



September 2, 2016

Jeffrey L. Quandt, Chief  
Vehicle Control Division  
Office of Defects Investigation  
National Highway Traffic Safety Administration  
1200 New Jersey Avenue, SE  
Washington DC, 20590

RE: Tesla Motors Second Response to PE16-007

Dear Mr. Quandt,

On behalf of Tesla Motors, Inc. ("Tesla" or "the Company"), this submission to the National Highway Traffic Safety Administration ("NHTSA" or the "Agency") responds to the remaining unanswered questions of the Agency's July 8, 2016 Preliminary Evaluation PE16-007 letter ("PE 16-007"), which requests information about performance of the Automatic Emergency Braking ("AEB") system and any other forward crash mitigation or forward crash avoidance systems in Tesla motor vehicles.

Specifically, answers to the Agency's questions 5-7 and 9-12 are set forth below. As requested, Tesla has repeated the applicable request verbatim above each of its responses. Tesla has provided responsive documents, data, and reports dated, up to and including, July 8, 2016. As we agreed, except where otherwise noted, the subject vehicles have been defined as all Tesla vehicles originally sold with Autopilot Convenience Features that have been manufactured for sale or lease in the United States and federalized territories.

**Question 5:** Describe all assessments, analyses, tests, test results, studies, surveys, simulations, reconstructions, investigations, inquiries and/or evaluations (collectively, "actions") that relate to, or may relate to the alleged defect that have been conducted, are being conducted, are planned, or are being planned by, or for, Tesla. For each such action, provide the following information:

- a. Action title or identifier;
- b. The actual or planned start date;
- c. The actual or expected end date;
- d. Brief summary of the subject and objective of the action;

- e. Engineering group(s)/supplier(s) responsible for designing and for conducting the action; and
- f. A brief summary of the findings and/or conclusions resulting from the action.

The response to this request should include a detailed description of all past, present and future actions by any and all engineering working groups (e.g., vehicle dynamics control task force) of which Tesla is an active member or is otherwise aware. This includes, at a minimum, all of the information requested in items "a" through "f."

For each action identified, provide copies of all documents related to the action, regardless of whether the documents are in interim, draft, or final form. Organize the documents chronologically by action.

**Response 5:** The requested information is provided in the folder titled, "Question 5", on the USB Flash Drive. This folder contains a document, "Question 5.pdf," that includes a table that provides the required information for each of the actions, with the actions organized chronologically by start date. The folder also contains a subfolder for each action, which contains the documents related to that action.

**Question 6:** Describe all modifications or changes made by, or on behalf of, Tesla in the design, programming, material composition, manufacture, quality control, supply, or installation of the Autopilot system or components, from the start of production to date, which relate to, or may relate to, the alleged defect or to Autosteer performance or use in the subject vehicles.

For each such modification or change, provide the following information:

- a. The date or approximate date on which the modification or change was incorporated into vehicle production or first released as an over-the-air update;
- b. The date or approximate date on which the modification or change was available fleet-wide as an over-the-air update;
- c. A brief description of the modification or change;
- d. A summary of the reason(s) for the modification or change;
- e. The version number of the change for all software related changes;
- f. The part number(s) (service and engineering) of the original component;
- g. The part number(s) (service and engineering) of the modified component;
- h. Whether the original unmodified component was withdrawn from production and/or sale, and if so, when;
- i. When the modified component was made available as a service component; and

j. Also, provide the above information for any modification or change that Tesla is aware of which may be incorporated into vehicle production within the next 120 days.

Include a general description of Tesla's processes for making software changes, including how field data are used to assess the need for changes, the design/development process used to decide upon the appropriate change, the validation process, and the process for evaluating the effectiveness of the changes after they are made. This should include all processes related to silent updates and early access program evaluations. Responses to 6.f through 6.i are only required for changes to hardware.

**Response 6:** The requested information is provided in the folder titled, "Question 6", on the USB Flash Drive. This folder contains a document, "Question 6.pdf," that includes Tesla's response to each part of question 6.

**Question 7:** Provide the following information related to the subject system:

- a. Provide a detailed description of the design and operation of the subject system in all crash modes, including system capability in intersection or road junction crossing path collisions over the full range of object detection (e.g., pedestrian, bicycle, various vehicle types) and closing speeds;
- b. Describe and provide copies of all documents related to system requirements documents and specifications for all features and functions including detailed descriptions of system design and operation and all associated sensor/camera technologies and specifications;
- c. Provide a list of all end-to-end system suppliers, sensor/camera types, and locations on the vehicle. For each sensor/camera used by the subject system, state the operational range and field of vision ("FOV");
- d. Describe the object recognition and classification process used for both rear-end collision scenarios and intersection or road junction crossing path collisions including monitoring time, sensor fusion logic, track maturity and overall system reaction planning and situation assessment;
- e. Describe how the AEB and Autosteer systems detect faults that may affect system performance (e.g., compromised or degraded sensor/camera signals) and provide the following information about the fault detection logic and failsafe operation for each system:
  - i) A general description of the fault detection logic for each system, including how the subject systems detect compromised or degraded sensor signals (camera or radar) and a description of the different levels of fault severity used in Tesla's functional safety architecture;

- ii) Describe when and how fault detection information is communicated to the driver, including all visual, audible and haptic messages/communications provided to the driver for different levels of fault severity occurring while in: 1) manual control; and 2) in Autosteer mode (include a description of the timing of the transition from automated to manual control for each fault condition occurring in Autosteer mode); and
  - iii) Describe how sensor fault detection, or other system faults, affect 1) the fusion logic for object recognition/classification and automatic braking function in manual control and Autosteer modes; and 2) the ability of the vehicle to determine steering/directional control when in Autosteer mode;
- f. Describe all kinematic models used by the subject system for judging collision risk, calculating time to collision, and/or making decisions about braking for target/threat objects in intersection or road junction crossing path collisions;
- g. Explain all inhibit and override/suppression conditions and operation points for the subject system, including minimum activation speed thresholds (mph), maximum operational speed (mph), brake pedal cancel threshold (mm, m/sec, kPa), steering wheel cancel threshold (force, displacement, and steering angle rate);
- h. Provide a detailed description of all designed-in system diagnostic and ad-hoc data logging including event images, event locations, sampling rates, trigger thresholds, data elements, recording controllers, and data retrieval methods;
- i. State the maximum braking authority and describe the sequence and timing of the cascade of events in an AEB activation (e.g., warning, pre-braking, full-braking);
- j. All vehicle-level testing and system simulations related to crossing traffic at-an-intersection (pedestrians, bicyclists, passing vehicle, passing truck...etc.), left-turn across path, and automatic rear-end emergency braking on straight roadways;
- k. All camera and sensor evaluations related to horizontal performance, vertical performance, ranging and detection, relative speed assessment, relative acceleration assessment, acquisition delay, update rates, and maximum number of tracked targets; and
- l. Explain all design and testing methodologies employed to filter false positive events and interventions while preserving true events overall system accuracy.

**Response 7:** The requested information is provided in the folder titled, "Question 7", on the USB Flash Drive. This folder contains a document, "Question 7.pdf," that includes Tesla's response to each part of question 7.

**Question 9:** Provide the following information related to the subject crash:

**Question 9a:** Identify the earliest times and distances of the Tesla vehicle from the subject crash at which each sensor used by the subject system may have been able to detect the truck in the median turning area before it crossed into the path of the Tesla;

**Response 9a:** [REDACTED]  
[REDACTED]  
[REDACTED]  
[REDACTED]

**Question 9b:** Provide diagrams showing the fields of view of each sensor used by the subject system with the Tesla in the positions identified in 9.a, shown on aerial views of the scene;

**Response 9b:** [REDACTED]  
[REDACTED]  
[REDACTED]



[REDACTED]



[Redacted]

**Question 9c:** State whether and how each sensor system in the subject Tesla would be expected to classify the truck and recognize the potential for a collision before the truck was in the path of the subject vehicle (i.e., as a laterally approaching vehicle or object); and

**Response 9c:** [Redacted]

**Question 9d:** State whether and how the each sensor system in the subject Tesla would be expected to classify the truck and recognize the potential for a collision after the truck crossed into the path of the subject vehicle.

**Response 9d:** [Redacted]

**Question 10:** Furnish Tesla's assessment of the alleged defect in the subject vehicles, including:

**Question 10a:** The reason that the subject system did not activate in the subject crash;

- i) If Tesla has not completed its investigation or has not made any final conclusions, provide a detailed description of the evidence known to date and the basis for all preliminary assessments or opinions, such as those stated in a meeting with NHTSA on June 14 and in public statements about the crash;
- ii) In addition, provide a copy of Tesla's plan for completing its investigation, including all completed and incomplete actions, their actual and target completion dates, and provide a copies of Tesla's final investigation report and conclusions, with all supporting documents, as soon as they are available;

**Response 10a:** [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

**Question 10b:** The types of collisions that the subject system is designed to prevent or mitigate;

**Response 10b:** Like other manufacturers' AEB systems, Tesla's AEB is designed to mitigate front-to-rear collisions.

**Question 10c:** Factors affecting system performance in intersection or road junction crossing collisions, including:

- i) subject vehicle speed;
- ii) target/threat vehicle speed;
- iii) target/threat vehicle composition, geometry, or appearance;
- iv) environmental factors, including light conditions and inclement weather; and

**Response 10c:** [REDACTED]

**Question 10d:** Describe the limitations of the subject system and crash types and conditions in which the system may not be effective.

**Response 10d:** Tesla's AEB is subject to the following limitations:

[REDACTED]

**Question 11:** Provide a spreadsheet list of all crashes occurring while operating with Autosteer activated or within 15 seconds of a transition/handoff from Autosteer to manual control. Crashes should include all events that include evidence that an impact may have occurred (e.g., airbag deployments, seat belt retractor signals, and hood latch signals). Include the following information for each such incident:

- a. Vehicle identification number;
- b. Whether the vehicle history included evidence of drive cycles with excessive "Hands on Wheel" warnings/alerts (include a definition of the criteria used to determine "excessive");
- c. Date of the crash;
- d. Vehicle mileage at the date or time of the crash;
- e. Road classification, if known;
- f. Vehicle speed at the time of the crash event;
- g. Airbags that deployed in the crash;

- h. Whether the crash occurred with Autosteer activated or after a transition/handoff to driver control;
- i. A summary of the number of all warnings and alerts recorded in the drive cycle prior to the crash event; and
- j. Copies of all documents containing customer concern narratives related to the crash event.

Responses to 11.a-c are due with the August 5, 2016 response. The remaining information is due by the final response date, August 26, 2016.

**Response 11:** The requested information is provided in the folder titled, "Question 11", on the USB Flash Drive. [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

**Question 12:** Provide the following information for all of the following subject vehicles designated by NHTSA by August 12, 2016: a) subject vehicles of interest based on Autopilot incident and/or crash history; and b) 50 subject vehicles randomly selected by NHTSA:

- a. Mileage operating with Autosteer activated;
  - b. The total number of "Hands on Wheel" Autosteer VISUAL warnings recorded;
  - c. The total number of "Hands on Wheel" Autosteer CHIME 1 warnings recorded;
- and

d. The total number of "Hands on Wheel" Autosteer CHIME 2 warnings recorded.

**Response 12:** The requested information is provided in the folder titled, "Question 12", on the USB Flash Drive. This folder contains a Microsoft Excel spreadsheet titled "Question 12.xlsx", which contains the information requested in question 12.a - d. [REDACTED]

[REDACTED]

\* \* \*

If you have any questions regarding the information provided in this response, you may contact me at (650) 681-5590 or [mschwall@tesla.com](mailto:mschwall@tesla.com).

Sincerely,



**Matthew Schwall, Ph.D.**  
Director, Field Performance Engineering