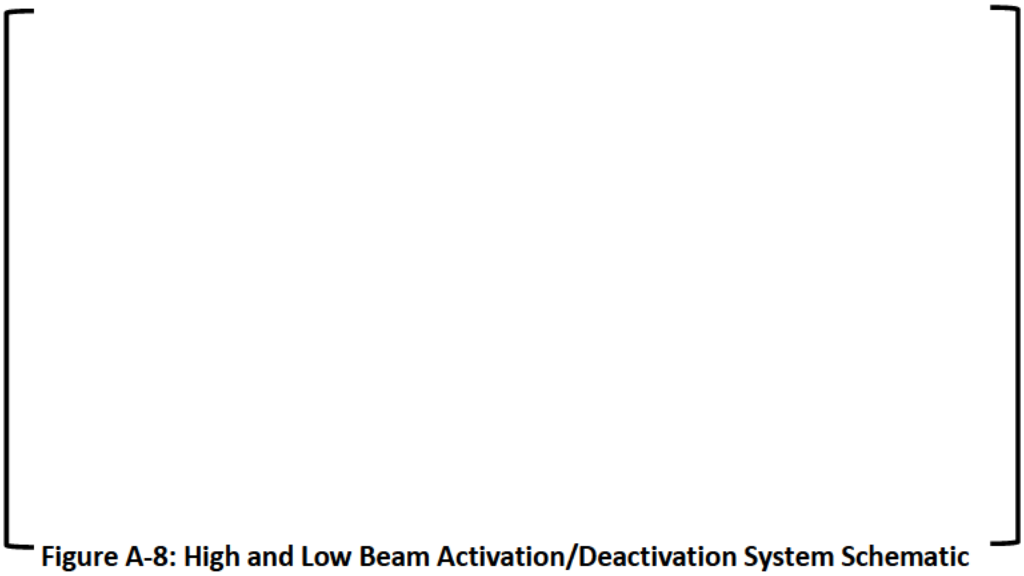

Figure A-8: High and Low Beam Activation/Deactivation System Schematic

Appendix B
Occupant Protection and Buckle to Ride Technical Data

A. Occupant Protection

1. Vehicle Design

GM designed, engineered, and built the Origin using best practices that are used for all GM vehicle designs to optimize overall vehicle crash protection in a variety of crash load cases. For example, the Origin is built with an extensive series of high-strength steels and other optimized materials that maximize energy absorption and provide technically advanced crash-force mitigation. Figure B-1 below illustrates the Origin's use of these materials.

[ ]

Figure B-1: Optimized Material Usage in the Origin

The Origin's subway-style doors were carefully engineered to provide protection in side impacts and rollovers, and to provide ejection mitigation. Specifically, these doors include various door interlocks, striker-latches, and a door-to-door interlock, all of which work to keep the doors closed in the event of a crash. Figure B-2, below, shows the locations of the four striker/latches and the interlocks between the front and rear doors.

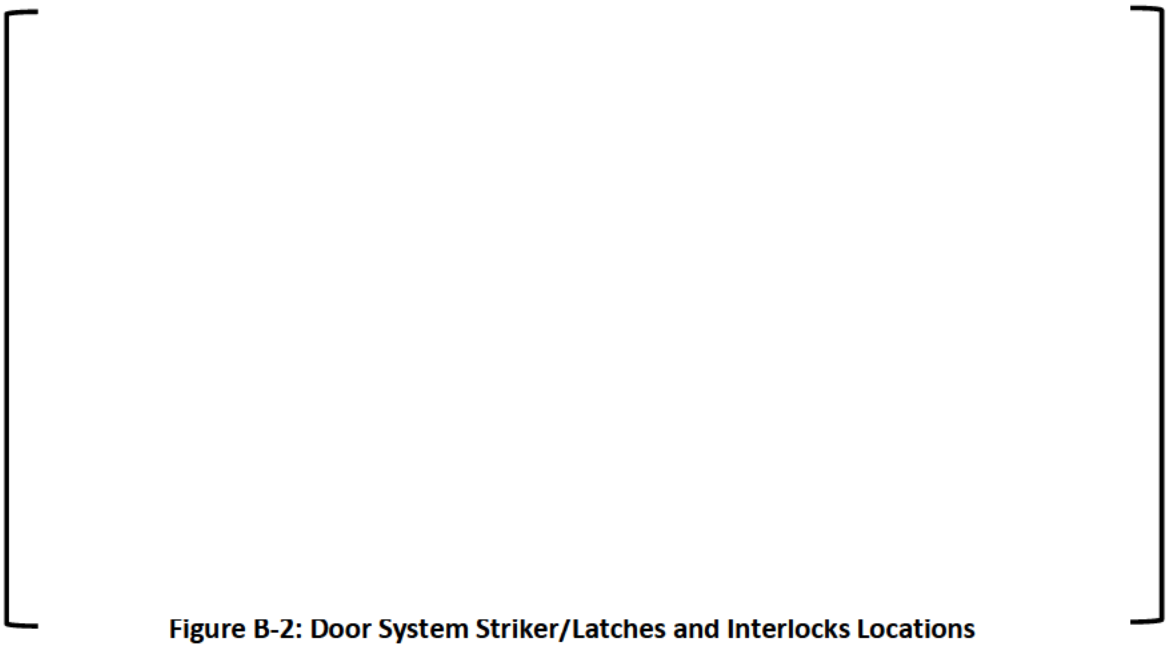

Figure B-2: Door System Striker/Latches and Interlocks Locations

2. Performance Studies

GM is evaluating the Origin's occupant protection performance across a range of belted occupant crash conditions for both the first and second row seating, including:

For each of the various impact conditions, GM has considered both FMVSS-regulated injury criteria and internal assessment values to achieve a desired overall performance balance across a range of occupant sizes and seating positions. Note that, as of the date of this submission, the occupant performance development is still in process. The tables in this section show the status and data to date based on evaluations conducted in vehicle tests and/or simulations.

Table B-1 through Table B-3 show the in-position, belted frontal and rear impact occupant performance data compared to Injury Assessment Reference Values ("IARVs") across a range of occupant sizes and seating conditions. Left (L) and right (R) seating positions are symmetrical, and the performance is assessed to be equivalent.

[ ]

Table B-1: 95th ATD In-Position, Belted, Frontal and Rear Impact Occupant Performance

[ ]

Table B-2: 50th ATD In-Position, Belted, Frontal and Rear Impact Occupant Performance [*Data not recorded]

[ ]

Table B-3: 5th ATD In-Position, Belted, Frontal and Rear Impact Occupant Performance

B. Buckle to Ride

1. Buckle to Ride Passenger Experience

The following steps describe how the Buckle to Ride feature works, starting before a passenger enters the Origin and continuing throughout the ride.

1. Prior to entering the Origin, the passenger may view information on seat belt use, child seat use/installation, as well as other safety information in the Cruise mobile app.
2. When a passenger sits on a seat or uses a seat belt, the Buckle to Ride feature begins to assess seat occupancy and seat belt status.
3. Upon pressing the Start Ride button:
    a. Unbelted passengers will be automatically reminded to buckle their seat belt with both audible chimes and visual reminders in the informational displays by means of a fasten seat belt message, as outlined in FMVSS 208.
    b. Additional reminders will be given to belted passengers whose seat belts are detected in an improperly routed condition. These

reminders may include the use of in-vehicle screens and/or audio messages.

4. If a detected passenger remains unbuckled despite multiple warnings, an escalation process will be initiated to further encourage the rider to buckle and/or determine why the seat belt status is detected as unbuckled. The escalation process may result in the ride being cancelled for failure to buckle, and the passenger being asked to exit the vehicle. It is possible that this escalation may lead to a scenario where an override of the seat belt detection system is appropriate and that the ride may start.[137]
5. Proper seat belt usage will be monitored for all seating positions during the entire ride. Seat belt reminder and improper seat belt routing warnings will be provided to passengers if their seat belt status changes during the ride. Warnings may be visual and/or audible.

2. Buckle to Ride Messaging

The Buckle to Ride feature operates throughout the trip and provides passengers with important information about proper seat belt usage. An overview of the seat belt-use messaging provided to passengers is illustrated in the flowchart in Figure B-3 below.

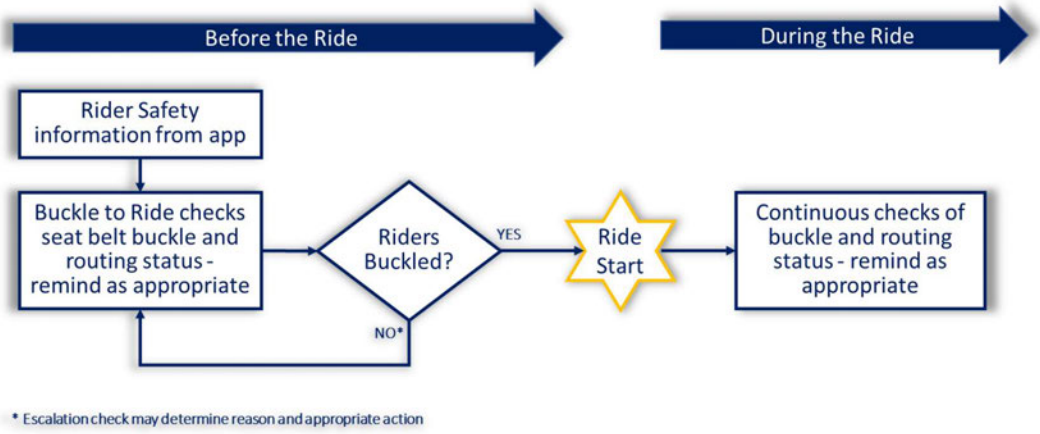

Figure B-3: Seat Belt Customer Messaging Flowchart

3. Buckle to Ride Studies

To detect improper routing, the Buckle to Ride feature uses input from three sensors described below.

1. Occupancy sensors at all seating positions. These are resistive-based sensor pads in the seat bottom intended to detect passengers the size of approximately 10 years of age and older.
2. Seat belt buckle sensors at all seating positions. These detect whether a seat belt latch is connected to the buckle.

[137] The limited exceptions include medical issues that prevent passengers from buckling their seat belt or instances in which luggage on the seat triggers the occupancy sensor.

3. Newly developed seat belt payout sensors at all seating positions. These sensors, located in each seat belt retractor, are designed to monitor the rotation of the internal webbing spool to help determine the amount of seat belt webbing that the passenger has pulled out (payout) of the retractor as they buckle up and during seat belt use.

In addition to these three sensors, the Buckle to Ride feature also uses a GM proprietary time-based algorithm that analyzes input from the three sensors to detect certain improper seat belt routing. The time-based algorithm and detection logic include three main components:

- Event/time-based logic which evaluates the sequence of the sensor activations and the webbing payout time-history.
- Magnitude-based logic which evaluates the webbing payout magnitude and compares it to calibrated thresholds.
- A combination of the event/time-based and magnitude-based logic that enables additional indication of certain improper seat belt routing scenarios.

To evaluate the capability of the Buckle to Ride feature to detect improper seat belt routing conditions, GM conducted a human study with [ ]participants of varying sizes and created[ ]discrete classification data points as shown in Table B-4 through Table B-6. The participants represented a range of passenger sizes from approximately a 10-year-old up to 95th percentile male passengers.

[ ]

Table B-4: Number of Participants Used in Improper Seat Belt Routing Assessment

[ ]

Table B-5: Discrete Number of Data Points by Seat Belt Routing Condition

Table B-6 shows the results of these studies and the effectiveness of the Buckle to Ride feature to detect each of the improperly routed seat belt conditions.

[ ]

Table B-6: Improper Routing Effectiveness

The data shows that the Buckle to Ride feature can detect improper seat belt routing for conditions “Belted and Sat-On” and “Shoulder Belt Only” are over 95% rate across a range of occupant sizes. Other seat belt misrouting conditions are under assessment at this time. The intent of such detection is to provide reminders, when possible, to help encourage proper seat belt routing usage.

Appendix C
Sensor Technical Data

A. Sensor Suite Overview

The Origin uses over eighty (80) state-of-the-art sensors to generate a 360-degree view of rich sensor data at least ten times a second, which enables its Autonomous Driving System (ADS) to perform the following driving tasks:

- Position itself relative to a high-fidelity 3D map of the world.
- Navigate through free, drivable space.
- Identify and classify road objects and actors.
- Respond with the appropriate driving behavior.

The Origin features the following sensors:

- Cameras (visible and long wave infrared / thermal)
- LiDAR
- Radar
- Microphones
- Ultrasonics
- TACT (Touch and Collision Transducer)

The Origin's multiple sensor modalities provide the following benefits:

- Allows the Origin to better classify and characterize its surrounding environment.
- Allows the Origin to operate under multiple operating conditions such as nighttime and inclement weather conditions.
- Provides redundancies that allow the Origin sufficient capabilities to navigate to a minimal risk condition in the event of sensor damage or failure.

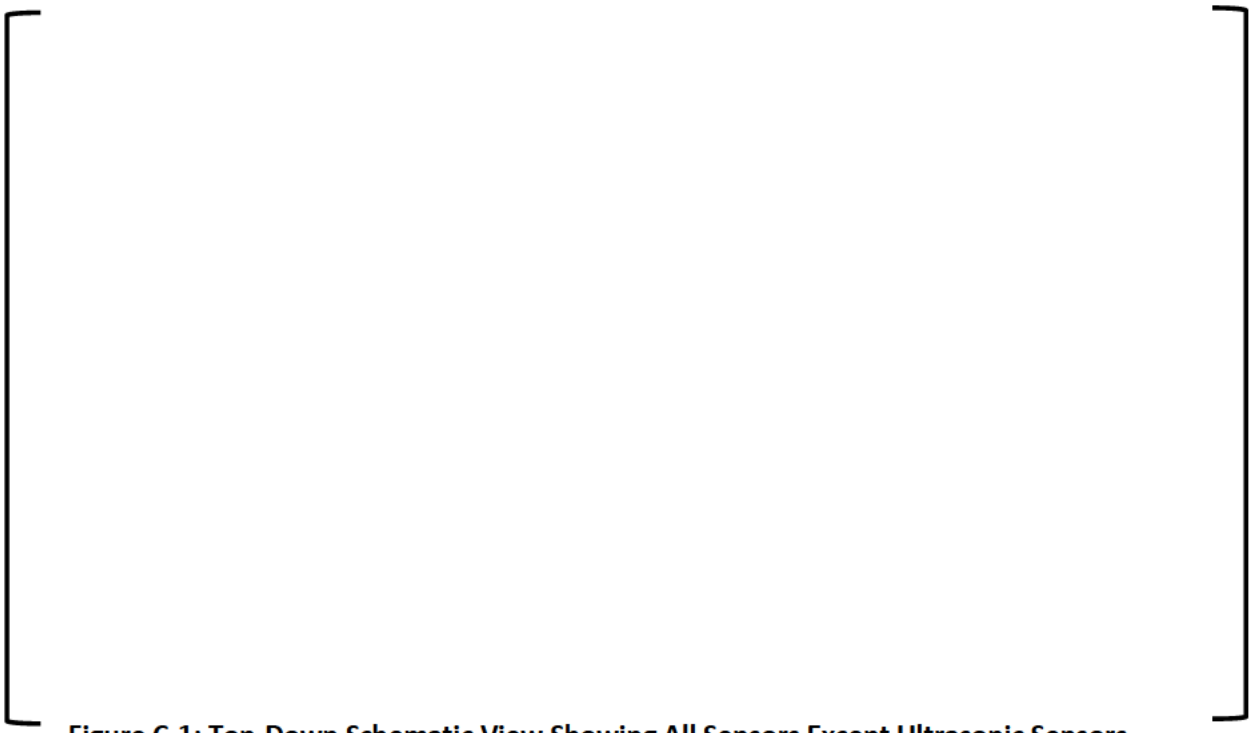

Figure C-1: Top-Down Schematic View Showing All Sensors Except Ultrasonic Sensors

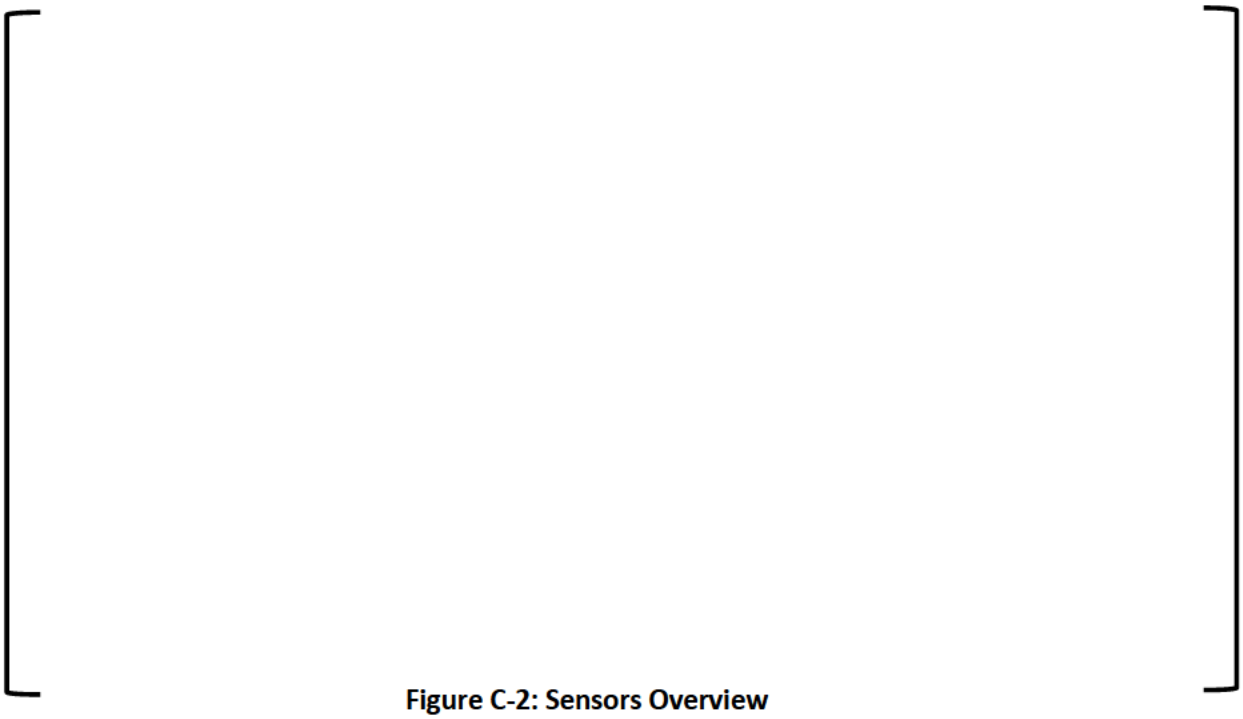

Figure C-2: Sensors Overview

In operation, all the Origin's sensors work together to provide a clear and constant 360-degree field of view of the Origin's surroundings.

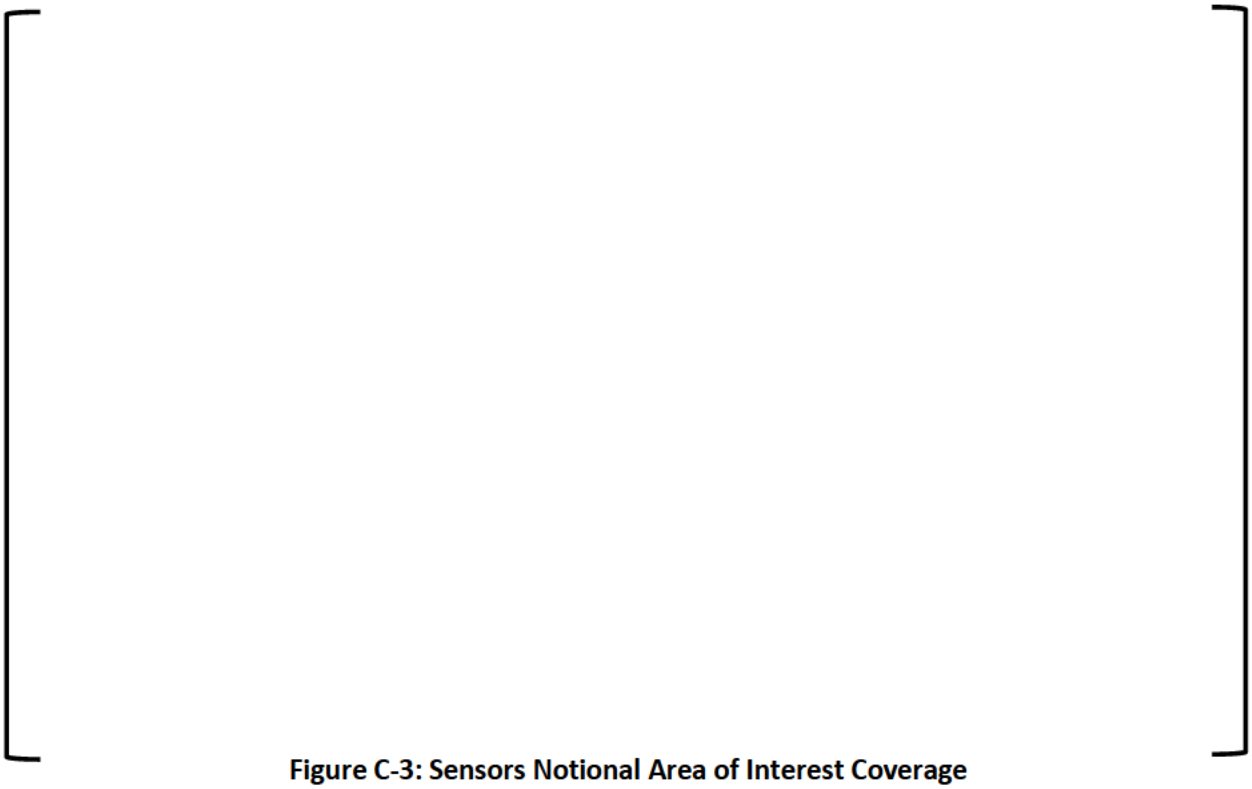

Figure C-3: Sensors Notional Area of Interest Coverage

B. Sensor Categories

1. Cameras

Cameras help the ADS classify and track objects to make confident, real-time driving decisions. Cameras capture images of pedestrians, bicyclists, vehicle types, construction zones, and traffic light states. Cameras also help provide scene context and relationships of objects relative to other objects in a given environment. A good example of this is characterizing a car door as part of the car and as having a swinging characteristic, which would allow the Origin to strategize an evasive maneuver response like a lane change or slowing down.

The Origin uses four types of camera systems:

- Surround (or Surround View)
- Medium Range Cameras
  - The Origin has two types of Medium Range Cameras: Medium Distance (Medium Resolution[138]) and Wide View (Low Resolution)
- Long Range Cameras
  - The Origin has two types of Long Range Cameras: Far Distance (High Resolution) and Infrared Thermal (also known as LWIR Thermal)

a. Surround View Cameras

[138] As used in this context, "resolution" refers to the angular resolution of the cameras, not the resolution of the cameras themselves.

There are six (6) Surround View Cameras installed on the Origin that provide a holistic near field camera view of the Origin's surroundings. The Surround View Cameras provide coverage for various AV maneuvers at low speeds, or from a stop, for the purpose of detecting vehicle signals, some traffic lights, and other road actors. Additionally, the Surround View Cameras are able to see to the dripline[139] and detect objects all the way to the ground, to protect vulnerable road users like small animals that are standing right next to the AV.

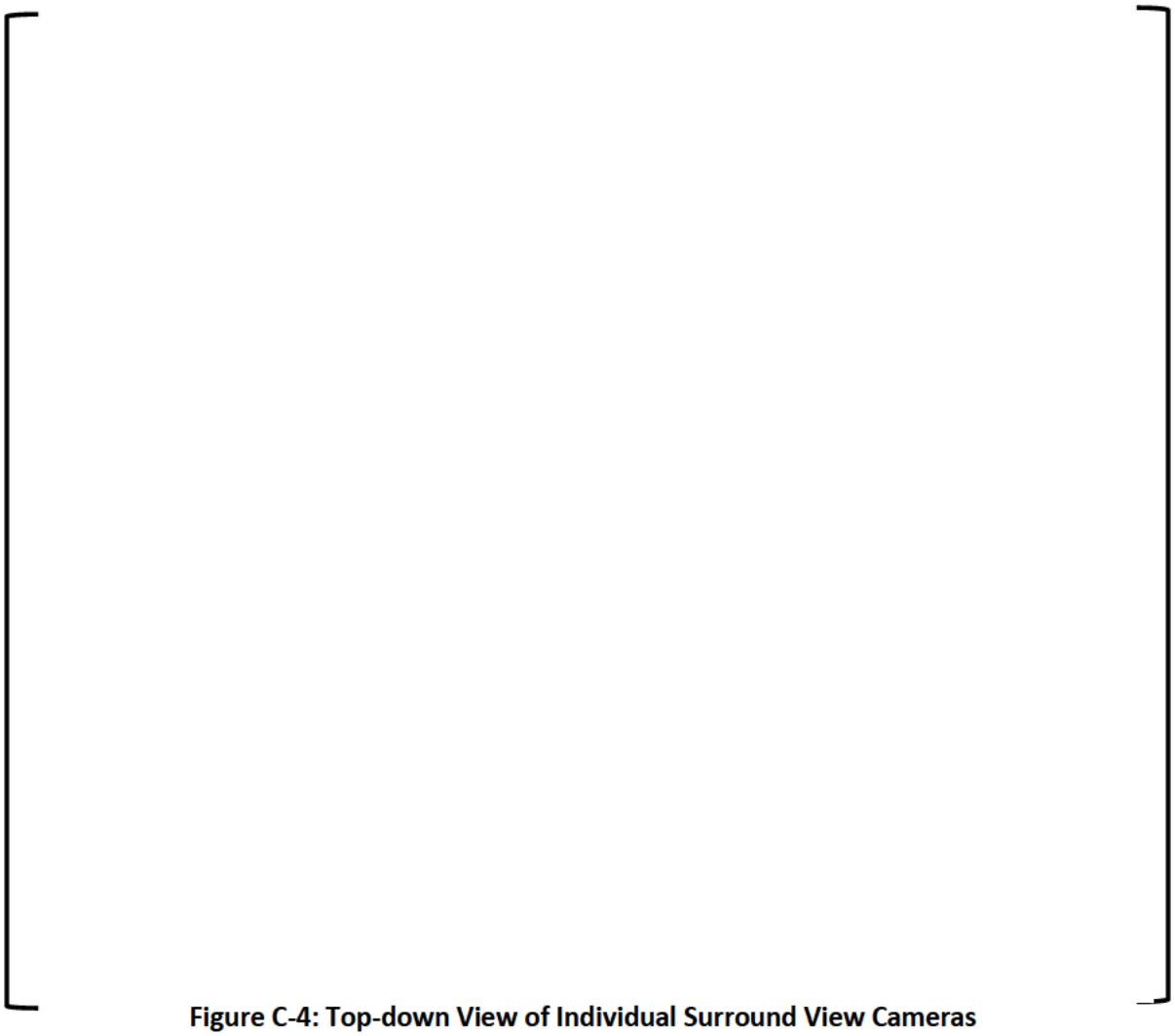

Figure C-4: Top-down View of Individual Surround View Cameras

The field of view provided by the sum of the Surround Cameras are shown below.

[139] "Dripline" refers to the pattern made by excess water shedding off the vehicle and onto the ground. It defines the projected footprint of the vehicle, and it includes the max width and length of all the vehicle body panels from the ground to the vehicle's max height. The camera's ability to see to the dripline means there are no blind spots, which protects the most vulnerable road users.

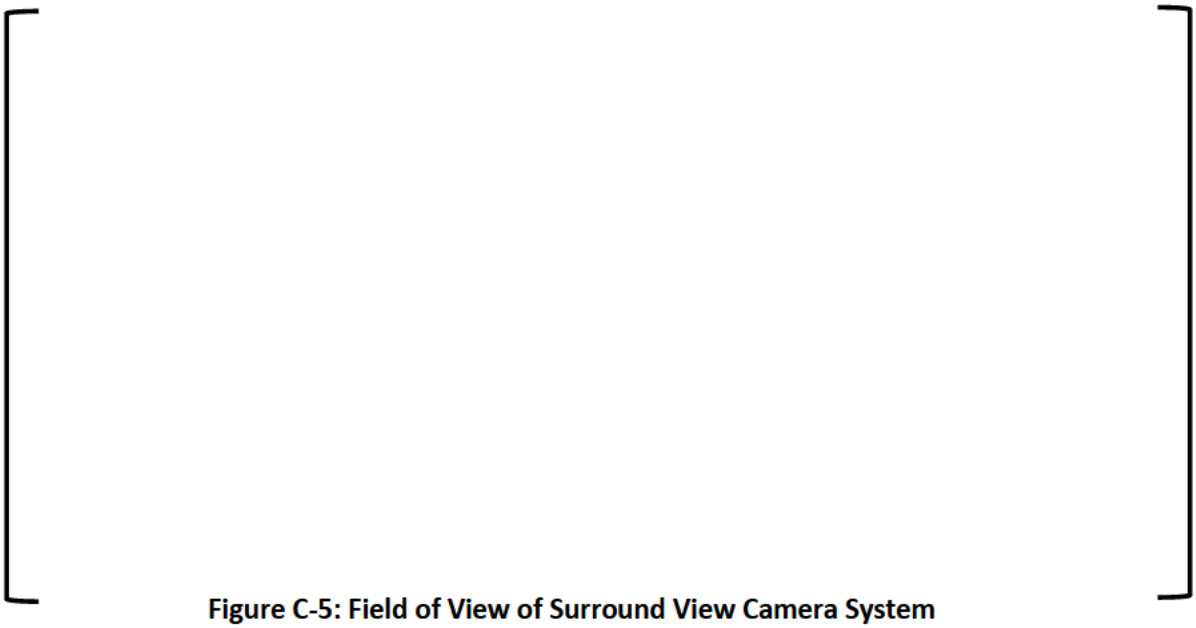

Figure C-5: Field of View of Surround View Camera System

b. Medium Range Cameras

Medium Range Cameras provide visual coverage for surroundings at medium distance from the Origin. Medium Resolution cameras provide persistent 360-degree coverage for various medium-speed situations, such as detecting an approaching vehicle during unprotected turns. In addition, the frontal cameras provide traffic light detection. The Origin is configured with two variants of Medium Range cameras: Medium Resolution (or Medium Distance) and Low Resolution (or Wide View).

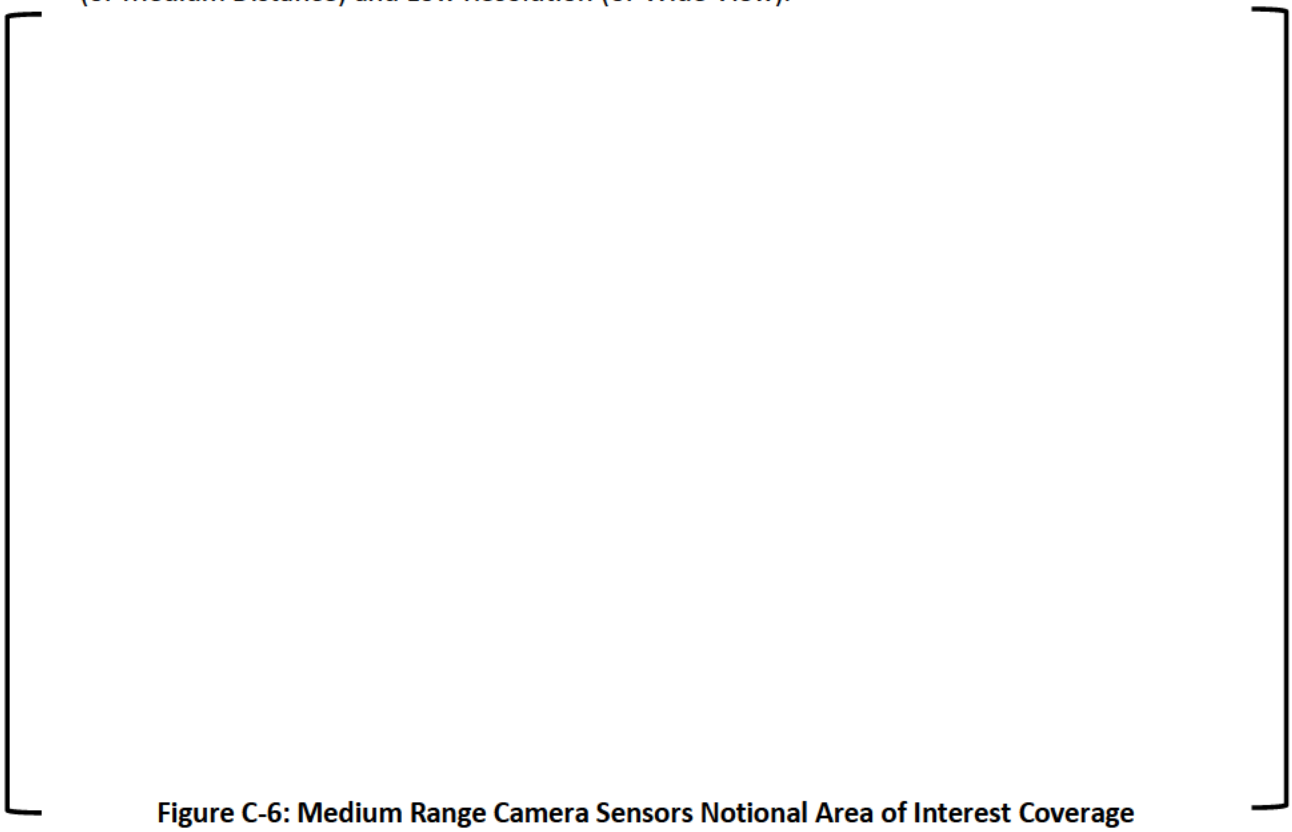

Figure C-6: Medium Range Camera Sensors Notional Area of Interest Coverage

There are seven (7) Medium Resolution Cameras installed on the Origin as illustrated below.

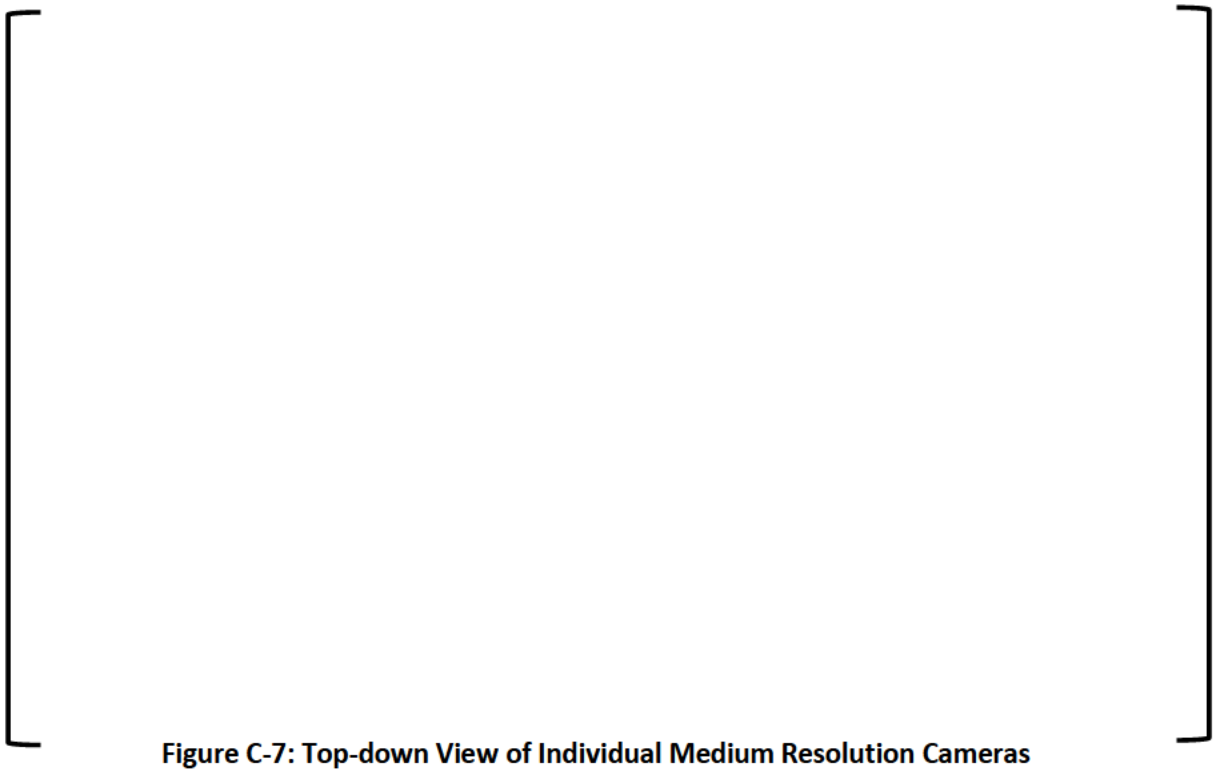

Figure C-7: Top-down View of Individual Medium Resolution Cameras

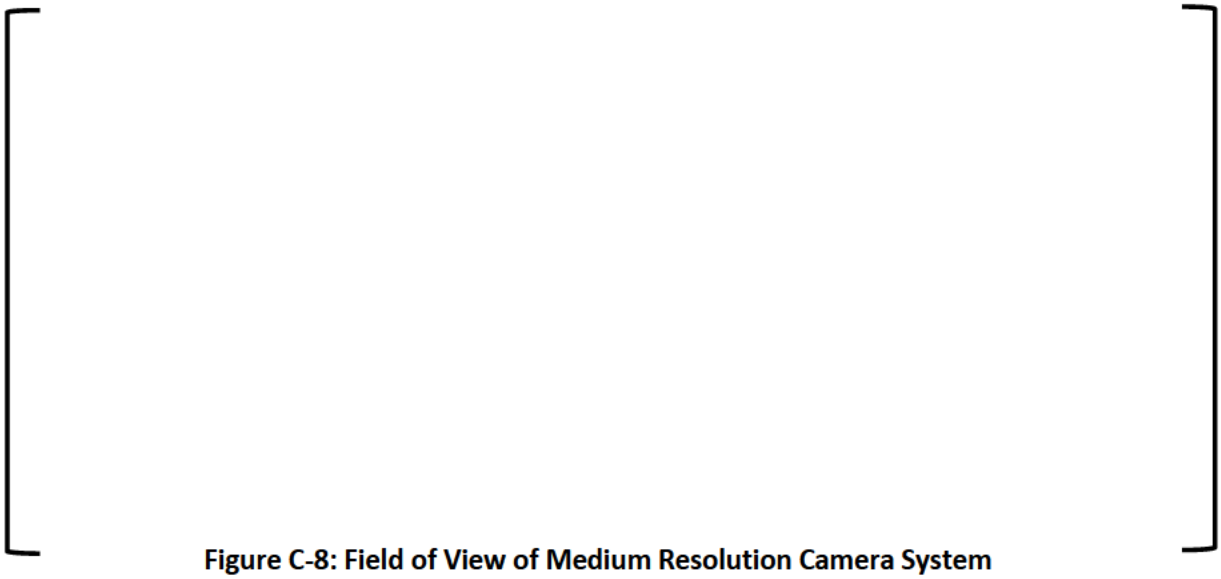

Figure C-8: Field of View of Medium Resolution Camera System

Low Resolution (or Wide View) Cameras provide sweeping visual fields of view and are supplementary to the Medium Resolution (or Medium Distance) Cameras described above. The front Low Resolution Camera is tilted up slightly to aid in detection of traffic lights positioned in higher-than-standard locations, whereas the rear-facing cameras provide additional blind-spot protection during maneuvers, such as lane changes with a vehicle approaching from the rear.

There are three (3) Low Resolution Cameras installed on the Origin as illustrated below.

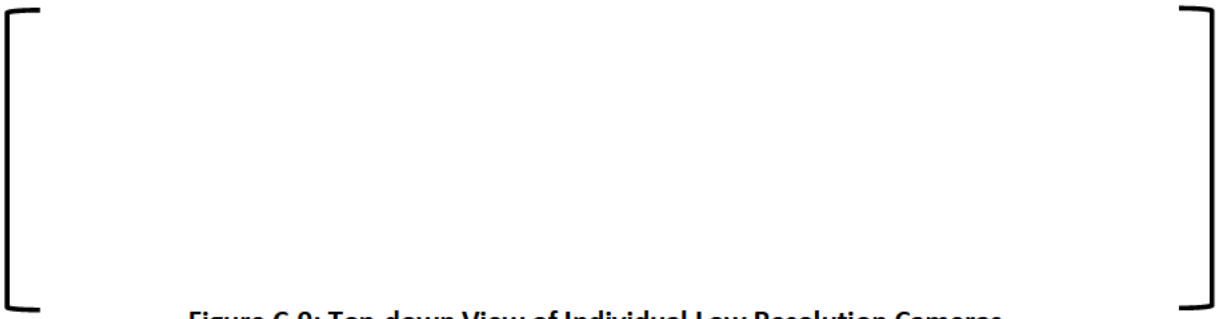

Figure C-9: Top-down View of Individual Low Resolution Cameras

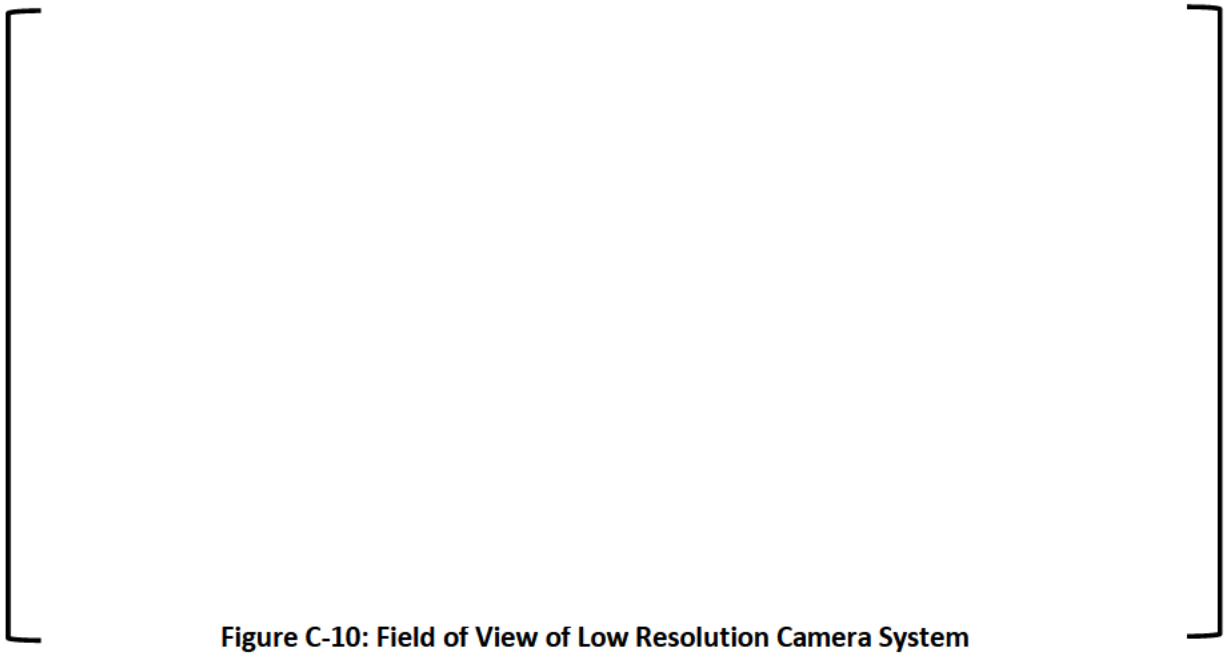

Figure C-10: Field of View of Low Resolution Camera System

c. Long Range Cameras

Long Range Cameras provide frontal coverage for various high-speed situations such as detecting an approaching vehicle during unprotected left turns or detecting debris or a pedestrian on the freeway. The Origin is configured with two variants of Long Range Cameras: Far Distance (High Resolution) Cameras and Infrared Thermal (Long Wave Infrared (LWIR)) Cameras.

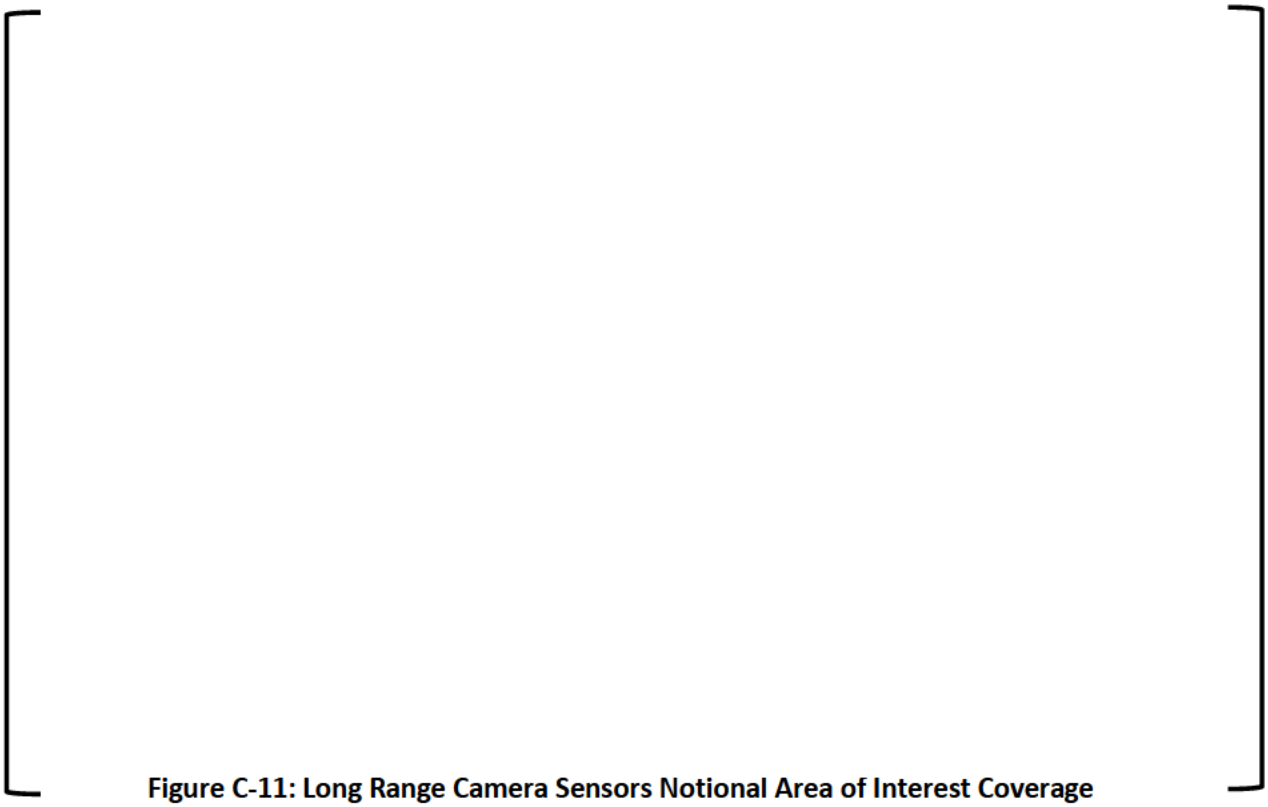

Figure C-11: Long Range Camera Sensors Notional Area of Interest Coverage

There are three (3) High Resolution Visible Cameras installed on the Origin as illustrated below.

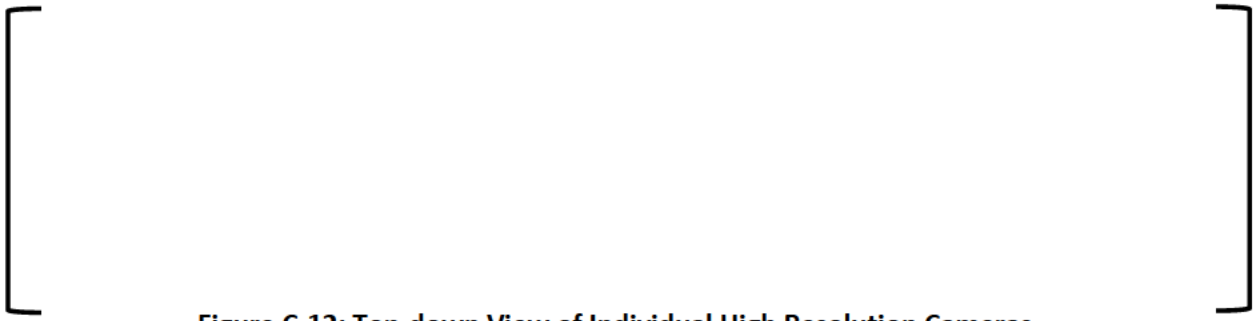

Figure C-12: Top-down View of Individual High Resolution Cameras

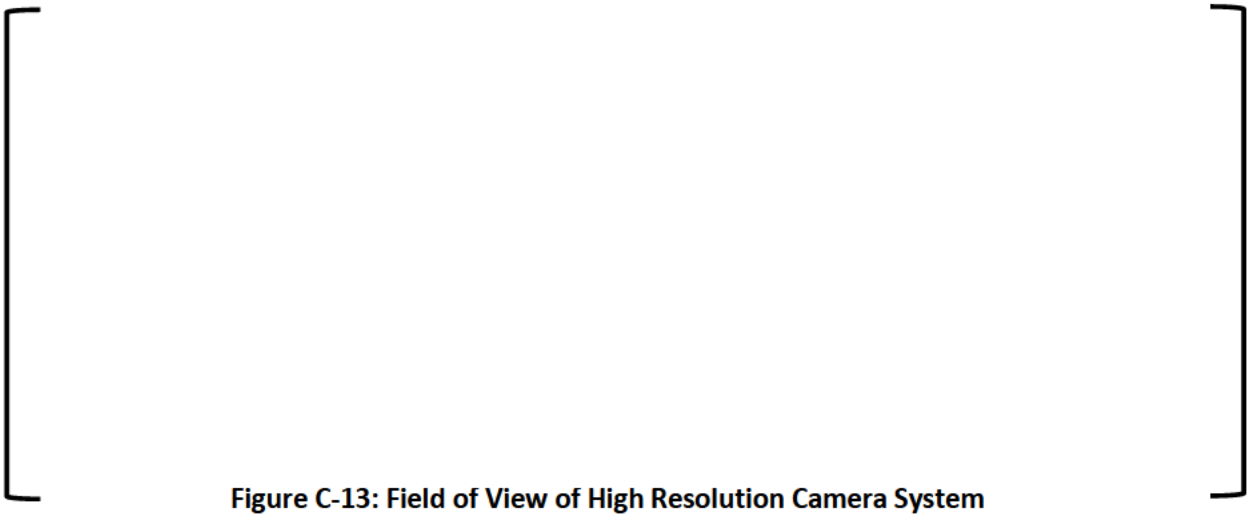

Figure C-13: Field of View of High Resolution Camera System

In particular, Thermal Cameras work well at night-time or other low-light conditions to detect objects that generate heat, such as pedestrians or animals, when the roadway lighting and/or headlights may not provide enough illumination for the visible cameras.

There are three (3) Thermal Cameras installed on the Origin as illustrated below.

Figure C-14: Top-down View of individual Thermal Cameras

d. Example Camera Views

GM conducted tests at its Milford Proving Grounds to verify the visual coverage achieved by its camera systems, and in particular to confirm that the fields of view provided by the Origin's rear-facing cameras meet the requirements of S6.2 and S6.1. Below are images captured at GM's Milford Proving Grounds from the Origin's various cameras.

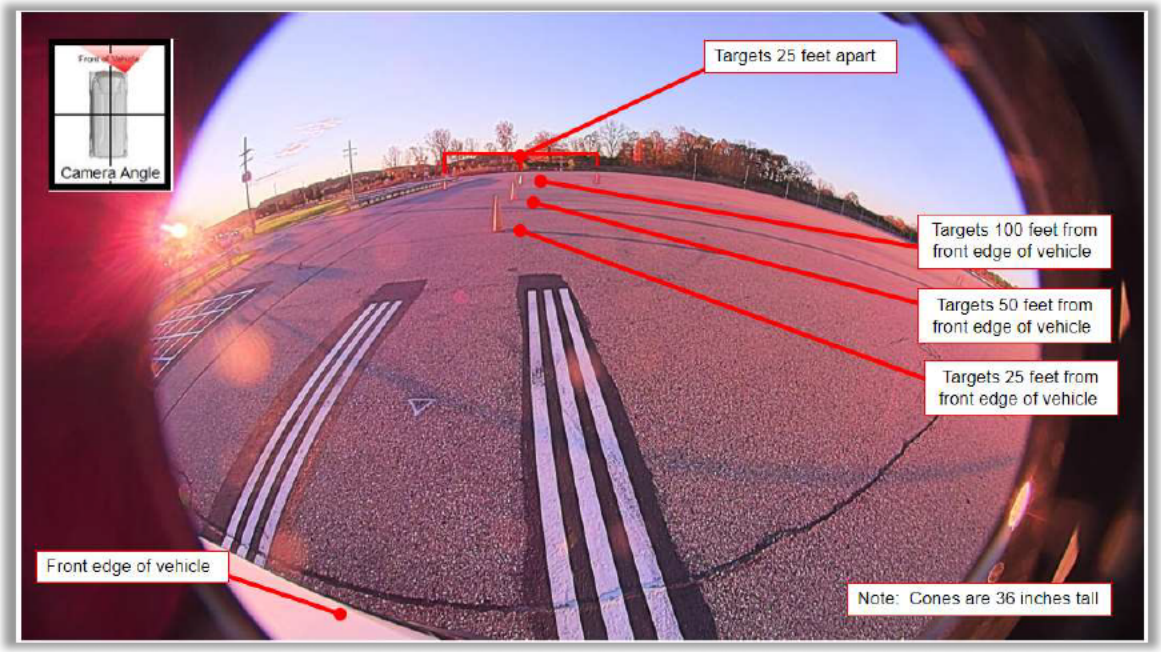

Figure C-15: Right/Front Side Surround View Camera Showing Forward Field of View

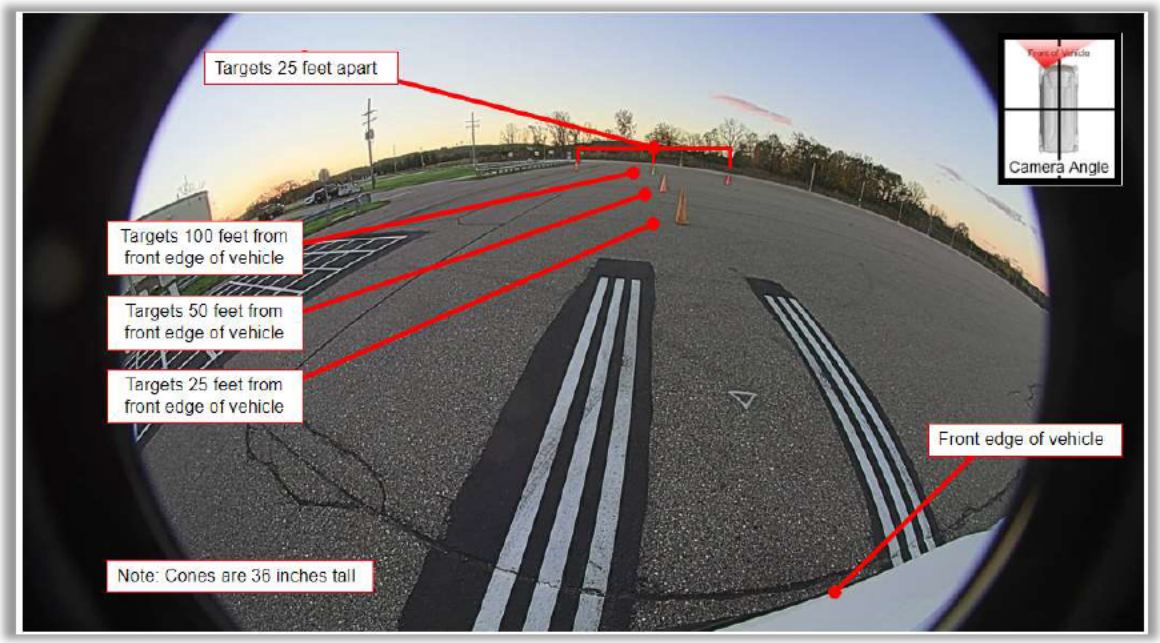

Figure C-16: Left/Front Side Surround View Camera Showing Forward Field of View

Figure C-17: Front Side Medium Resolution Camera Showing Forward Field of View

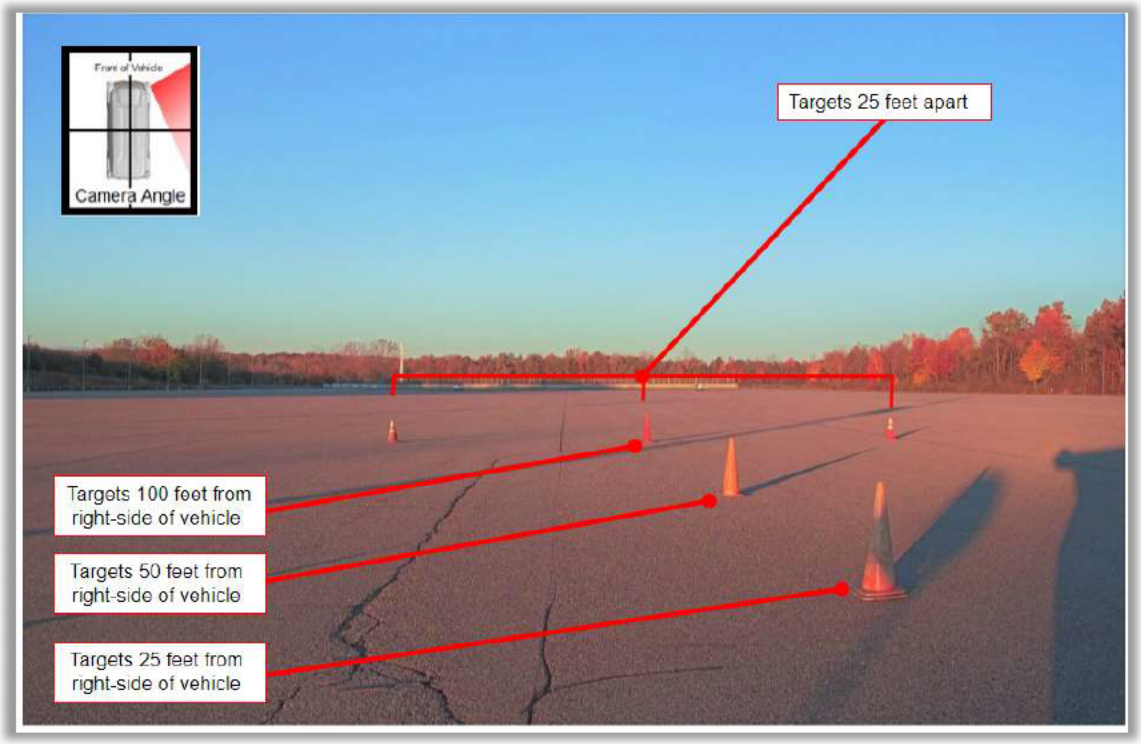

Figure C-18: Right Side Medium Resolution Camera Showing Right Side Field of View

Figure C-19: Left Side Medium Resolution Camera Showing Left Side Field of View

Figure C-20: Right Side Low Resolution Camera Showing Rear Right Side Field of View

Figure C-21: Left Side Low Resolution Camera Showing Rear Left Side Field of View

2. LiDAR

LiDAR sensors use an array of lasers to measure the distance between objects—down to the centimeter—to create a 3D visualization of the world. LiDAR helps the Origin determine its own position in the world relative to the 3D high fidelity, high definition map pre-loaded in the vehicle, as well as to reliably detect surrounding pedestrians, vehicles, and other objects. The Origin uses eight (8) near-field LiDAR sensors ("Time of Flight" or "TOF") that detect objects in close vicinity; and four (4) spinning primary LiDAR sensors that detect objects further from the vehicle.

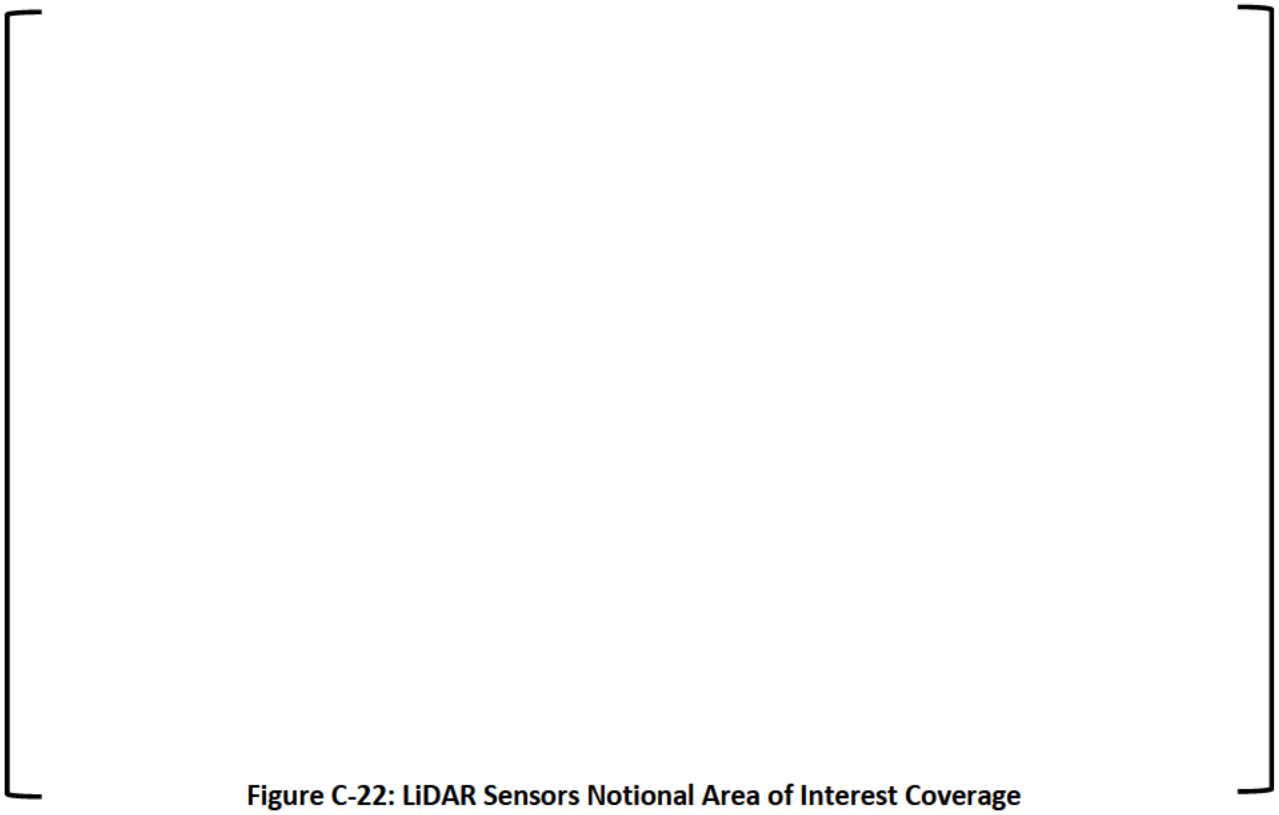

Figure C-22: LiDAR Sensors Notional Area of Interest Coverage

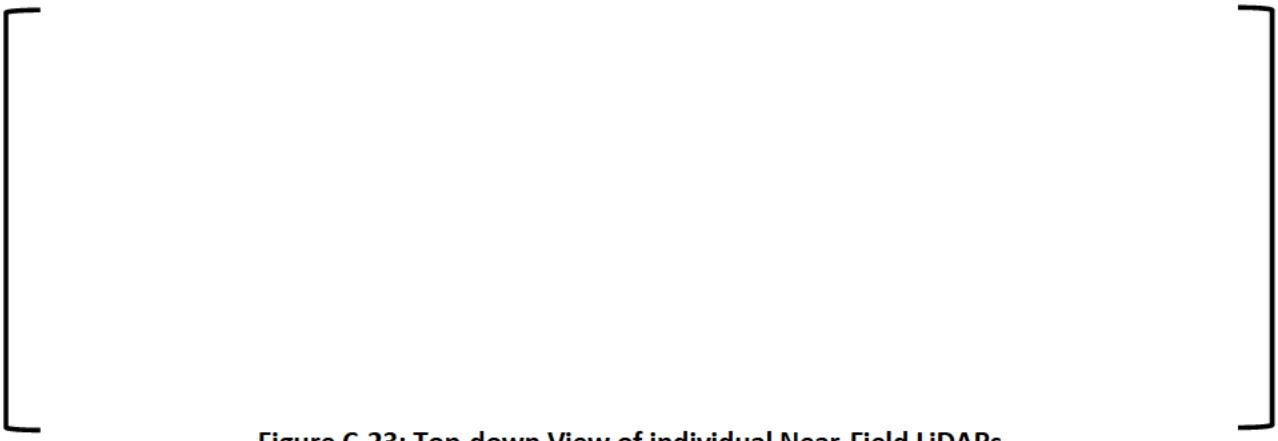

Figure C-23: Top-down View of individual Near-Field LiDARs

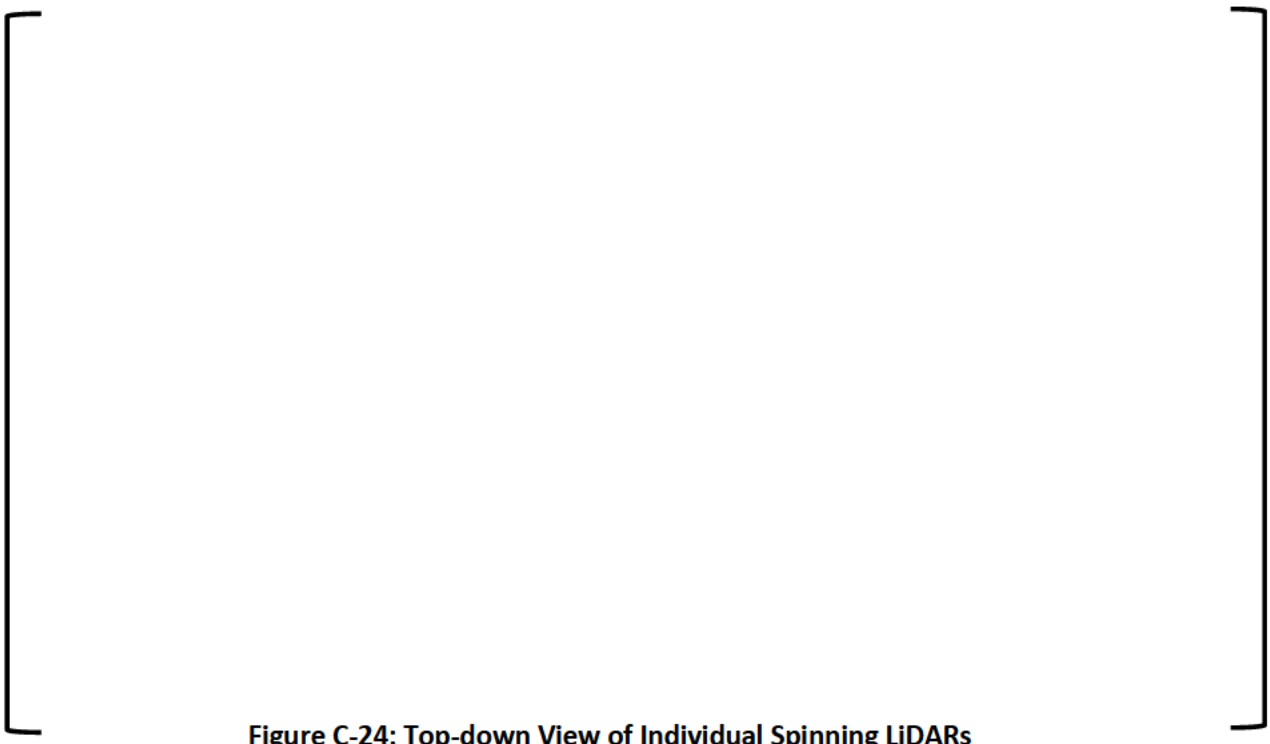

Figure C-24: Top-down View of Individual Spinning LiDARs

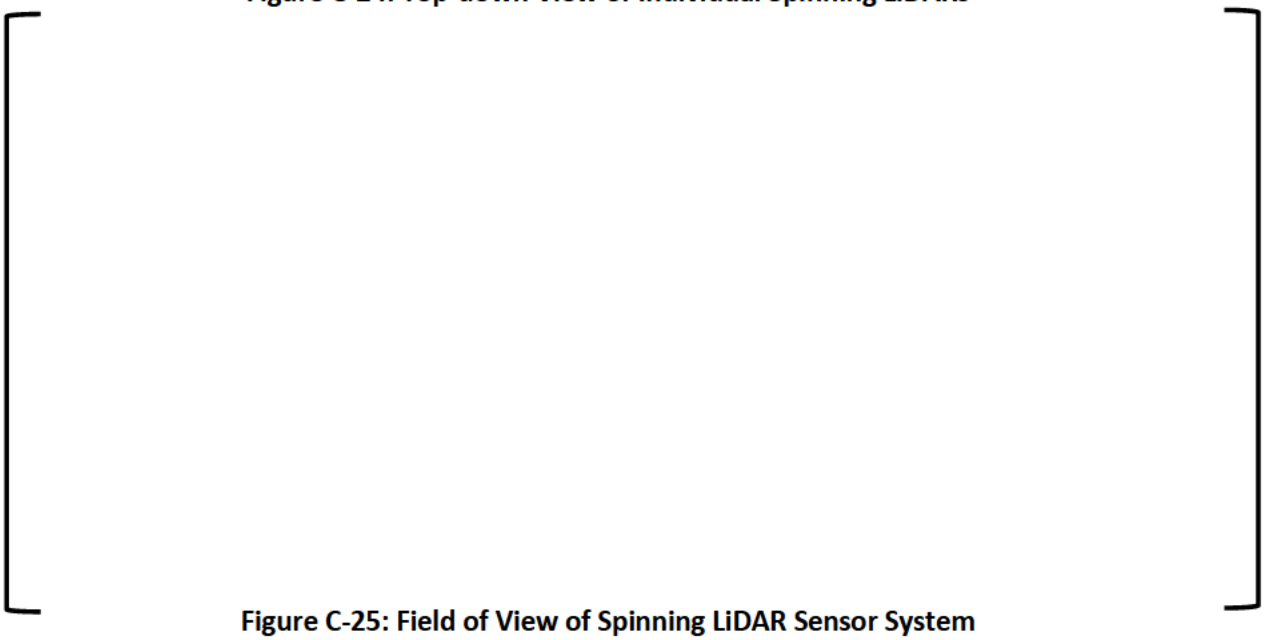

Figure C-25: Field of View of Spinning LiDAR Sensor System

3. Radar

Radar is a ranging sensor that emits radio waves to determine the radial distance, angle, and doppler (also known as range rate) of surrounding objects. This enables the Origin to not only detect objects at any given moment in time, but also project trajectories of those objects in the shared environment due to instantaneous velocity measurements.

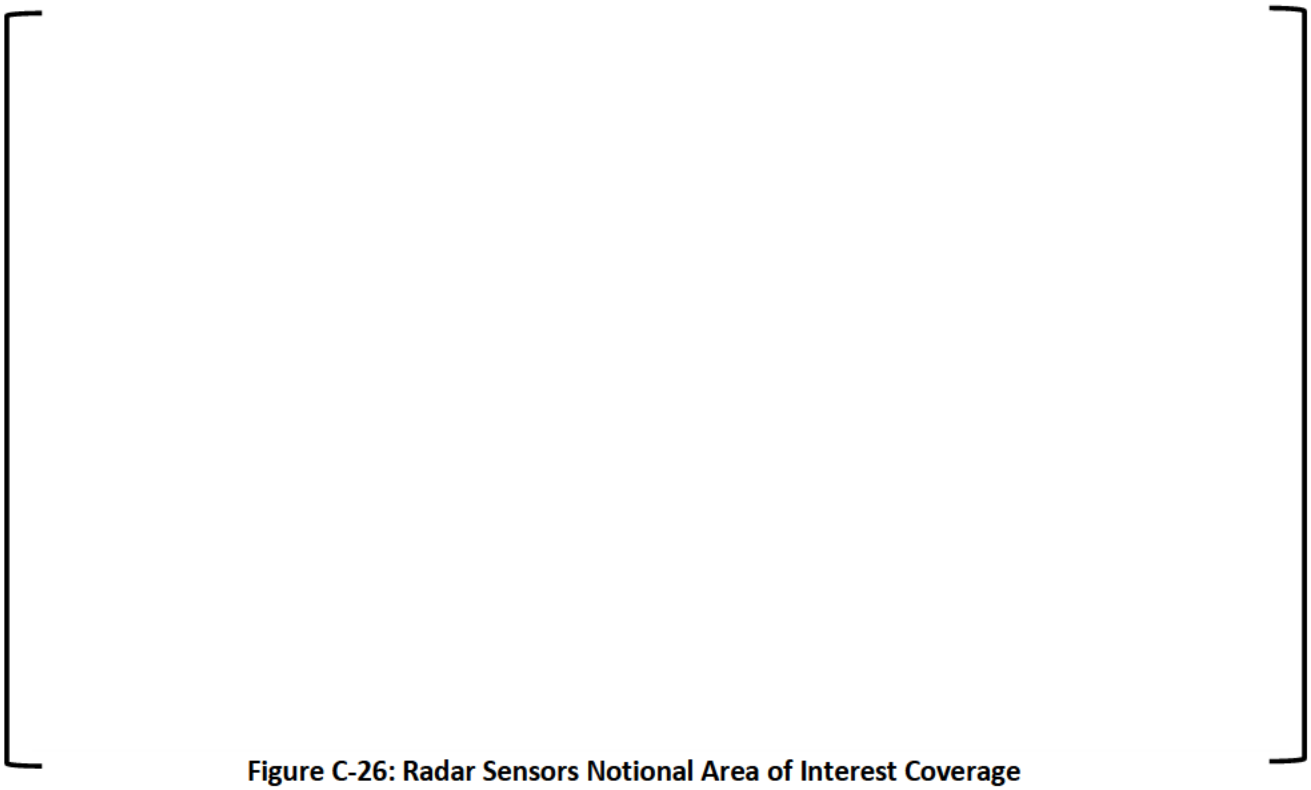

Figure C-26: Radar Sensors Notional Area of Interest Coverage

The position and coverage of the Origin's six (6) high-resolution radar sensors are illustrated below.

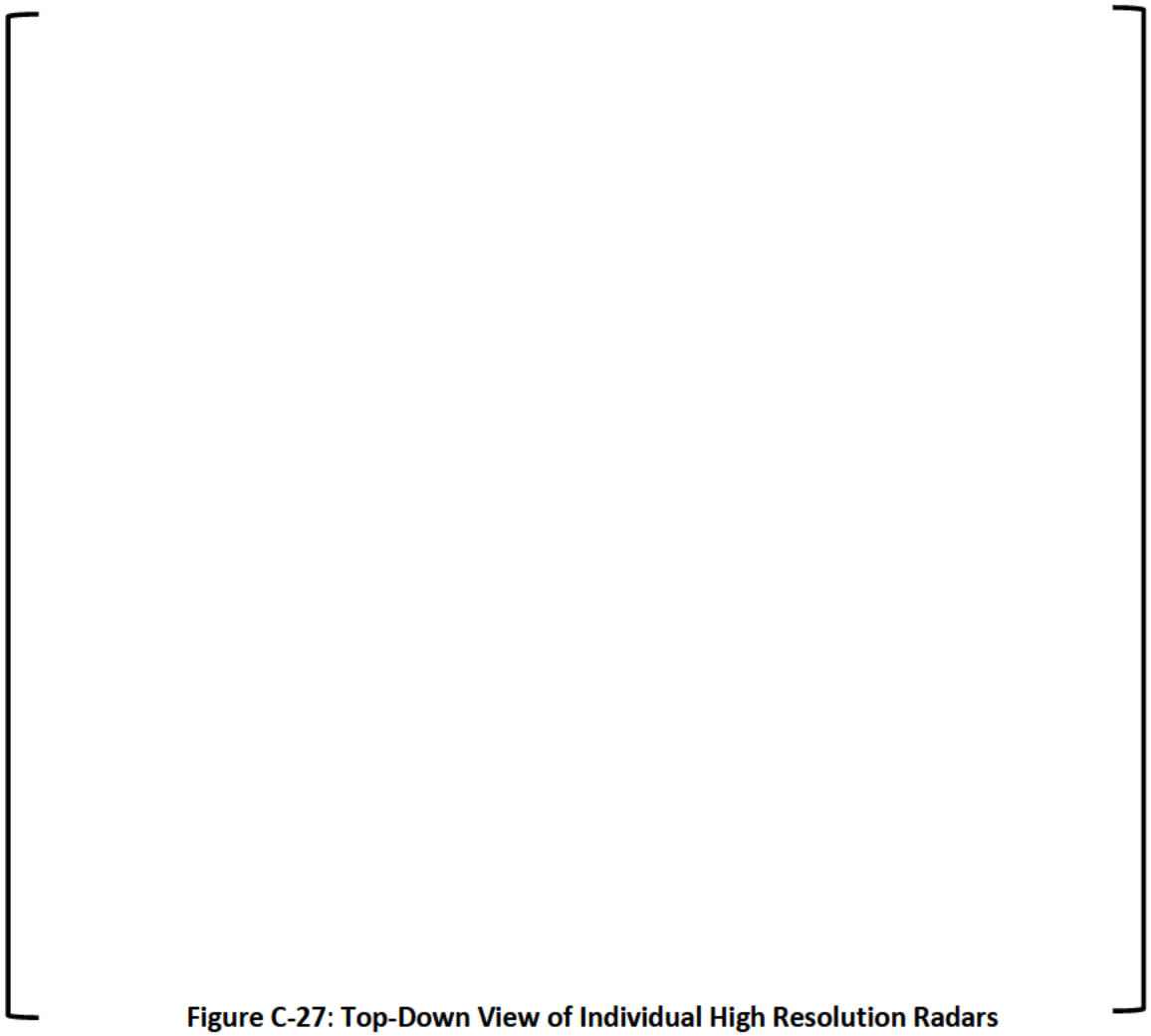

Figure C-27: Top-Down View of Individual High Resolution Radars

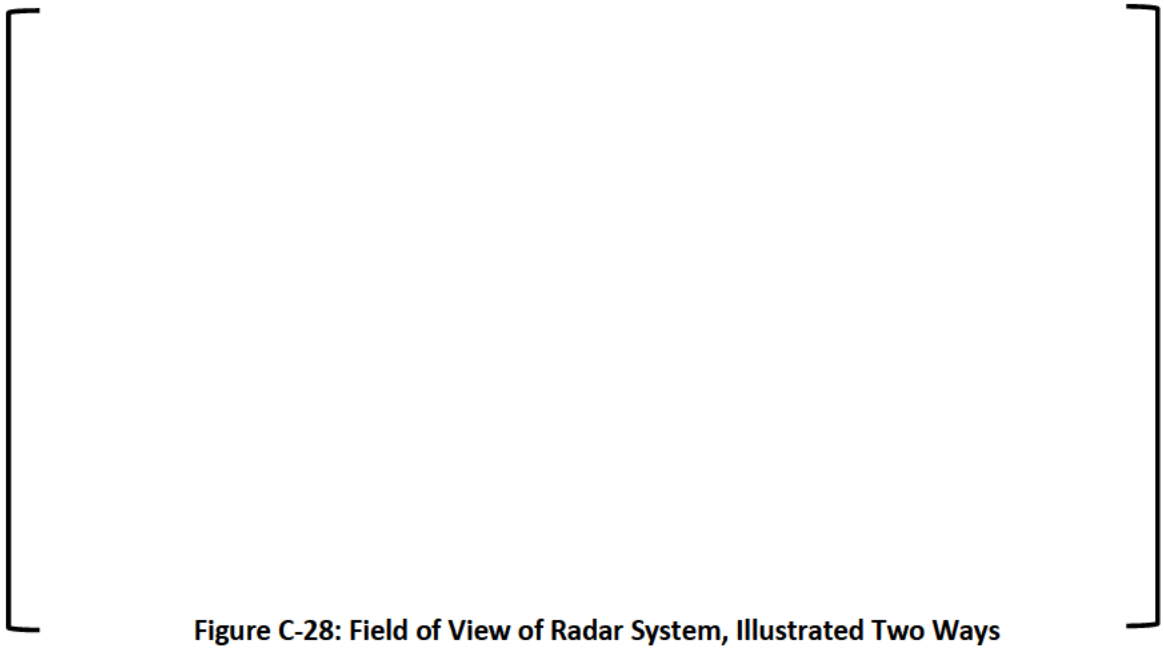

Figure C-28: Field of View of Radar System, Illustrated Two Ways

C. Other Sensors

In addition to Camera, LiDAR, and Radar sensors, the Origin features ultrasonics, microphones, and the touch and collision transducer ("TACT") as part of its multiple sensor modalities.

1. Ultrasonics

Ultrasonic sensors use inaudible sound waves to detect nearby objects all around the vehicle. Modern conventional vehicles use ultrasonic sensors to sense when the vehicle is approaching a nearby obstacle to assist human drivers with parking and other maneuvers. The Origin uses twenty-two (22) ultrasonic sensors, allowing the Origin to determine the proximity of nearby objects from all directions.

a. External Microphones

External microphones allow the Origin to listen for audio cues that may require dynamic driving responses, such as detecting an emergency vehicle by the sound of its siren—despite the emergency vehicle being obscured or otherwise out of line of sight. The Origin uses four (4) microphone arrays to provide localization of the sound sources and respond accordingly.

b. TACT (Touch and Collision Transducer)

Finally, the Origin has an advanced tactile sensing capability incorporated into the exterior of the vehicle that allows it to detect whether the vehicle has had physical contact, ranging from soft touch to heavy impact. The Origin uses its TACT detectors to detect touch events and respond dynamically as appropriate to the magnitude of the touch. Additionally, the Origin reaches out to a Remote Operator (described further in Appendix E) upon contact to review footage of the touch event and classify the event, and operational response, accordingly.

D. Sensor Data

Technical specifications for each of the sensors used in the Origin, including resolution, sensor frequency, scene revisit interval and overall latency, are provided below.

Table C-1 provides exemplary detection distances for the infrared, radar, LiDAR, and camera sensors used by the Origin. From sensor simulation data, the estimated performance of the Origin sensors is shown below. The objects' approximate sizes (in height and width) cover a wide variation of sizes. The larger objects can be detected by multiple arrays at distances greater than 200 m (up to almost 400 m), and the smallest objects can be detected by certain sensors at distances greater than 100 m.

[ ]

[

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Table C-1: Origin Sensor Arrays - Estimated Detection Distances

Appendix D
Cooperation with State and Local Authorities on Operational & Customer Safety

Safety is the cornerstone of GM and Cruise's approach to product development—from vehicle design and function to operational systems and protocols, to customer support, service reliability, and law enforcement interactions. Alongside our ongoing dialogue with NHTSA on vehicle safety—including the specific exemptions sought for the Origin in this Petition—Cruise works hand-in-hand with regulators in every jurisdiction in which it operates, including a Native American tribal nation in Arizona, to ensure adherence to all regulatory, operational and passenger safety requirements.

Cruise currently operates its AV fleet in California and Arizona. In both jurisdictions, Cruise engages regularly with the regulatory bodies that oversee operational and passenger safety requirements for autonomous vehicles. The processes in place, established through statute, rulemaking and/or Executive Order, ensure the states and/or tribal authorities can thoroughly assess Cruise's approach to operational and passenger safety.

Cruise is proud to have been granted the following testing and deployment permits in our states of operation:

California			
California Department of Motor Vehicles (DMV)			
Name	Authorization	Date of Receipt	Notes
DMV Drivered Test Permit	Allows Cruise to test AVs with a human safety driver behind the wheel	June 2015	This permit requires Cruise to attest that its AVs have been tested under controlled conditions that simulated its ODD as closely as practicable and that all test drivers completed a training program.
DMV Driverless Test Permit	Allows Cruise to test AVs without a human safety driver behind the wheel	October 2020	Cruise is one of seven companies to have received this permit and the only company in California to receive this permit for a complex urban environment. This permit requires Cruise to submit a law enforcement interaction plan and attest that its AVs met the description of a level 4 or level 5 automated driving system under SAE International's Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles, standard J3016 (SEP2016).

DMV Deployment Permit	Allows Cruise to charge fare for transport of goods and people in an AV (drivered or driverless)	September 2021	Cruise is one of three companies to receive this permit and is the only company in California to receive this permit for driverless operations of a rideshare service. This permit requires Cruise to attest that its AVs can detect and respond to roadway situations in compliance with all provisions of the California Vehicle Code and local regulations. This required Cruise to attest that it had conducted test and validation methods and was satisfied that its AVs were safe for deployment on public roads in California.
California Public Utilities Commission (CPUC)			
Name	Authorization	Date of Receipt	Notes
CPUC Drivered Test Permit	Allows Cruise to transport members of the public in an AV with a human safety driver behind the wheel	February 2020	Cruise is one of nine companies in California to have received a CPUC Drivered Test Permit. This permit requires Cruise to comply with all applicable State and Federal regulations as it relates to AVs and passenger transport.
CPUC Driverless Test Permit	Allows Cruise to transport members of the public in a driverless AV, without fares	June 2021	Cruise is the only company in California to receive a CPUC Driverless Test Permit. This permit requires Cruise to comply with all applicable State and Federal regulations as it relates to AVs and passenger transport.
CPUC Driverless Deployment Permit	Allows Cruise to transport members of the public in driverless AV, with fares	Applied for on November 5, 2021	As of this submission, Cruise is the only company in California to apply for a CPUC Driverless Deployment Permit. Permit requires Cruise to comply with all applicable State and Federal regulations as it relates to AVs and passenger transport.
Arizona			
Arizona Department of Transport (ADOT)			
Name	Authorization	Date of Receipt	Notes

ADOT Drivered Permit	Allows Cruise to transport goods and provide fared service to members of the public in a drivered AV	May 2019	Cruise is currently using its ADOT Drivered Permit to operate a delivery partnership with Walmart. This permit requires Cruise to certify that its vehicle is capable of complying with all applicable traffic and motor vehicle safety laws and regulations of the State of Arizona. Cruise is planning to secure a driverless permit in 2022.
Salt River Pima-Maricopa Indian Community (SRPMIC)			
Name	Authorization	Date of Receipt	Notes
SRPMIC Special Use Permit	Allows Cruise to transport goods in the SRPMIC part of the company's partnership with Walmart	May 2021 (original) February 2022 (renewal)	The SRPMIC Tribal Government currently has established an annual permitting cadence and is working to develop a permanent permitting process for AV service and the Origin within its territory.

Table D-1

Cruise has submitted the above permits to NHTSA through the AV TEST portal.

Additionally, Cruise has engaged with local and state law enforcement authorities in each state and locality in which Cruise operates its AV fleet. In addition to informative meetings and interactive, hands-on sessions with the Cruise AV, Cruise has drafted and made available on its public website its Law Enforcement Interaction Plan ("LEIP") to assist law enforcement personnel to interact with the Cruise AV.[140] A further example of the company's desire to ensure law enforcement personnel are comfortable with Cruise's operation, Cruise prepared a video on how to interact with the Cruise AV, which even demonstrates how to cut into the vehicle in extreme circumstances.[141] Cruise is in the process of updating its LEIP for the Origin, and will continue to work with law enforcement in each jurisdiction where it operates to ensure that law enforcement understands how to interact with the Origin.

[140] *See* Driverless Deployment Program Guidance for First Responders (updated Oct. 2021), *at* https://www.getcruise.com/firstresponders. The full Law Enforcement Interaction Plan can be accessed at https://www.getcruise.com/leip.

[141] *See* Cruise, *Interacting with a Cruise Autonomous Vehicle: A Guide for First Responders* (Nov. 19, 2021), https://www.youtube.com/watch?v=ZM3kfauMgZY.

Appendix E
The Origin's ODD

A. Operational Design Domain ("ODD")

Table E-1 describes the initial intended operational design domain of the Origin. This intended ODD represents an incremental approach to deployment, which GM and Cruise believe firmly promotes bringing the benefits of this technology to the public in a responsible manner. Cruise and GM will continue to prioritize safety and responsibility as the Origin's ODD is updated and expanded over time, and will ensure that NHTSA, and all other relevant local, State, and Federal regulators and stakeholders are informed of such updates and expansions.

ODD Element	Description
Level of Automation	The Origin meets the description of a Level 4 automated driving system under SAE International's Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles, standard J3016 (SEPT2016). The Origin's ADS is designed to perform the entire dynamic driving task within a defined operational design domain and has the capability to achieve a minimal risk condition without any expectation that a human driver will intervene.
Geographic Area	The Origin will operate in areas where its ADS has been tested and validated, which currently includes portions of San Francisco and the Phoenix metropolitan area at the time of submission.
Roadway Type	The intended operational design domain will include highways, local and arterial roads and will exclude steep hills, bridges, tunnels, overpasses, and roundabouts.
Speed Range	The Origin is capable of speeds up to 80 miles per hour.
Weather Conditions	The intended operational design domain will exclude the following weather conditions: -Heavy Fog -Heavy Rain -Heavy Smoke -Hail -Sleet -Snow
Time of Day	The Origin will operate during all times of day and night.

Table E-1: Initial Intended Operational Design Domain

Appendix F
Cruise Back Office, Live Customer Support, and Risk Mitigation

The Cruise Back Office is composed of a combination of human and automated systems that provide support to the Origin and passengers as needed. As detailed below, the Cruise Back Office includes human personnel, such as the Cruise Customer Support team, Cruise Remote Assistance team, and OnStar Emergency Assistance. Automated tools include, but are not limited to, the Origin's Automatic Crash Response system and tools that identify vehicle health issues. The Cruise Back Office actively monitors the Origin fleet and leverages risk mitigation tools to take fleetwide action if necessary.

A. Centralized Fleet Management

1. 24/7 Fleet Monitoring

Multiple systems and teams work in tandem to provide 24/7 monitoring of the Origin fleet. As an example, a 24/7 team within Cruise monitors fleet health and triages any issues while vehicles are in operation. This team works hand-in-hand with Remote Assistance to provide technical expertise in real time and can stop a vehicle and remove it from the road in the event of an AV health issue requiring deeper investigation. Cruise has automated systems, with human oversight, for vehicle dispatch and routing—similar to a traffic control center—and those systems can receive information from the field about roadway closures, and can prevent fleet routing until the closure is cleared. These systems also involve human review and input for decisions, as needed. For example, Cruise personnel may investigate and confirm that a road should be avoided by the Origin fleet for a specific period of time, e.g., in response to a demonstration that is blocking a roadway.

2. Operational Risk Reduction

If a high risk event is identified by Cruise's 24/7 fleet monitoring or safety reporting processes, Cruise has procedures in place to rapidly address the risks through the Cruise operational teams. In the most extreme cases, a safety issue could call for Cruise's Remote Assistance teams to immediately pullover and halt a specific Origin, a subset of the Origin fleet, or the entire Origin fleet in the field, relative to the level of risk perceived. Cruise personnel would then retrieve the Origin(s) manually. When there is a risk that is specific to a block or area, such as a local emergency or large building fire, Cruise's round-the-clock fleet monitoring team can restrict the Origin fleet from that geographic area within minutes. This enables Cruise to take swift fleet-wide action to avoid local emergency areas after even a single Origin has reported the issue. Cruise also uses this feature to proactively optimize the safety of Origin rides by optimized routing to limit or prevent travel through areas of the city where data shows higher risk corridors that are more likely to have incidents or collisions.

B. Emergency Preparedness and Incident Response

1. Crisis Management and Preparedness Exercises

With Cruise's Crisis Management Team ("CMT"), Cruise has established cross-functional capability to rapidly respond to events that may impact safe operation of the Origin fleet. CMT's guiding principles are to keep people and assets safe, create predictable,

sustainable processes, make efficient, well-informed decisions, and effectively communicate with relevant stakeholders. CMT mobilization is tailored based on the nature of the situation but can include representatives from both GM and Cruise Safety, Security, Engineering, Operations, Legal, Government Affairs, Communications, People, and other teams. To date, this capability has been used to coordinate response to COVID-19, civil unrest, wildfires, and other contingency situations. As visualized below, Cruise has adopted a defined process to identify, mobilize and respond to unforeseen crises.

Figure F-1: Crisis Management Team Process[142]

Cruise also conducts regular preparedness exercises for test readiness to respond to safety-related incidents. These exercises range from "tabletop" discussions in which key responders walk through a response to hypothetical crisis situations to full-scale exercises designed to simulate a real event as closely as possible. These exercises help promote not only the completeness of these procedures but also Cruise's readiness to exercise them in the event of a safety-related incident.

2. First Responder Interaction and Response

GM and Cruise's joint goal is to develop AVs that improve road safety, and we are committed to doing so in a way that supports the crucial work of public safety officials. Cruise has conducted multiple training sessions with first responders to provide them with the information they need to safely identify and interact with the Cruise AV, and Cruise will do the same for the Origin. Based on these interactions, Cruise developed a Law Enforcement Interaction Plan ("LEIP") that is designed to equip public safety officials with the information they need to safely interact with the Cruise AV and the Origin in multiple scenarios. The LEIP includes information about National Fire Protection Association ("NFPA") standards for appropriately interacting with the vehicle battery, if needed.

Each Origin is also equipped with a two-way audio communications link inside the vehicle that provides 24/7 OnStar functionality and can be used to directly connect with the appropriate remote team member depending on the situation. In the event of an incident or medical emergency, OnStar Emergency Advisors work with Cruise Customer Support to provide 24/7 support for passengers and coordinate with first responders as necessary.

[142] "SLT" in Figure F-1 refers to Cruise's Senior Leadership Team.

C. Support for Cruise Passengers

Currently, there are four teams at Cruise and GM tasked with direct communication with passengers: Cruise Remote Assistance, Cruise Customer Support, Cruise Field Support, and General Motors OnStar Emergency Assistance. Each team is described below, followed by a description of protocols in place to respond to passenger emergencies.

1. Remote Assistance

The Origin will leverage Cruise Remote Assistance Advisors to provide an additional layer of safety and passenger support for on-road operation. If a passenger needs action from a Remote Assistance Advisor, the passenger connects with Customer Support, and Customer Support communicates with Remote Assistance as needed. Remote Assistance Advisors have access to an interface to monitor video feeds from the Origin's external-facing cameras and the Origin's situational awareness data. If the Origin is unable to navigate the environment independently due to unforeseen circumstances, Cruise's Remote Assistance team can assist the Origin in determining how best to proceed: for example, by confirming the Origin's classification of an object, or by confirming that the Origin's intended path is not obstructed. Remote Assistance, however, does not remotely drive the vehicle and is not responsible for performing the dynamic driving task.

Remote Assistance Advisors receive extensive training, and must pass certification exams before beginning to support AVs on public roads. They are shadowed by experienced Remote Assistance Advisors until they have achieved the minimum number of successful sessions to let them safely assist AVs without being shadowed. Throughout their work as a Remote Assistance Advisor, sessions continue to be audited by their peers and expert auditors on an ongoing basis, and they receive weekly coaching to support their continuous skill development.

2. Customer Support

The Cruise Customer Support team handles all communications with passengers . Customer Support can be accessed within the Origin during the ride, in-app, or by phone or email. Customer Support has visibility into the state of the AV and is able to assist passengers with an array of questions, ranging from providing verbal way-finding cues to assist the passenger in locating the Origin to a request to change the destination for a ride. Customer Support can help passengers understand details about their Cruise account. Customer Support can also communicate with third parties, such as law enforcement, during emergency situations.

3. Field Support

Cruise Field Support serves as the on-scene response unit to provide direct, in-person support to passengers or to interact with third parties and public safety officials when necessary.

4. OnStar Emergency Assistance

OnStar Emergency Advisors work with the Cruise Customer Support team to provide 24/7 support for passengers and coordinate with first responders as necessary. In addition,

OnStar functionality includes Automatic Crash Response for low or high-speed collisions. Should a significant collision occur, OnStar Automatic Crash Response will automatically initiate contact with a trained OnStar Emergency Advisor and Cruise Customer Support to notify 9-1-1 dispatch and send our Field Support without needing passenger initiation.

Passengers can initiate a voice call to Customer Support using conveniently located buttons in the front and rear of the cabin, which are lighted for ease of use at day and night, and are intended to be easily accessible to all passengers, including those with disabilities.

Additionally, passengers can access voice support buttons within their mobile app, even while inside the cabin. If a passenger experiences an emergency in the cabin and reaches out or requests emergency support via the mobile app, Customer Support will immediately provide support. If a passenger presses the "Stop Ride" button in the vehicle compartment, the Origin will pull over at the nearest safe location available. Once the Origin has pulled over, the passenger will receive a message that the ride is over and the passenger can exit.

Figure F-2 below illustrates various forms of support available to our passengers. All teams that support passenger safety undergo rigorous, specialized training and continued education for their specific functions.

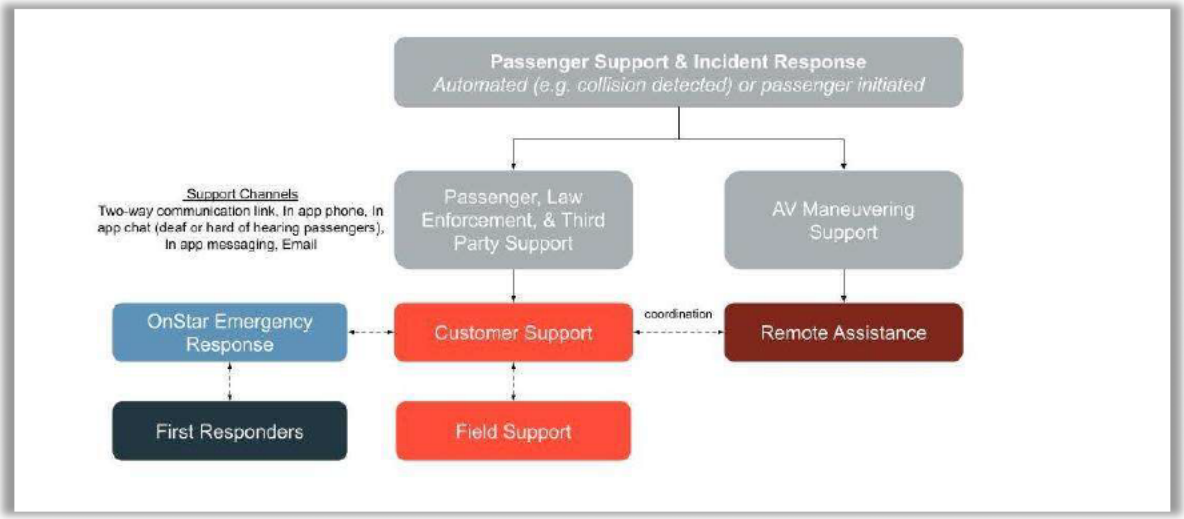

Figure F-2: Passenger Support Options

5. Passenger Emergencies

During an emergency, passengers in an Origin can initiate phone calls through buttons in the vehicle, or through their mobile app, to receive assistance. In the event a collision occurs, Cruise is prepared to address it. The Origin uses a fused hardware and software approach to reliably detect collisions and any contact with the exterior of the vehicle. Upon detecting a collision, the Origin initiates the appropriate dynamic driving task fallback maneuver and achieves a minimal risk condition. If a vehicle collision occurs, Customer Support will automatically receive a collision notification and initiate a support call into the vehicle to check on the passengers. The collision notification also triggers a

request for Field Support. As detailed previously, the Origin is also equipped with an Automatic Crash Response system that automatically alerts Customer Support that a low or high-speed collision has occurred. They are trained to immediately notify 9-1-1 dispatch and our Field Support team, all without passenger initiation.

After arriving at the scene of the collision, Cruise's Field Support team communicates with the passengers and exchanges information with any relevant third parties and with law enforcement. Cruise Field Support personnel also document the scene and condition of the involved vehicles and facilitate recovery of the Origin. Back at headquarters, Cruise engineers analyze the collision by reviewing incident data from the ADS and work to identify the causal factors. Their analysis informs any fleet modification decision and drives engineering work meant to prevent the occurrence of similar collisions in the future.

If a passenger is able to initiate a call and then is unresponsive (e.g., they are unable to speak due to choking or facing a physical danger), Cruise can initiate an in-cabin camera stream to determine if the passenger is unconscious or undergoing another type of emergency and, as needed, escalate to an emergency responder on-scene support. In the event a car door does not open as expected at the end of a trip, Cruise will also receive notifications and can initiate a similar wellness check using an interior camera stream. Cruise will provide clear advance notice of such streaming to passengers prior to the start of a ride.

Appendix G
System Redundancy and Minimal Risk (Fallback) Capabilities

A. System Diversity and Redundancy

GM and Cruise have designed and built the Origin with redundancy and cross sensor coverage for all critical systems—from the computer systems, to the brakes, to the LiDAR array, and to system power—to enable the Origin to retain sufficient safety performance in the event of single-point hardware or software failures or plausible multi-point failures. This design employs established safety design principles from the automotive sector, as well as a fully independent diagnostics system for vehicle health under any condition. The Origin is equipped with the following redundant systems:

- **Self-Driving Computer**
    - The Origin has two main computer systems operating simultaneously. If the primary computer has a problem, the secondary system will take over.
- **Signal Communications**
    - Communications between computers, sensors and actuators have an alternate path if the primary path fails.
- **Sensors**
    - Sensor diversity provides confidence that the ADS can detect, track, and classify objects around it. Field of view overlaps enable 360-degree vision even if a sensor fails.
- **Redundant Collision Avoidance System**
    - The Origin includes a collision-imminent braking system calibrated to work as a backup to the ADS that can apply the brakes to stop the car if necessary.
- **Vehicle Localization**
    - The Origin's location is estimated by many different methods, which means that even if the localization information from one system becomes unavailable, the vehicle can use localization information generated by other sources, such as LiDAR data or from the Origin's inertial tracking system.
- **Electrical Power**
    - The Origin has redundant electrical power sources and power distribution for all important systems. Main power is provided through the high voltage electric vehicle battery. Should power from that battery fail, backup batteries will power all critical sensors, computers, and actuators.
- **Steering and Braking**
    - The Origin's steering and braking systems have redundant motor actuators, electrical power, and computer electronics so the vehicle can respond appropriately and keep performing during a failure.

- **Integrated Vehicle Health Monitor**
    - The Origin is equipped with an Integrated Vehicle Health Monitor, which keeps track of all the Origin's diagnostics and determines the operating state of the vehicle.

B. Diagnostic Coverage and Fault Detection for Functional Safety

The Origin is equipped with a comprehensive set of internal diagnostics which can detect malfunctions within both the base vehicle hardware and software and within the AV systems. The Origin's diagnostic system continuously monitors the state of all critical AV systems (including the ADS) as well as other vehicle systems necessary for safe operation. Most diagnostics run at a rate of 100 Hz, whereas diagnostics within safety critical systems like steering and braking run much faster at 1000 Hz.

As mentioned above, the Origin has two primary self-driving computers—one primary and one backup. Each set of computers has its own diagnostics, providing the ability for each computer to diagnose other computers and other parts of the ADS.

If there is a fault in the vehicle, these vehicle health monitoring systems determine the safest course of action to mitigate any potential risk—e.g., switch to a backup system or take other actions, such as maneuvering the vehicle to achieve a minimal risk condition ("MRC").[143] In the event of an issue, the Origin is designed to reach an MRC, and what the Origin does to reach that MRC depends on how serious the issue is and the urgency of the response.

The Origin is designed to respond to fault conditions according to a hierarchy appropriate for the specific condition, according to a vehicle health level or "degraded state." Higher numbers for a degraded state represent less residual AV performance, but the highest level of availability and integrity (i.e., a Degraded State 1 has the highest AV capability remaining, while a Degraded State ("DS") 5 has the lowest AV capability remaining). GM and Cruise have reserved the highest degraded states (i.e., DS 4 and 5) for rare, multipoint failures or failures in high integrity, high reliability systems. The degraded state levels and the Origin's response to them are summarized in the table below.

Degrade State Level	Fault Description and the Origin's Response
Degraded State 1	The Origin has a benign latent malfunction alerting the need for service and maintenance attention. The AV maintains full capability to perform the dynamic driving task ("DDT") and dynamic driving task fallback ("DDT-F"). The malfunction does not lead to a hazard, so normal vehicle use until the end of the day (or until the next vehicle power cycle) is expected.

[143] These areas can span any number of functions that are safety critical and therefore need a form of detection and diagnostic for degraded state functionality. These could include both sensor systems (such as LiDAR, radar, or cameras), or other systems within the AV's prediction, perception, planning, and control functions. A functional example would be a LiDAR diagnostic that detects a corruption in data processing, leading to a degraded state.

Degrade State Level	Fault Description and the Origin's Response
	The Origin may continue all on-road operations for the remainder of that Origin's shift.
Degraded State 2	The Origin has a tolerated malfunction in a safety system and maintains the capability to perform the DDT and DDT-F and return to the fleet service facility for repair. The Origin is capable of completing the current mission by falling back to stricter driving constraints or limitations as needed, to help maintain an acceptable level of risk until the AV returns to the fleet service facility and the failure is resolved. The Origin is recovered by the Field Support team at the fleet service facility for repair. No new fleet operation missions will be assigned to the Origin in this state.
Degraded State 3	The Origin has a malfunction in a system that results in degraded vehicle performance risking the capability to perform the DDT or DDT-F. The Origin is capable of pulling over to a safe location at the side of the road, followed by engaging Park state and activating hazard flashers. The Origin is retrieved by the Field Support team to the fleet service facility for repair. No new fleet operation missions will be assigned to the Origin in this state.
Degraded State 4	The Origin has partial loss of primary ADS functionality, requiring fallback to the secondary ADS to perform the DDT-F The Origin is capable of gradually slowing to a stop while steering to a safe location out of high-risk areas such as intersections, followed by engaging Park state and activating hazard flashers. The Origin is retrieved by the Field Support team to the fleet service facility for repair. No new fleet operation missions will be assigned to the Origin in this state.
Degraded State 5 (approximately 5x less frequent than Degraded State 4)	The Origin has total loss of primary ADS functionality. The Origin is capable of aggressively slowing down to a stop in its lane of travel, followed by engaging Park state and activating hazard flashers.

Degrade State Level	Fault Description and the Origin's Response
	The Origin is retrieved by the Field Support team to the fleet service facility for repair. No new fleet operation missions will be assigned to the Origin in this state.

Table G-1

Appendix H
Cybersecurity

Security architects have been involved in the development of the Origin since the inception of the program and have designed an architecture that follows cybersecurity best practices. For example, the design architecture of the vehicle deliberately isolates core components from those which can communicate with the outside world. In other words, components capable of "talking" to the outside world cannot directly communicate with modules such as brake controllers. All such communications must pass through a bridge device that can inspect, block, and alert on any suspicious behaviors.

The Origin security architecture also isolates customer-facing devices (e.g., smartphone) into a "dirty" network (e.g., potentially not secure) that is physically separated from critical AV components such as the ADS compute system, for example. Borrowing from proven safety-related concepts made common in the airline industry, the Origin uses physical mechanisms to only allow a one-way flow of data from critical components to the dirty network. Consequently, when a customer uses a personal device to connect to the vehicle's internal Wi-Fi, there is no physical or electronic connection between these devices and critical vehicle components, further improving system security.

The Security Team has also adopted concepts from traditional software engineering, such as continuous validation. The team leverages software that can validate and analyze vehicle components and firmware, respectively, ensuring that regressions have not occurred prior to production of any given vehicle. The dedicated vehicle security team is constantly developing new technologies to combat cyber threats and implementing best practices for our next-generation vehicle. The numerous vehicle security controls that GM and Cruise have developed include the following:

- Cryptographic verification of firmware and configurations leveraging SHA-256 hashing algorithms and RSA-2048 bit signatures. This ensures the code running on our components is genuine and has not been manipulated.
- Message authentication (CMAC-128) provides authentication for component-to-component communication for safety critical components that use datagrams for transport. This ensures that messages received can be verified as legitimate and cannot be manipulated.
- Mutual transport layer security (mTLS) connections provide RSA-2048 bit encrypted streams for end-to-end secure streaming communications. This ensures that all communications within the vehicle or between the vehicle and back-office components are mutually authenticated and encrypted.
- On-board data volume cryptographic verification leveraging dm-verity utilizing SHA-256 hashes and RSA 2048-bit signatures. This ensures that the file systems used by our components are legitimate and have not been manipulated.
- Utilization of multiple security domains. Cruise leverages different levels of trust for different components in the vehicle depending on use case, including but not limited to whether that component can access the Internet or if customers can interact with it. Cruise protects each more-trusted domain from any components within or from a less-trusted domain.

Appendix I
The Origin's Comparative Advantages to Improving Roadway Safety

As NHTSA is acutely aware, trends in roadway injuries and fatalities highlight the urgent need to change the transportation status quo. As illustrated below, the Origin has the capability to improve occupant and roadway safety, ranging from redressing persistent problems in human behavior to benefits that accompany the Origin's model of fleet deployment and fleet learning.

Safety Factor	FMVSS-Compliant Human-Driven Vehicle	Origin Capability
Occupant Protection	• 47% of passenger vehicle occupant fatalities were unbelted, with occupant ejection-related fatalities up 20% in 2020.[144]	• Origin rides are designed to start only when a passenger is detected and buckled, with limited exceptions.[145] • The Origin's Buckle to Ride feature includes Fasten Seat Belt reminders for each seating position when the system detects unbuckled passengers.
Driver	• Over 38,000 auto fatalities in 2020.[146] • 2.7m injuries in the US annually from auto crashes.[147] • The overwhelming majority of serious and fatal crashes includes at least one human behavioral issue as a contributing factor.[148] • Must handle all driving conditions.	• The Origin has the potential to reduce crashes caused by human error, such as crashes attributable to impaired driving, texting, or other operating distractions. • Will only operate in its ODD, in conditions it has demonstrated that it can manage.
Distraction	• Distraction-affected crashes led to 3,142 traffic fatalities in 2019, 8.7% of the total.[149]	• The Origin is not susceptible to distractions.

[144] NHTSA, *Occupant protection in passenger vehicles: 2018 data* (Report No. DOT HS 812 967, June 2020), at 2, https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812967; NHTSA, *Early Estimates of Motor Vehicle Traffic Fatalities and Fatality Rate by Sub-Categories in 2020* (Report No. DOT HS 813 118, June 2021) at 1, https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813118.

[145] *See* Section II.G.5, above, discussing the novel Buckle to Ride feature.

[146] NHTSA, *Early Estimates of Motor Vehicle Traffic Fatalities and Fatality Rate by Sub-Categories in 2020* (Report No. DOT HS 813 118, June 2021) at 5, https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813118.

[147] NHTSA, *National Statistics* (May 2021), https://cdan.nhtsa.gov/tsftables/National%20Statistics.pdf.

[148] 2022 National Roadway Safety Strategy at 14.

[149] NHTSA, *Overview of motor vehicle crashes in 2019* (Report No. DOT HS 813 060, Dec. 2020) at 9, https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813060.pdf.

Safety Factor	FMVSS-Compliant Human-Driven Vehicle	Origin Capability
Impairment	• Alcohol-impaired fatalities totaled 10,142 in 2019, or 28% of traffic fatalities that year.[150] • Approx. half of US drivers admit to getting behind the wheel while tired.[151]	• The Origin is not subject to alcohol- or fatigue-related impairment.
Continuous Improvement Across Entire Fleet	• Each new driver has a learning curve and individual experience matters (e.g., teenage drivers are more likely to get in crashes than older, more experienced drivers).[152] • In the US, the fatal crash rate per mile driven for 16- to 19-year-olds is nearly three times the rate for drivers aged 20 and over.[153] • No learnings from driver to driver.	• The Origin is always connected to the fleet and to the Cruise Back Office; all Origins share learnings across the entire fleet.
Upkeep and Maintenance	• Inconsistent maintenance by individual owners and limited to no oversight (more than half of states do not require periodic safety inspections).[154] • More than 55 million vehicles and motor vehicle equipment were impacted by vehicle safety recalls in 2020. 25% go unrepaired.	• Trained professionals will perform regular service and maintenance checks on every Origin. • Centralized fleet operation ensures safety recall repairs are completed.
Operational Oversight	• Law enforcement.	• Continuous real-time monitoring. • 24/7 customer support.

[150] *Id.*

[151] National Safety Council, *Drivers are Falling Asleep Behind the Wheel* (2020), https://www.nsc.org/road-safety/safety-topics/fatigued-driving#:%7E:text=According%20to%20the%20National%20Sleep,once%20in%20their%20driving%20careers.

[152] NHTSA, *Young drivers: 2018 Data* (Report No. DOT HS 812 968, Oct. 2020) at 1, https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812968.

[153] Insurance Institute for Highway Safety, *Fatality Facts 2019 – Teenagers* (Mar. 2021), IIHS.org/topics/fatality-statistics/detail/teenagers#population-and-mileage-rates.

[154] Das et al, "Measuring the Effectiveness of Vehicle Inspection Regulations in Different States of the U.S.," Transportation Research Record, (1-12), March 2019, https://www.researchgate.net/publication/331641580_Measuring_the_Effectiveness_of_Vehicle_Inspection_Regulations_in_Different_States_of_the_US.

Safety Factor	FMVSS-Compliant Human-Driven Vehicle	Origin Capability
	• May have automated crash notifications.	• Has automated crash notifications. • Incident response protocols.

Table I-1