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Mr. Paul A. Hemmersbaugh
Chief Counsel
National Highway Traffic Safety Administration
1200 New Jersey Avenue SE
Washington, DC 20590

Re: Request by Google, Inc., for an Interpretation Regarding the Application of Certain Federal Motor Vehicle Safety Standards to Self-Driving Vehicles

Dear Mr. Hemmersbaugh:

As you know, Google, Inc. ("Google") has been developing and testing fully autonomous motor vehicles, *i.e.*, vehicles whose operations are controlled exclusively by a Self-Driving System ("SDS") and, thus, have no need for a human driver. These fully self-driving vehicles ("SDV") will provide significant safety benefits. As just some examples, the SDVs will not be subject to driver distraction or impairment. They will react faster than human-driven cars to unanticipated problems and comply with all traffic laws.

In its May 2013 *Preliminary Statement of Policy Concerning Automated Vehicles* ("Policy Statement"), the National Highway Traffic Safety Administration ("NHTSA") underscored "the enormous safety potential" of new vehicle automation technologies, noting that "many are inspired by the vision that the vehicles will do the driving for us." The Policy Statement also pointed to the non-safety benefits that vehicle automation can provide, including reduced fuel consumption and greenhouse gas emissions stemming from more efficient driving and reduced traffic congestion. The Policy Statement also noted the potential mobility benefits for those with a range of disabilities "if the basic driving functions can be safely performed by the vehicle itself." In October 2015, the White House underscored these potential benefits: "Accelerating the development and deployment of advanced vehicle technologies could save thousands of lives annually. The Administration is launching new efforts to accelerate the path to deployment for these promising technologies."[1]

Google is now actively developing fully self-driving passenger cars (referred to as "Level 4" vehicles in the Policy Statement) that will provide the environmental, mobility, and safety benefits that NHTSA, the U.S. Department of Transportation, and the White House have envisioned as the important outcomes of advanced vehicle automation. Google recognizes that

[1] *A Strategy for American Innovation (October 2015)* at page 7.

these vehicles must comply with all applicable Federal Motor Vehicle Safety Standards ("FMVSS"). However, because virtually all of the FMVSSs were promulgated before SDVs were contemplated, let alone a reality, the application of some of the provisions in several FMVSSs to SDVs raises interpretive issues. In particular, since Level 4 SDVs are controlled exclusively by a self-driving system, they have no need for--and in the case of our Level 4 SDVs will not have--some components that are designed for and used by human drivers in conventional, non-autonomous vehicles (*e.g.*, the brake pedal, steering wheel, accelerator pedal, and certain controls and displays). We write to seek NHTSA's concurrence in our understanding of the applicability, or in some cases the non-applicability, of those provisions to Level 4 SDVs.

Overview of Google's Planned Self-Driving Vehicle

Safety has been and remains Google's top priority during its development of a fully self-driving vehicle. Through its safety-focused design process, extensive road experience with its fleet of self-driving cars, a structured testing program, and its functional safety analyses, Google has identified and mitigated a wide range of driving hazards involving typical and non-typical driving scenarios.

Thus far, Google has operated various versions of its SDVs in autonomous mode for more than a million miles without a crash having been caused by a failure of the self-driving system. Every test drive is monitored carefully to identify any possible safety problems and to identify opportunities to further mitigate potential safety hazards. Using field data, Google also runs extensive simulations, equivalent to over three million miles driven every day, to expand our capacity to identify and mitigate potential driving hazards. Our feedback process ensures that safety issues are identified and resolved.

Google's first SDVs were modified production vehicles designed to always have Google personnel on board, who could disengage the autonomous mode and drive the vehicle manually if necessary or appropriate. Within the past year, we manufactured a fleet of 50 low-speed vehicles certified as complying with FMVSS No. 500 (referred to by Google as engineering prototype vehicles) that can operate without a human driver. The lessons learned from our experiences with all of these vehicles have led to enhancements in Google's SDS that have prepared the way for SDVs that will function at a very high level of safety with no driver. The White House has recently underscored the life-saving benefits of such innovations.[2]

[2] "Accelerating the development and deployment of advanced vehicle technologies could save thousands of lives annually by applying the split-second reaction times and precision decision-making of machine intelligence to the more than 90 percent of crashes involving human error." *A Strategy for American Innovation* at page 92.

This interpretation request concerns Level 4 vehicles, as defined by NHTSA in its Policy Statement, designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip, in which occupants will not be expected to be available for control at any time during the trip. By design, safe operation rests solely on the automated vehicle system (*i.e.*, the SDS).[3]

Google's Level 4 SDV's primary operational control functions (steering, acceleration, and braking) as well as all other functions (such as lighting, wipers) will be operated by the SDS, which uses a collection of computers controlled by a master computer to process a continuous stream of sensor inputs, and, through the immediate application of safe driving logic, will assure the safe operation of the vehicle.[4] The inputs come from a range of sensors including lidars, radars, positioning systems, and cameras. The sensors detect vehicles, people, and objects; the computers process the sensor data to identify any condition that may present a hazard; and the computers send commands to the propulsion, steering, and braking systems to direct the vehicle to its intended destination, while avoiding perceived potential hazards. The system includes fail-safe features to ensure that the vehicle will be brought to a safe stop in the very unlikely event of a system failure.

Google's Level 4 SDV will operate only on existing roadways that have been meticulously mapped. This process enables Google to incorporate into the SDS knowledge of each specific road's features and idiosyncrasies, and there is no risk of operations outside of mapped areas. Of course, the vehicle's knowledge of the roads will constantly be updated during each trip, and the SDS will recognize and respond properly even to previously unknown hazards such as new construction zones, emergency vehicles, and changes in traffic patterns.

Given the nature of Google's business as a large Internet company, we have extensive knowledge and experience in designing software that is resistant to cyber attacks, which are frequently attempted against our various systems. We have and will continue to consult closely with the company's cyber security experts to ensure that our work on the SDV benefits from their expertise in identifying and addressing any potential cyber vulnerabilities.

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[3] At the time NHTSA issued its Policy Statement in May 2013, the agency stated that it was not aware of any Level 4 prototype vehicles capable of operating on public roads without the presence of a person in the driver's seat who is ready to control the vehicle. Google's Level 4 vehicles will have that capability.

[4] Given their commercial sensitivity, Google has not included technical details about the Level 4 SDV in this request. If NHTSA wishes, Google will provide those details for the agency's internal use along with a request that the information be treated as confidential business information.

While Google has a great deal of confidence in its Level 4 SDV's crash avoidance capabilities, we cannot assure that crashes will never occur, since there could be errors by drivers of other vehicles or unforeseen circumstances. Therefore, Google has designed the SDV to meet or exceed NHTSA's crashworthiness standards.

Google's Requested Interpretations Align Well With Previous NHTSA Interpretations Supporting Innovation

As discussed below, Google believes that its understanding of the applicability of the relevant FMVSS provisions in the context of Level 4 SDVs is reasonable and appropriate. Our suggested interpretations are consistent with the letter and spirit of the FMVSS provisions at issue, they would not result in any degradation of safety, and they will in fact enhance the safety of the vehicles. Indeed, as mentioned earlier, our vehicles will operate in ways that avoid many of the major contributing factors for crashes, injuries, and deaths on U.S. roads. These include impairment, distraction, drowsiness, fatigue, speeding, etc.[5]

Moreover, Google's suggested interpretations would be consistent with the approach taken by NHTSA in the past in applying other FMVSSs to promising new motor vehicle technologies not contemplated at the time the FMVSSs in question were drafted. In those cases, NHTSA took a flexible, forward-looking approach, interpreting and applying the FMVSSs in ways that preserved the safety protections and purposes of the FMVSSs and simultaneously allowed the development and timely deployment of the new technologies.

One example relates to "idle stop" technology, which was not contemplated at the time that S3.1.3 of FMVSS No. 102 was originally adopted. As originally adopted, that provision stated, "The engine starter shall be inoperative when the transmission shift lever is in a forward or reverse drive position." In an October 22, 1999 interpretation to Mr. Yaichi Oishi of Toyota,[6]

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[5] While other companies may develop Level 4 SDVs in the future that have somewhat different features and different software, Google recognizes that the interpretations we are requesting would apply to other fully autonomous vehicles under identical or quite similar facts. Google believes that no vehicle manufacturer would produce Level 4 SDVs for operation on the public roads unless and until it confirmed the safety of such SDVs through extensive testing and analysis, as Google has done. However, in the unlikely event that a safety problem were to arise due to the inability of a self-driving system to properly operate the vehicle, the manufacturer would have to recall the vehicles to remedy a safety-related defect. Of course, the risk that less cautious or successful SDV manufacturers would seek to avail themselves of any interpretation issued to Google is no different than the risk that exists whenever NHTSA issues an interpretation on the application of any FMVSS. Reliance on NHTSA's recall and remedy system as a safeguard in those circumstances is equally applicable here.

[6] http://isearch.nhtsa.gov/files/19796-2.html.

NHTSA noted, "Your hybrid electric vehicle would not comply with a literal reading of this provision because the gasoline engine starts automatically with the transmission in any position . . . ." Nevertheless, the agency concluded, ". . . we do not interpret S3.1.3 as prohibiting your design. In construing our standards, we bear in mind the purpose underlying the provision that we have been asked to interpret . . . ."[7] NHTSA followed up on this interpretation by amending FMVSS No. 102 to explicitly allow for idle stop systems.

Similarly, in several interpretations addressing various forms of electronic key systems, NHTSA recognized that it was appropriate to interpret standards that had been adopted before the development of new technologies in a manner that accommodated, and indeed facilitated, those technologies. For example, as NHTSA noted in a January 30, 1997 interpretation to an anonymous requestor,[8] "Although the language of [FMVSS No. 114] was not intended for PASS-cards, we must apply it as best we can to your system." NHTSA similarly followed up this interpretation with an amendment to FMVSS No. 114 to clarify the legality of keyless entry systems.

In other analogous interpretations, NHTSA determined that, when an FMVSS does not specify or limit itself to a particular test condition, the FMVSS's test requirements most appropriately must be met when the equipment item in question is "being operated for its intended purpose." See October 2, 1990 interpretation to Mr. S. Kadoya of Mazda, discussing application of various FMVSSs to Mazda's active height suspension system.[9]

As was the case with respect to the issues addressed in the idle stop and keyless entry interpretations discussed above, the interpretations that Google now requests would be consistent with the safety purposes of the standards at issue. Further, they would facilitate the implementation of new technologies that offer the promise of enhanced overall safety. NHTSA's Policy Statement has recognized the enormous benefits that vehicle automation, and especially Level 4 vehicles, can bring to the American public. Given the enormous potential safety and mobility benefits promised by SDVs, such an approach is equally appropriate here.

The interpretations also would be consistent with the interpretations identified in footnote 9 concerning FMVSS test conditions. In the context of Level 4 SDVs, the items of

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[7] NHTSA issued a similar interpretation to Mr. William Willen of Honda on January 17, 2001. http://isearch.nhtsa.gov/files/honda-spw-jan172001.html.

[8] http://isearch.nhtsa.gov/files/12496-3.pja.html.

[9] http://isearch.nhtsa.gov/files/2705y.html. *See also* NHTSA's interpretation to a confidential requestor dated February 12, 2015, http://isearch.nhtsa.gov/gm/85/1985-01.30.html; and NHTSA's interpretation to Patrick Raher dated July 24, 1998, http://isearch.nhtsa.gov/files/17056niv.df.html.

motor vehicle equipment used for human control of conventional vehicles simply are not operated for their conventionally-intended purposes, and therefore they need not be operational, or even present. Rather, all control functions are handled by the vehicle's SDS. As such, application of FMVSS requirements meant for equipment designed for use by human operators in conventional vehicles would be anomalous.

Construing the FMVSSs in the Context of Level 4 Self-Driving Vehicles

A. Priority Interpretive Issues

While this request covers many interpretive issues, there are a few that are high priorities for Google. We will summarize those priority issues here and discuss them more fully below.

1. Service brake activation. For the reasons discussed below in the section on FMVSS No.135, we request an interpretation saying that neither this standard nor any other requires that a Level 4 SDV have a foot control to activate its service brake, which will be activated by the SDS.

2. Turn signal cancellation. For the reasons discussed below in the section on FMVSS No.108, we request an interpretation saying that, in a Level 4 SDV, the standard does not require turn signal self-cancellation by a steering wheel or a manual control to cancel a turn signal because a Level 4 SDV does not need a steering wheel and will properly cancel turn signals through the SDS.

3. Controls and displays. For the reasons discussed in detail below under "Standards That Refer to a Driver" and the section on FMVSS No. 101, in view of the absence of a human driver, we request an interpretation saying that controls need not be visible to or operable by any occupant of a Level 4 SDV, since the controls will be operated by the SDS rather than a human driver. However, with respect to required indicators and telltales, Google is requesting that NHTSA interpret the "driver" to refer to an occupant of the left front seating position.

4. Headlamp beam switch. For the reasons discussed below in the section on FMVSS No.108, we request an interpretation saying that the standard does not require that a means for switching between low and high beams be present in a Level 4 SDV, in which the SDS will automatically select the proper setting based on real-time conditions.

B. Standards That Refer to a "Driver"

The FMVSSs do not require a human driver to be present in a motor vehicle. However, they do contain several references to the "driver," the "operator," and the "driver's seating position."[10] Indeed, the term "driver" is defined as "the occupant of a motor vehicle seated immediately behind the steering control system." 49 CFR 571.3. The drafters of the standards assumed, quite reasonably at the time, that vehicles would always have a human driver. However, that assumption is no longer true. By definition, a Level 4 SDV does not require a human driver, and – at least in Google's Level 4 SDV – there is no occupant "seated immediately behind the steering control system."[11]

Google believes that there are two possible approaches to interpreting the term "driver" in the context of SDVs. First, NHTSA could conclude that provisions in the FMVSSs that impose requirements that refer to a "driver" simply do not apply to a vehicle that does not have a human driver. This would be consistent with prior agency interpretations that have addressed circumstances in which a feature of a vehicle raised issues that were not contemplated when the FMVSS at issue was promulgated.[12] Similarly, NHTSA has recognized in several instances that if it is not possible to test a vehicle in accordance with the procedures specified in a standard, compliance with the underlying requirement will not be required.[13] Of course, even if NHTSA

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[10] For example, S5.1.1 of FMVSS No. 101 refers to controls located "so they are operable by the driver;" the definition of "turn signal operating unit" in S4 of FMVSS No. 108 refers to "the operator of the vehicle;" and S7.1.1.5(a) of FMVSS No. 208 refers to "the driver's position."

[11] The steering control system in the Level 4 SDV vehicle is located in the SDS and not in the passenger compartment. Clearly, no human occupant is seated "immediately behind" that system.

[12] For example, in a March 30, 2007 interpretation to Chris Tinto of Toyota, NHTSA concluded, after considering the purpose of certain seat positioning requirements in FMVSS Nos. 208 and 214, that "the test conditions should be limited to only those in which there would be a person occupying the seat." *See* http://isearch.nhtsa.gov/files/06-005822as.htm.

[13] For example, S5.3(b)(3) of FMVSS No. 214 provides, "Passenger cars, multipurpose passenger vehicles, trucks and buses need not meet the requirements of S7 (moving deformable barrier test) as applied to the rear seat for side-facing rear seats and for rear seating areas that are so small that a Part 572 Subpart V dummy representing a 5th percentile adult female cannot be accommodated according to the positioning procedure specified in S12.3.4 of this standard." *See also* S5(e) of FMVSS No. 225, which provides, "A vehicle with a rear designated seating position for which interference with transmission and/or suspension components prevents the location of the lower bars of a child restraint anchorage system anywhere within the zone described by S9.2 or S15.1.2.2(b) such that the attitude angles of S15.1.2.2(a) could be met, is excluded from the requirement to provide a child restraint anchorage system at that position. . . ."

were to conclude that the requirements that refer to a driver did not apply to SDVs, Google would assure that the safety purposes of those requirements are fully achieved through the functionality of the SDS.

Alternatively, NHTSA could conclude that the terms "driver" and "operator" should be read as referring to the entity that operates the vehicle's controls, which in the context of a Level 4 SDV is a computer-controlled self-driving system, not a human "seated immediately behind the steering control system." In place of the human driver, this system makes and effectuates all of the driving decisions in a Level 4 SDV. This reading would give full effect to the provisions using those terms and achieve their safety purposes. For example, if a standard required that a specific indicator be "visible to the driver," the information conveyed by that indicator would need to be received by the SDS. Similarly, a standard requiring that a control, such as the headlamp switch, be "operable" by the driver would mean that the SDS must be able to operate the headlamps.

Moreover, construing the SDS to be the "driver" of an SDV would avoid the safety problems that likely would arise if a non-driving occupant of an SDV were able to utilize vehicle controls, such as the lighting controls or the brakes, in a manner that is inconsistent with the decisions made by the SDS.

In Attachment A, Google has identified a number of FMVSS provisions to which the prior discussion applies, *i.e.*, provisions for which the term "driver" or "operator" should be construed as referring to the SDS of a Level 4 SDV. Attachment A may not be all inclusive, and we would be glad to discuss any additional provisions to which this principle should apply.

On a related issue, several FMVSSs refer to the "driver's seat" or the "driver's designated seating position," in order to identify which seat or which side of the vehicle is regulated by the standard or should be tested under the standard. For example, S5.1.3 of FMVSS No. 114 requires an audible warning under certain circumstances when the key is in the starting system and "the door located closest to the driver's designated seating position is opened." Of course, a Level 4 SDV does not have a driver, and therefore it will not have a "driver's designated seating position." Therefore, in order to comply with the requirements that use this terminology, the manufacturer of an SDV will need to know which seat will be considered the "driver's seat." Google believes that, in the context of SDVs, NHTSA should construe such references to the location of the driver or the driver's seating position as referring to the left front outboard seating position, since that is the seating position where a driver would sit in a conventional vehicle.

In Attachment B, Google has identified a number of provisions to which the preceding paragraph applies, *i.e.*, provisions for which the "driver's position" or "driver's designated seating position" should be construed as referring to the left front outboard seating position of a Level 4 SDV. Here, too, Attachment B may not be all-inclusive, and we would be glad to discuss any additional provisions to which this principle should apply.

Google also notes that in several of the crashworthiness standards, the positioning procedures for the test dummies placed in the driver's seat and the front passenger seat differ, primarily because of the presence of a steering wheel (for example, compare S10.6.1 and S10.6.1.2 of FMVSS No. 208; and compare S12.1.1 and S12.1.2 of FMVSS No. 214). Since Google's Level 4 SDV will not have a steering wheel (there is not a requirement for one in the FMVSSs), Google plans to treat both front seating positions as though they were passenger positions in order to assure that all vehicle occupants are adequately protected in the event of a crash. As such, S19, S21, and S23 of FMVSS No. 208, which provide protection for children from injuries that could be caused by an airbag, would apply to both outboard front seating positions. Google seeks confirmation from NHTSA that this approach is acceptable (if not mandatory) in SDVs that are not equipped with a steering wheel.

Conversely, S25 of FMVSS No. 208, which provides protection for out-of-position drivers, applies only to the driver position. Since there will be no human driver in a Level 4 SDV, and since the dummy positioning procedures of S26 cannot be implemented in the absence of a steering wheel, Google seeks confirmation from NHTSA that S25 does not apply to SDVs that do not have a steering wheel.

Finally, although the seat belt adjustment requirements of FMVSS No. 208 differ for the driver's seating position compared to other seating positions (compare S7.1.1.1 and S7.1.1), Google plans to install seat belts that satisfy the adjustment requirements applicable to non-driver positions at all seating positions.

C. Specific Regulatory Provisions Requiring Interpretation

1. FMVSS No. 135, "Light Vehicle Brake Systems"

The purpose of FMVSS No. 135 is "to ensure safe braking performance under normal and emergency driving conditions." By definition, the self-driving system in a Level 4 SDV will fully achieve this purpose by sensing situations that warrant braking and by applying the brakes appropriately, in most cases much more reliably and quickly than a human driver would. We ask that NHTSA interpret FMVSS No. 135 so as not to require a foot control (brake pedal) to activate the service brakes in a Level 4 SDV.

Google recognizes that SDVs must comply with all of the performance requirements specified in FMVSS No. 135, such as the stopping distance requirements set out in S6 of the standard, and it has designed its Level 4 SDV to do so. However, Google believes that one provision of FMVSS No. 135 may impose an equipment requirement that is irrelevant to and inconsistent with the concept of Level 4 SDVs, and that NHTSA should interpret as being inapplicable to SDVs. Specifically, the first sentence of S5.3.1 of FMVSS No. 135 provides, "The service brakes shall be activated by means of a foot control." In context, we read this as a locational requirement for the service brake control in a vehicle operated by a human driver, and not as a requirement that the service brakes in all vehicles – even those whose brakes are always activated autonomously – be operable by a foot control.

As noted above, Google's Level 4 SDVs will be fully controlled by the SDS. With respect to braking, this means that the SDS will apply the brakes as needed, and will do so without any assistance from any vehicle occupant. Functioning in this fashion, the SDS will assure that the SDV stops safely and in accordance with all performance requirements of FMVSS No. 135. Moreover, the SDS will provide better braking performance than a human driver would provide. Specifically, there will be no potential for driver distraction, no potential for the brakes to be applied with too much or little force, no time lag between the time that the SDS identifies a need to apply the brakes and their application, and no potential for pedal misapplication that could lead to unintended acceleration.

Given the above, there is no need for the kind of brake pedal found in conventional vehicles, where the braking function is handled by a human driver. Moreover, the presence of a functioning brake pedal in a Level 4 SDV would allow an occupant to knowingly or inadvertently apply the brakes in a manner that is inconsistent with the decisions made by the SDS, which could create safety risks.

Google's requested interpretation should be acceptable to NHTSA. NHTSA has acknowledged that the requirement for a foot control for light vehicle service brakes is not critical to safety performance and is overly restrictive from a design standpoint. Indeed, when NHTSA adopted Subpart C of 49 CFR Part 595, "Make Inoperative Exemptions," which authorizes modifications that would otherwise take a vehicle out of compliance with several FMVSSs, NHTSA noted that the foot control requirement is one of several "design criteria within the applicable standards that have no impact on vehicle performance." 66 Fed. Reg. 12638, 12642 (February 27, 2001). Moreover, as NHTSA noted, the requirement was imposed by the agency for non-safety reasons: ". . . FMVSS No. 135 requires the brake be operated by a foot control, even though this requirement was included in the standard to achieve harmonization rather than because of a need based on engineering principles." *Ibid.* As NHTSA noted later in that final rule, ". . . neither FMVSS No. 105 nor FMVSS No. 121 requires braking via a foot pedal. *The requirement for such a pedal in FMVSS No. 135 is overly restrictive.*" *Id.* at 12646 (emphasis supplied).

In addition, for several years, NHTSA has promoted automatically operating service brakes – which are analogous in many ways to Google's SDV design – as a critical new technology to enhance safety. On November 2, 2015, NHTSA announced its decision to add automatic emergency braking as a recommended technology in its New Car Assessment Program. 80 Fed. Reg. 68604 (November 5, 2015). Recently, at NHTSA's urging, several vehicle manufacturers agreed to install automatic braking systems in their vehicles in the near future. During some forms of automatic emergency braking (specifically, what NHTSA calls "crash imminent braking" or "CIB"), the service brakes will not be "activated by means of a foot control." In NHTSA's words, "CIB systems provide automatic braking when forward-looking sensors indicate that a crash is imminent and the driver is not braking." 80 Fed. Reg. 4630 (January 28, 2015). In encouraging and supporting this new technology, NHTSA implicitly, if not explicitly, has recognized that vehicles with such automatic braking systems will not violate S5.3.1 and that such systems can offer substantial safety benefits over human brake application.

Allowing the service brakes of a Level 4 SDV to be applied by the SDS without utilizing a "foot control" should be equally acceptable to NHTSA, since it will further the safety benefits of SDVs. Of course, all SDVs will need to satisfy all of the braking performance requirements in FMVSS No. 135, including stopping distance requirements.

Google recognizes that S6.5.1 of FMVSS No. 135 provides, "All service brake system performance requirements . . . must be met solely by use of the service brake control." In Google's view, the absence of a brake pedal in an SDV does not affect compliance with this provision, since the service brakes in an SDV will be activated by the SDS. Google requests NHTSA to confirm that in testing for compliance with the performance requirements of this standard, it will be sufficient to have the service brakes applied by the SDS.

2. FMVSS No. 101, "Controls and Displays"

The purpose of FMVSS No. 101, set out in S2, is:

> to ensure the accessibility, visibility and recognition of motor vehicle controls, telltales and indicators, and to facilitate the proper selection of controls under daylight and nighttime conditions, in order to reduce the safety hazards caused by the diversion of the driver's attention from the driving task, and by mistakes in selecting controls.

The self-driving system in a Level 4 SDV will fully achieve these purposes, but not in exactly the same way that the standard contemplates. S5 establishes requirements (location, identification, illumination, color, brightness, etc.) for certain controls, indicators, and telltales if a vehicle is fitted with them. Some of these devices are required by other FMVSSs. Others are not mandated, but, if provided, must meet the requirements of S5.

S5.1.1 of FMVSS No. 101 requires the controls listed in Table 1 and Table 2 of the standard to be "located so that they are operable by the [belted] driver." Similarly, S5.1.2 of the standard requires the telltales and indicators listed in those Tables and their identification to be "located so that, when activated, they are visible to a [belted] driver." Clearly, Level 4 SDVs do not have a [belted] human driver. Rather than having a human driver whose attention can be diverted or who can make mistakes in selecting controls or fail to observe or mis-read the various indicators, the SDS will obtain all relevant information instantaneously through its sensor systems and will ensure through its computers and safety logic that appropriate action is taken. Therefore, for the reasons set out in Section B, above, Google urges NHTSA to interpret these requirements in a manner consistent with the functionality of a Level 4 SDV.

The occupant compartment of our Level 4 SDVs will not be fitted with any of the controls listed in Tables 1 and 2.[14] Rather, the SDS will fully control all aspects of the vehicle's operations. For example, the SDS will fully control the turn signals and all lamps. Allowing the occupants of a Level 4 SDV to operate the vehicle's controls could be detrimental to safety. As with the brake pedal discussed above, allowing SDV occupants the ability to use in-vehicle controls to override the SDS's decisions to, for example, turn on and off headlamps and tail lamps or activate and deactivate the turn signals could compromise the safe and appropriate operation of those components and systems by the SDS, putting both the SDV occupants and those of other vehicles at risk. For these reasons, Google does not plan to install such controls in the occupant compartment of its Level 4 SDV, and we urge NHTSA to conclude either that S5.1.1 of FMVSS No. 101 is inapplicable to Level 4 SDVs due to the absence of a human driver or that, for purposes of S5.1.1, the "driver" of a Level 4 SDV is the SDS.

The SDS also will be immediately informed electronically of the information communicated by the telltales and indicators regulated by FMVSS No. 101, such as those related to brake conditions, the electronic stability control ("ESC") system, engine oil pressure, low tire pressure, fuel levels, and the like. Further, the SDS is programmed to promptly take appropriate actions, without the assistance of any vehicle occupant, to assure the safe operation of the SDV

[14] The term "control" is defined in S4 of the FMVSS No. 101 as "the hand-operated part of a device that enables the driver to change the state or functioning of the vehicle or a vehicle subsystem." None of the devices regulated by FMVSS No. 101 will be "hand-operated" in a Level 4 SDV, which arguably would not have any "controls" within the meaning of FMVSS No. 101.

based on such information. Thus, the non-driving occupants of a Level 4 SDV have no need to be aware of the information conveyed by those displays during the vehicle's operations. Nevertheless, Google currently plans to include in the occupant compartment of its Level 4 SDVs the telltales and indicators required by other FMVSSs (*e.g.*, malfunctions of the brake system, electronic stability control system, or tire pressure monitoring system). With regard to these required indicators and telltales, our Level 4 SDV will meet the requirements of FMVSS No. 101 such as being "visible to the driver." However, as explained in Section B, above, we urge NHTSA to confirm that, for purposes of S5.1.2 of FMVSS No. 101 and similar provisions identified in Attachment B, the "driver" should be considered to be the occupant of the left front seating position.

3. FMVSS No. 108, "Lamps, reflective devices, and associated equipment"

The purpose of FMVSS No. 108, as set out in S2, is to reduce injuries and deaths from traffic accidents by providing adequate illumination of the roadway and enhancing conspicuity of vehicles so that their presence is perceived and their signals understood in daylight and in darkness or other reduced visibility situations.

Google recognizes that all vehicles must comply with all of the performance requirements of FMVSS No. 108 with respect to external lamps and reflectors. However, Google is requesting NHTSA to confirm that Level 4 SDVs do not need to be equipped with some of the internal components addressed by S6.6.1 of FMVSS No. 108, which provides: "All vehicles to which this standard applies, except trailers, must be equipped with a turn signal operating unit, a turn signal flasher, a turn signal pilot indicator, a headlamp beam switching device, and an upper beam headlamp indicator meeting the requirements of S9." In a Level 4 SDV, the functions associated with these components will be performed by the SDS, rather than a human driver. Moreover, the presence and potential operation of the controls identified in S6.6.1 by an occupant of an SDV would create a safety risk. As explained in more detail below, Google requests NHTSA to interpret FMVSS No. 108 as allowing these controls to be excluded from the occupant compartment, as long as their functions are performed by the vehicle autonomously.

a. *Turn signal operating unit.*

This term is defined in S4 of FMVSS No. 108 as "an operating unit that is part of a turn signal system by which the operator of a vehicle causes the signal units to function." The turn signals in SDVs will be operated and controlled by the SDS, which will activate the turn signals (front and rear) prior to all turns and lane changes, and deactivate them when the applicable maneuver is completed. Therefore, as explained in Section B, above, it is appropriate to interpret the term "operator" in this definition as the SDS.

S9.1.1 of FMVSS No. 108 provides that "[t]he turn signal operating unit . . . must be self-canceling by steering wheel rotation and capable of cancellation by a manually operated control." Since the SDS will fully control the SDV's driving function, Google's SDV will not be equipped with a steering wheel; nor will it have a conventional turn signal stalk that is operable by a vehicle occupant. Nonetheless, Google believes that NHTSA can and should conclude that Google's SDV complies with these provisions.

As an initial matter, nothing in S9.1.1 or in any other FMVSS requires a vehicle to be equipped with a steering wheel. We would appreciate NHTSA's expressly acknowledging this point. As in the case of the brake pedal discussed above, a steering wheel is neither necessary, given the SDS's full control of the steering function, nor desirable. Indeed, the presence of a functioning steering wheel in an SDV would create the risk that an occupant might attempt to override the SDS's steering inputs, with obvious adverse potential safety consequences.

Despite the absence of a conventional steering wheel, the turn signal operating unit still will be self-cancelling by the SDV's steering control system. When the steering system, operated by the SDS, completes a turn or lane change, the turn signal will be cancelled in the same fashion as it would in a conventional vehicle. Indeed Google is currently operating its low-speed research prototype vehicle (compliant with FMVSS No. 500) on public roads, and it reliably provides the turn signal activation and cancellation functions autonomously.

Finally, while Google could install a control that allows occupants to manually cancel the turn signal, such an approach would once again lead to safety risks. As noted, the SDS will activate and cancel the turn signals as appropriate. Any effort by a vehicle occupant to use a manually operating turn signal to override or interfere with the SDS function would pose obvious hazards. As such, it would be appropriate for NHTSA to interpret the manually operated control provision of S9.1.1 as inapplicable to SDVs.

Significantly, a flexible approach to the application of S9.1.1 would be consistent with NHTSA's treatment of this provision in the make inoperative exemptions in 49 CFR Part 595. Section 595.7(c)(2) authorizes the removal of the turn signal control in motor vehicles that are "modified to be driven without a steering wheel or for which it is not feasible to retain the turn signal canceling device installed by the vehicle manufacturer." *See* 49 CFR 595.7(c)(2); *see also* 66 Fed. Reg. at 12645. In similar fashion here, where there is no steering wheel, and where inclusion of a manually operable turn signal is not feasible because it would interfere with the safe operation of the SDV, the requirement should be deemed inapposite and inapplicable.

b. Headlamp beam switching device.

The requirements for such a "switching device" are contained in S9.4 of FMVSS No. 108, which provides, "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." However, as explained above, an SDV will not have a human driver who is operating the lights, or any other aspects of the SDV's operations, through movements of his or her hands or feet. As with other SDV functions, the task of switching between lower and upper headlamp beams will be fully and appropriately controlled by the SDS. Providing an in-vehicle switch that would allow an occupant to interfere with or override the SDS's commands would be inimical to safety. For these reasons, the provisions of S9.4 should either be deemed not applicable to SDVs or satisfied by treating the SDS as the driver of the SDV.

4. Miscellaneous Provisions in Other FMVSSs

In addition to the FMVSSs discussed in detail above, other standards also contain language that merits examination in the context of Level 4 SDVs.

a. FMVSS No. 111, "Rear visibility"

The purpose of FMVSS No. 111 is "to reduce deaths and injuries that occur when the driver of a motor vehicle does not have a clear and relatively unobstructed view to the rear." S2. The standard requires that vehicles have external and internal rear view mirrors (S5.1 through S5.4) and a rear visibility system (*i.e.*, a camera with an internal viewing screen) that provides a visual "rearview image" of certain dimensions (S5.5(b)) to "the vehicle operator" (see definition of "rearview image" in S4) during reverse movement. In view of the absence of a human driver and the fact that the non-driving occupants of a Level 4 SDV have no need for a view to the rear of the vehicle, Google believes that NHTSA should interpret these standards as requiring that the specified view be provided to the SDS. See Attachment A. Thus, the vehicle would be deemed compliant if the SDS receives sensor input at least equivalent to the images a driver would be able to view through mirrors and a rear visibility system meeting the field of view and other performance requirements of the standard.

b. FMVSS No. 114, "Theft protection and rollaway prevention"

S5.3 requires a brake transmission shift interlock on any vehicle that has an automatic transmission with a "park" position. The interlock requires the service brake "to be depressed" before the transmission can be shifted out of "park." As explained above, a Level 4 SDV does not need, and Google's Level 4 SDV will not have, a brake pedal, so there is no physical brake pedal to be depressed. However, the SDS will determine the appropriate transmission position and will not select a position other than park unless the service brake is first applied by the SDS. Accordingly, we request that NHTSA interpret this provision as permitting the SDS to achieve the standard's purpose.

c. FMVSS No. 126, "Electronic stability control systems"

FMVSS No. 126 is intended to prevent crashes "in which the driver loses directional control of the vehicle." S2. The standard requires that vehicles be equipped with an electronic stability control ("ESC") system that meets certain performance standards. One element of the definition of an ESC system in S4 of the standard refers to "a means to monitor driver steering inputs." Although a Level 4 SDV will not have a driver, the SDS will monitor all steering inputs and make the necessary adjustments. In addition, the test conditions (S6) and test procedures (S7) make references to steering wheel velocity and angle. As noted above, Google's Level 4 SDV will not have a steering wheel. Therefore, Google requests that NHTSA interpret the relevant provisions of FMVSS No. 126 to allow compliance with the performance requirements of the standard to be tested on the basis of appropriate steering inputs provided by the SDS.

Conclusion

For the reasons explained above, Google respectfully asks that NHTSA construe the standards discussed here in the manner Google recommends. Doing so will demonstrate that NHTSA fully intends to facilitate vehicle safety innovations such as fully self-driving vehicles while ensuring that the important safety purposes of the FMVSSs are achieved. Because your decision on these matters is extremely important for further development of our Level 4 SDVs and will have a major impact on that development, Google appreciates your prompt consideration of these issues. If you have any questions, please contact the undersigned at curmson@google.com.

Sincerely,

Chris Urmson
Director, Self-Driving Car Project

cc: Dr. Mark R. Rosekind, Administrator, National Highway Traffic Safety Administration

Google™

Attachment A

REQUIREMENTS FOR WHICH THE "DRIVER" OR "OPERATOR" SHOULD BE CONSIDERED TO BE THE SELF-DRIVING SYSTEM

FMVSS	Paragraph	Requirement
101	S5.1.1	The controls listed in Table 1 and in Table 2 must be located so they are operable by the [belted] driver . . . .
102	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 . . . .
102	S3.1.4.4	All of the information required to be displayed by S3.1.4.1 or S3.1.4.2 shall be displayed in view of the driver in a single location.
108	S4	*Turn signal operating unit* means an operating unit that is part of a turn signal system by which the operator of a vehicle causes the signal units to function.
108	S4	*Vehicular hazard warning signal operating unit* means a driver controlled device which causes all required turn signal lamps to flash simultaneously to indicate to approaching drivers the presence of a vehicular hazard.
108	S9.4	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. . . .
108	S9.6.2	The [vehicular 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.
111	S4	*Rearview image* means 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.
111	S5.5.1	*Field of view* [for rear visibility] When tested in accordance with the procedures in S14.1, the rearview image shall include: (a) A minimum of a 150-mm wide portion along the circumference of each test object located at positions F and G specified in 14.1.4; and (b) The full width

		and height of each test object located at positions A through E specified in S14.1.4.
124	S1	*Scope.* This standard establishes requirements for the return of a vehicle's throttle to the idle position when the driver removes the actuating force from the accelerator control, or in the event of a severance or disconnection in the accelerator control system.
	S4.1	*Driver-operated accelerator control system* means all vehicle components, except the fuel metering device, that regulate engine speed in direct response to movement of the driver-operated control and that return the throttle to the idle position upon release of the actuating force. *Throttle* means the component of the fuel metering device that connects to the driver-operated accelerator control system and that by input from the driver-operated accelerator control system controls the engine speed.
	S5.1	There shall be at least two sources of energy capable of returning the throttle to the idle position within the time limit specified by S5.3 from any accelerator position or speed whenever the driver removes the opposing actuating force. In the event of failure of one source of energy by a single severance or disconnection, the throttle shall return to the idle position within the time limits specified by S5.3, from any accelerator position or speed whenever the driver removes the opposing actuating force.
	S5.2	The throttle shall return to the idle position from any accelerator position or any speed of which the engine is capable whenever any one component of the accelerator control system is disconnected or severed at a single point. The return to idle shall occur within the time limit specified by S5.3, measured either from the time of severance or disconnection or from the first removal of the opposing actuating force by the driver.
126	S4	*Electronic stability control system* or *ESC system* means a system that has all of the following attributes . . . . (4) That has a means to monitor driver steering inputs . . . .
	S5.1.2	Vehicles to which this standard applies must be equipped with an electronic stability control system that is operational during all phases of driving . . . except when the driver has disabled ESC . . . .
	S5.4.1	The vehicle's ESC system must always return to the manufacturer's original default ESC mode that satisfies the requirements of S5.1 and S5.2 at the initiation of each new ignition cycle, regardless of what ESC mode the driver had previously selected . . . .

	S5.6.1	*ESC System Technical Documentation*. . . . the vehicle manufacturer must make available to the agency, upon request, . . . a system diagram that identifies all ESC system hardware. The diagram must identify what components are used to generate brake torques at each wheel, determine vehicle yaw rate, estimated side slip or the side slip derivative and driver steering inputs.
135	S4	*Brake power assist unit* means a device installed in a hydraulic brake system that reduces the amount of muscular force that a driver must apply to actuate the system, and that, if inoperative, does not prevent the driver from braking the vehicle by a continued application of muscular force on the service brake control. *Brake power unit* means a device installed in a brake system that provides the energy required to actuate the brakes, either directly or indirectly through an auxiliary device, with driver action consisting only of modulating the energy application level.
	S5.1.3	*Regenerative braking system*. . . . if there is no means provided for the driver to disconnect or otherwise deactivate it . . .

Attachment B

REQUIREMENTS FOR WHICH THE "DRIVER" SHOULD BE CONSIDERED TO BE A PERSON SEATED IN THE LEFT FRONT DESIGNATED SEATING POSITION

FMVSS	Paragraph	Requirement
101	S5.1.2	The telltales and indicators listed in Table 1 and Table 2 and their identification must be located so that, when activated, they are visible to a [belted] driver . . . .

The indicators and telltales listed in Table 1 and Table 2 of FMVSS No. 101 that are required by a specific FMVS5 and for which Google is requesting an interpretation are discussed in connection with the standards in question. If a required item is not identified in Attachment A or in the interpretation request, Google intends to comply with that requirement as specified in FMVSS No. 101, with the understanding that, for purposes of FMVSS No. 101, the "driver" will be considered to be a belted occupant seated in the left front seat.

Other items listed in Table 1 and Table 2 are not independently required by any FMVSS. Google understands that if an indicator or telltale listed in Table 1 or Table 2 is provided in the occupant compartment, the item must meet the requirements of FMVSS No. 101, even if it is provided voluntarily.

104	S3(b)	*Plan view reference line* means (b) For vehicles with individual-type seats, either (i) A line parallel to the vehicle longitudinal centerline which passes through the center of the driver's designated seating position; or (ii) A line parallel to the vehicle longitudinal centerline located so that the geometric center of the 95 percent eye range contour is positioned on the longitudinal centerline of the driver's designated seating position.
108	S6.1.3.4.1	A high-mounted stop lamp mounted inside the vehicle must have means provided to minimize reflections from the light of the lamp upon the rear window glazing that might be visible to the driver when viewed directly, or indirectly in the rearview mirror.
108	S9.3.1	Turn signal pilot indicator ("Where any turn signal lamp is not visible to the driver, the vehicle must also have an illuminated pilot indicator to provide a clear and unmistakable indication that the turn signal system is activated.")
108	S9.5	Each vehicle must have a means for indicating to the driver when the upper beams of the headlighting system are activated.

110	S4.3	*Placard.* Each vehicle . . . shall show the information specified in S4.3(a) through (g) . . . on a placard permanently affixed to the driver's side B-pillar. . . .
111	S5.1.1	*Field of view* [for inside rearview mirror]. . . . The location of the driver's eye reference points shall be those established in Motor Vehicle Safety Standard No. 104 (§571.104) or a nominal location appropriate for any 95th percentile male driver.
	S5.2.1	*Field of view* [for outside rearview mirror—driver's side] The mirror shall provide the driver a view of a level road surface extending to the horizon from a line, perpendicular to a longitudinal plane tangent to the driver's side of the vehicle at the widest point, extending 2.4 m out from the tangent plane 10.7 m behind the driver's eyes, with the seat in the rearmost position. . . . The location of the driver's eye reference points shall be those established in Motor Vehicle Safety Standard No. 104 (§571.104) or a nominal location appropriate for any 95th percentile male driver.
114	S5.1.3	Except as specified below, an audible warning to the vehicle operator must be activated whenever the key is in the starting system and the door located closest to the driver's designated seating position is opened. . . .
126	S5.3	The vehicle must be equipped with a telltale that provides a warning to the driver of the occurrence of one or more malfunctions that affect the generation or transmission of control or response signals in the vehicle's electronic stability control system. . . .
	S5.3.1	As of September 1, 2011, [the ESC malfunction telltale] must be mounted inside the occupant compartment in front of and in clear view of the driver.
	S5.5.3	As of September 1, 2011, the "ESC Off" telltale must be mounted inside the occupant compartment in front of and in clear view of the driver.
135	S5.1.2	*Wear status.* The wear condition of all service brakes shall be indicated by either (a) Acoustic or optical devices warning the driver at his or her driving position when lining replacement is necessary, or (b) A means of visually checking the degree of brake lining wear, from the outside or underside of the vehicle, utilizing only the tools or equipment normally supplied with the vehicle. The removal of wheels is permitted for this purpose.
	55.5	*Brake system warning indicator.* Each vehicle shall have one or more visual brake system warning indicators, mounted in front of and in clear

		view of the driver, which meet the requirements of S5.5.1 through S5.5.5. . . .
	S5.5.5	*Labeling.* (a) Each visual indicator shall display a word or words in accordance with the requirements of Standard No. 101 (49 CFR 571.101) and this section, which shall be legible to the driver under all daytime and nighttime conditions when activated.
138	S4.3.1	Each tire pressure monitoring system must include a low tire pressure warning telltale that (a) Is mounted inside the occupant compartment in front of and in clear view of the driver . . . .
	S4.4	(a) The vehicle shall be equipped with a tire pressure monitoring system that includes a telltale that provides a warning to the driver not more than 20 minutes after the occurrence of a malfunction that affects the generation or transmission of control or response signals in the vehicle's tire pressure monitoring system. The vehicle's TPMS malfunction indicator shall meet the requirements of either S4.4(b) or S4.4(c).
201	S3	*A-pillar* means any pillar that is entirely forward of a transverse vertical plane passing through the seating reference point of the driver's seat. *B-pillar* means the forwardmost pillar on each side of the vehicle that is, in whole or in part, rearward of a transverse vertical plane passing through the seating reference point of the driver's seat . . . . *Pillar* means any structure . . . which: (1) Supports either a roof or any other structure (such as a roll-bar) that is above the driver's head.
206	S3	*Side Front Door* is a door that, in a side view, has 50 percent or more of its opening area forward of the rearmost point on the driver's seat back, when the seat back is adjusted to its most vertical and rearward position. *Side Rear Door* is a door that, in a side view, has 50 percent or more of its opening area to the rear of the rearmost point on the driver's seat back, when the driver's seat is adjusted to its most vertical and rearward position.
	S4.3.1	Each rear side door shall be equipped with at least one locking device which has a lock release/engagement mechanism located within the interior of the vehicle and readily accessible to the driver of the vehicle or an occupant seated adjacent to the door . . . .

	S5.1.1.4(b)(ii)	(C) Transverse Setup 1. Orient the vehicle so that its transverse axis is aligned with the axis of the acceleration device, simulating a driver-side impact.
207	S4.1	*Driver's seat.* Each vehicle shall have an occupant seat for the driver.
208	S7.3(a)	A seat belt assembly provided at the driver's seating position shall be equipped with a warning system . . . .
216a	S7.1	. . . Measure the longitudinal vehicle attitude along both the driver and passenger sill. Determine the lateral vehicle attitude by measuring the vertical distance between a level surface and a standard reference point on the bottom of the driver and passenger side sills. The difference between the vertical distance measured on the driver side and the passenger side sills is not more than ±10 mm.
226	S4.2.2	Vehicles that have an ejection mitigation countermeasure that deploys in the event of a rollover must have a monitoring system with a readiness indicator. The indicator shall monitor its own readiness and must be clearly visible from the driver's designated seating position.
	S6.1(d)	Pitch: Measure the sill angle of the driver door sill and mark where the angle is measured.
	S5.1(f)	Support the vehicle off its suspension such that the driver door sill angle is within ±1 degree of that measured at the marked area in S6.1(d) . . . .