National Transportation Safety Board

Washington, DC 20594

Safety Recommendation Report

Addressing Systemic Problems Related to the Timely Repair of Traffic Safety Hardware in California

Accident Number:	HWY18FH011
Location:	Mountain View, California
Date:	March 23, 2018
Recommendation Number:	H-19-13
Adopted:	August 12, 2019

The National Transportation Safety Board (NTSB) is an independent federal agency charged by Congress with investigating every civil aviation accident in the United States and significant accidents in other modes of transportation—railroad, highway, marine, and pipeline. We determine the probable causes of the accidents and issue safety recommendations aimed at preventing future accidents or lessening their severity.

Ongoing Investigation

The NTSB is investigating a fatal collision between a sport utility vehicle (SUV) and a previously damaged and nonoperational crash attenuator in Mountain View, California, on March 23, 2018. In the course of the investigation, we identified systemic problems within the California Department of Transportation (Caltrans) that negatively affect the timely repair of traffic safety hardware. Consequently, the NTSB is issuing a safety recommendation to the California State Transportation Agency (CalSTA).[1] The NTSB is providing the following information in support of the recommendation.[2]

Crash Description

On Friday, March 23, 2018, about 9:27 a.m., a 2017 Tesla Model X P100D electric-powered SUV, occupied by a 38-year-old driver, was traveling south on US Highway 101 (US-101) in Mountain View, Santa Clara County, California. At this location, US-101 has six southbound traffic lanes, including a high occupancy vehicle (HOV) exit lane to State Route 85 (SR-85) southbound on the far left. As the Tesla approached the US-101–SR-85

[1] CalSTA is a cabinet-level state agency that focuses on addressing the state's transportation issues. CalSTA agencies and departments include Caltrans, the California Highway Patrol, the California Transportation Commission, the Office of Traffic Safety, and the Department of Motor Vehicles, among others.

[2] For more information, see the Highway Factors Group Chairman Report in the public docket for this investigation; search for NTSB accident HWY18FH011.

interchange, it was traveling in the lane second from the left, which was an HOV lane for continued travel on US-101.

According to performance data downloaded from the vehicle, the driver was using the Advanced Driver Assistance System (ADAS) features Traffic Aware Cruise Control and Autosteer (a lane-keeping assist system), which Tesla refers to as Autopilot.[3] As the Tesla approached the paved gore area dividing the main travel lanes of US-101 from the SR-85 left exit ramp, it moved to the left and entered the gore area.[4] The Tesla continued traveling through the gore area and struck a nonoperational crash attenuator at a speed of about 71 mph. The crash attenuator was positioned on the end of a concrete median barrier. The impact rotated the SUV counterclockwise and caused the front body structure to separate from the rear of the vehicle. The Tesla was involved in subsequent collisions with two other vehicles, a 2010 Mazda 3 and a 2017 Audi A4.

During the collision sequence, the Tesla's high-voltage battery was breached and a postcrash fire ensued. After the crash, bystanders found the driver in his seat with his lap/shoulder belt buckled. They removed him from the vehicle before it was engulfed in fire. The driver was transported to a local hospital, where he died from blunt force trauma injuries. The driver of the Mazda sustained minor injuries, and the driver of the Audi was uninjured.

Crash Attenuator

Background Information

The concrete barrier that separates the left exit HOV lane (which leads to SR-85 southbound) and the HOV lane on US-101 was shielded by a proprietary crash attenuator.[5] The crash attenuator was an SCI SmartCushion® 100GM crash cushion manufactured and marketed by Work Area Protection Corporation.[6] The crash attenuator uses a hydraulic cylinder and cable assembly to provide a variable stopping force based on vehicle impact speed. Upon frontal impact, the attenuator telescopes rearward to absorb impact energy. The crash attenuator is intended to protect motorists by reducing collision forces as the attenuator slows vehicles more gradually and helps absorb a colliding vehicle's impact energy.

On the day of the crash, the crash attenuator was in a nonoperational, damaged state due to a previous crash, which occurred on March 12, 2018. Figure 1(a) (photograph on the left) depicts the precrash condition of the attenuator as photographed by a Caltrans worker on March 20, 2018, 3 days before the subject crash. Figure 1(b) (photograph on the right) shows an undamaged crash attenuator beside the damaged attenuator. Figure 2 shows the condition of the attenuator following the Mountain View crash.

---

[3] ADASs are designed to help drivers in performing certain driving tasks (for example, staying in the lane, parking, avoiding collisions, reducing blind spots, and maintaining a safe headway). ADASs are generally designed to improve safety or reduce the driver's workload. Tesla's Autopilot system provides automated longitudinal and lateral control of the vehicle.

[4] (a) A *gore area* is a triangular-shaped boundary created by white lines marking an area of pavement formed by the convergence or divergence of a mainline travel lane and an exit/entrance lane. (b) The Autopilot system did not detect the driver's hands on the steering wheel at this time.

[5] In this report, the terms "crash attenuator" and "crash cushion" should be considered synonymous and are used to describe the traffic safety hardware shielding the concrete median barrier on US-101.

[6] See Work Area Protection website, accessed May 28, 2019.

Figure 1. (a) Fully collapsed crash attenuator as it was before the subject crash; it had been damaged during an earlier collision. A Caltrans worker took the photograph on March 20, 2018. (Source: Caltrans) (b) An undamaged attenuator (left) beside the crash-damaged attenuator (right). (Source: Caltrans)

Figure 2. Postcrash photograph of the damaged crash attenuator with vehicle components lodged inside its hollow interior section. (Source: California Highway Patrol)

NTSB investigators attempted to determine why the crash attenuator had not been repaired before the March 23, 2018, crash. Investigators learned that the attenuator was damaged 11 days earlier, on March 12, 2018, at 10:30 p.m., during a single-vehicle traffic collision. A 2010 Toyota Prius, operated by a 31-year-old male driver, was traveling southbound on US-101, entered the gore area, and collided with the crash attenuator at a speed in excess of 75 mph. The

lap/shoulder-belted Toyota driver survived the crash; he was transported to the hospital and treated for a fractured finger on his left hand and a small tear of the intimal layer of the aorta.[7]

The California Highway Patrol (CHP) responded to the March 12 crash but did not notify Caltrans of the damage to state property as required by policy and interagency operational agreements.[8] Two Caltrans maintenance workers patrolling the area discovered that the crash attenuator was damaged and nonfunctional on March 20, 2018. The maintenance workers took pictures of the damage and forwarded them to the maintenance supervisor. The maintenance supervisor directed the workers to put cones and barricades up until a new crash attenuator could be located to replace the damaged attenuator.[9]

No date was scheduled for the replacement because the Caltrans maintenance supervisor had to locate a replacement attenuator. The maintenance supervisor told the NTSB that staffing shortages, other necessary repair work, and 12-hour storm patrol shifts that were required on March 21 and 22 delayed the immediate repair of the attenuator. In addition, the supervisor did not have a replacement crash attenuator at the local maintenance facility and had to call other facilities to find one. When two crash attenuators were found at a neighboring Caltrans maintenance facility, the supervisor had to obtain higher management approval from Caltrans District 4 to install them at the crash location because they had been reserved for installation at other locations.

On Friday, March 23, 2018, the date of the fatal Mountain View crash, the maintenance supervisor and his crew were off work. The supervisor worked over the weekend to coordinate a replacement crash attenuator, plan for a full highway lane closure, and find a maintenance crew to complete the replacement work. On March 26, 2018, 14 days after the crash attenuator was damaged during the Toyota Prius crash and 3 days after the Tesla Model X crash, the attenuator was replaced.

Maintenance and Crash History

NTSB investigators reviewed crash and maintenance records and determined that the attenuator at the crash location had been damaged/repaired more frequently than any other left-exit

[7] NTSB investigators inspected the Toyota at an insurance company impound facility and downloaded the event data recorder. Data showed that, although the Toyota struck the undamaged and operational crash attenuator at a higher speed than the Tesla's when it collided with the attenuator on March 23, 2018, the collision forces experienced by the Toyota driver were significantly lower than those resulting from the later crash with the damaged, nonoperational attenuator due to a longer ride-down time to dissipate crash energy. In general, increasing the ride-down time in a crash and reducing the collision forces are associated with an increased likelihood of survival. (Additional survivability aspects will be presented in the final Mountain View crash investigation report.)

[8] (a) Caltrans told investigators that the CHP never notified it of the damaged crash attenuator. CHP dispatch records were checked, and no evidence was found indicating that the damaged attenuator was reported. In a review of 3 years of crash records for the crash location, NTSB investigators found no other incidents in which the CHP failed to report crash attenuator damage. (b) For more information, see the CHP/Caltrans Joint Operational Statement and the Caltrans Traffic Incident Management Guidelines in the public docket for this investigation; search for NTSB accident HWY18FH011.

[9] A Type 1 sawhorse-style barricade was found lying on the ground immediately north of the damaged crash attenuator just after the crash. Additionally, two orange traffic cones were in place north of the crash attenuator, aligned with the solid white gore line separating the gore from the exit lane to SR-85.

crash attenuator in Caltrans District 4—it had more than double the repairs of any other location.[10] A review of traffic collision data showed that, in the 3 years before the crash, the attenuator was struck at least five times, including one strike that resulted in fatal injuries. The crash attenuator at this location was struck again on May 20, 2018, about 2 months after the crash involving the Tesla.

In reviewing the circumstances of a previous fatal crash at this location, which occurred on November 14, 2015, NTSB investigators determined that the crash attenuator was not functional at the time because it had not been repaired following a collision that occurred more than 45 days earlier. The attenuator was not replaced until December 23, 2015. A further review of Caltrans maintenance records identified other examples of delayed repair of the crash attenuator at this location. In one case, the crash attenuator was damaged in January 2017 and not repaired until April 2017.

Caltrans Maintenance of Traffic Safety Devices

The *Caltrans Maintenance Manual* provides guidance on the maintenance of safety devices.[11] The manual describes crash attenuators as vehicle "energy dissipaters" and states that they are "intended to protect the motorist from the consequences of collision with a fixed object." It states that routine surveillance should be performed to ensure that traffic safety devices remain functional and that detailed inspections should be made to ensure that the components are in satisfactory condition. The manual also states that "damage that impairs the functional integrity of the attenuators should be repaired as soon as possible." Damage to a crash attenuator is considered a "safety" item, with an immediate response required to remove crash cushion debris. Repair and replacement of damaged attenuators has a priority code of 1, requiring repair within 1 week.

On July 31, 2015, the Caltrans chief of maintenance sent a policy memorandum to subordinate maintenance managers indicating a need to improve the maintenance of safety devices. The policy memorandum detailed actions for the repair and installation of traffic safety devices. NTSB investigators reviewed Caltrans's maintenance policies and determined that the following required actions described in the policies did not occur with respect to the crash attenuator associated with the subject crash:

- The local maintenance crew must respond immediately to all vehicle collisions that involve any traffic safety device.
- For maintenance items that have a response time of 1 week, the crew supervisor must notify the area superintendent within 2 business days if the crew is not able to initiate permanent repairs within the 1-week timeframe.
- The Caltrans district safety devices coordinator must be notified of every repair, and work orders should not be closed until the coordinator has approved the work.

[10] (a) The maintenance records reviewed were within the Caltrans Integrated Maintenance Management System database. Traffic collision report data were retrieved from the Caltrans Traffic Accident Surveillance and Analysis System and the CHP's Statewide Integrated Traffic Records System. (b) Caltrans District 4 is headquartered in Oakland, California, and serves the state's Sonoma, Napa, Solano, Marin, San Francisco, Contra Costa, Alameda, San Mateo, and Santa Clara counties.

[11] *Caltrans Maintenance Manual*, Chapter M, "Pavement Delineation, Signs, and Safety Devices," July 2014 edition.

- All districts must have on-call contract(s) in place to be able to repair guardrail, guardrail end treatments, median barriers, and crash attenuators. These contracts augment Caltrans forces so that necessary repairs are initiated within the times prescribed in the maintenance manual.[12]

The NTSB's Previous Identification of Caltrans Maintenance Program Deficiencies

The NTSB identified problems with the Caltrans maintenance program during the investigation of a January 19, 2016, fatal crash involving a motorcoach that collided with a crash attenuator on US-101 in San Jose, California.[13] Through the investigation, the NTSB determined that the crash attenuator had been damaged in a previous crash, 44 days earlier, and was still missing a retroreflective object marker when the January 19 crash occurred. The NTSB further determined that the retroreflective marker being missing from the crash attenuator contributed to the cause of the early morning crash in moderate-to-heavy rain conditions. The NTSB also determined that an inadequate work order tracking system contributed to Caltrans not completing the necessary repairs to the crash attenuator in a timely manner. As a result of the San Jose crash investigation, we issued four recommendations to Caltrans, including Safety Recommendation H-17-4, which reads as follows:[14]

> H-17-4
>
> Modify your work order tracking system to show completion status and to include a means of providing reminders when work orders, particularly those for proprietary devices, are overdue or incomplete.

Repair of Traffic Safety Hardware

The *Caltrans Maintenance Manual*, guidance documents, and best practices discuss the components necessary for an effective maintenance and repair program. These program elements include the following:

- Close coordination between agencies and departments to ensure that critical traffic safety hardware is repaired quickly when damaged.
- A proactive surveillance and inspection program that ensures that traffic safety hardware remains functional.
- A fail-safe reporting system that guarantees that reports and complaints regarding damaged traffic safety hardware are documented and scheduled for timely repair.

---

[12] NTSB investigators found no evidence in maintenance records that repairs and replacement of crash attenuators were completed through on-call contracts.

[13] *Motorcoach Collision with Crash Attenuator in Gore Area, US Highway 101, San Jose, California, January 19, 2016*, NTSB/HAR-17/01 (Washington, DC: NTSB, 2017).

[14] The NTSB sent a safety recommendation letter concerning the San Jose crash (see attachment) to the Caltrans director on April 18, 2017. The letter requested a response within 90 days detailing the actions Caltrans had taken or intended to take. As of July 30, 2019, the NTSB had received no response to the recommendation. The status of the recommendation is "Open—Await Response." The NTSB is continuing to communicate with Caltrans to obtain an update on the status of the recommendations issued in the San Jose report.

- A risk-based maintenance system that prioritizes repairs based on risk factors such as crash history, location, vehicle speed, traffic volume, and potential collision consequences.
- A work order tracking system that provides feedback to maintenance personnel concerning overdue or incomplete work.
- A management-level commitment to timely repairs of traffic safety hardware that makes certain that adequate resources (that is, equipment and personnel) are available to meet maintenance and repair demands.
- An on-call contract program that augments maintenance forces when necessary repairs cannot be completed in a timely manner.

Although Caltrans replaced the damaged crash attenuator 3 days after this accident, maintenance records show several other instances in which the damage at that location was not repaired within the timeframe recommended in Caltrans guidance. The safety benefits of a functioning crash attenuator were demonstrated by the differences between the level of driver injuries in the two March 2018 crashes that took place at this location and support the policy for timely repair or replacement of damaged attenuators. Therefore, the NTSB concludes that the California Department of Transportation's maintenance and repair program has been ineffective in ensuring the timely repair of traffic safety hardware.

Recommendation

To the California State Transportation Agency:

Develop and implement a corrective action plan that guarantees timely repair of traffic safety hardware and includes performance measures to track state agency compliance with repair timelines. (H-19-13)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

ROBERT L. SUMWALT, III
Chairman

JENNIFER HOMENDY
Member

BRUCE LANDSBERG
Vice Chairman

Report Date: August 12, 2019

Attachment

National Transportation Safety Board
Washington, DC 20594

Safety Recommendation

Date: April 18, 2017

In reply refer to: H-17-4 through -7

Mr. Malcolm Dougherty
Director
California Department of Transportation
1120 N St. (MS-49)
Sacramento, CA 95814

The National Transportation Safety Board (NTSB) is an independent federal agency charged by Congress with investigating every civil aviation accident in the United States and significant accidents in other modes of transportation—railroad, highway, marine, and pipeline. The NTSB determines the probable cause of the accidents and issues safety recommendations to help prevent future accidents. In addition, we carry out special studies concerning transportation safety and coordinate the resources of the federal government and other organizations to assist victims and their family members affected by major transportation disasters. We are providing the following information to urge the California Department of Transportation (Caltrans) to act on the safety recommendations being issued in this letter.

On March 28, 2017, we adopted our report concerning the January 19, 2016, San Jose, California, crash.[1] In the predawn hours of January 19, a 2014 Motor Coach Industries International, Inc. (MCI), D4505 motorcoach, operated by Greyhound Lines, Inc., was traveling northbound on US Highway 101 (US-101) when it entered and traveled in an unmarked gore area, rather than the intended high-occupancy vehicle (HOV) lane, and collided with a crash attenuator. The crash occurred at the US-101–State Route 85 (SR-85) interchange, where a 990-foot-long gore separates the left exit HOV lane for SR-85 from the US-101 HOV lane. The gore widens to about 22 feet at the point where the nine-cylinder crash attenuator is in place, which was missing its retroreflective object marker. Following the impact, the bus traveled another 65 feet, rolled 90 degrees, and came to rest on its right side atop a concrete barrier, straddling two lanes of traffic. As a result of the crash, two passengers were ejected and died, and the driver and 13 passengers were injured. Additional information about this crash and the resulting recommendations may be found at the NTSB website, under report number NTSB/HAR-17/01.

[1] See *Motorcoach Collision With Crash Attenuator in Gore Area, US Highway 101, San Jose, California, January 19, 2016*, Highway Accident Report NTSB/HAR-17/01 (Washington, DC: NTSB, 2017).

56705

Attachment (continued)

As a result of this investigation, we issued 11 new recommendations, including two to the Federal Highway Administration, one to the American Bus Association and the United Motorcoach Association, four to Greyhound Lines, Inc., and the following four recommendations to Caltrans:

H-17-4

Modify your work order tracking system to show completion status and to include a means of providing reminders when work orders, particularly those for proprietary devices, are overdue or incomplete.

H-17-5

Add the left exit plaque to the left exit sign at the crash location and to all left exit guide signs on California highways, as required by the Federal Highway Administration.

H-17-6

Delineate the neutral area of the gore at the crash site using the best traffic guidance practices, such as chevrons or diagonal cross-hatching.

H-17-7

Revise the California *Manual on Uniform Traffic Control Devices for Streets and Highways* to change the delineation of left exit gores, such as by using chevrons or diagonal cross-hatching, from an optional to, at minimum, a recommended guidance practice.

We also reiterated one previously issued recommendation each to the Federal Motor Carrier Safety Administration, the National Highway Traffic Safety Administration, and the state of California; and two previously issued recommendations to MCI.

These safety recommendations are derived from the NTSB investigation and are consistent with the evidence we found and the analysis we performed. Then-Acting Chairman DINH-ZARR and Members HART, SUMWALT, and WEENER concurred in these recommendations.

The NTSB is vitally interested in these recommendations because they are designed to prevent accidents and save lives. We would appreciate receiving a response from you within 90 days detailing the actions you have taken or intend to take to implement them. When replying, please refer to the safety recommendations by number. We encourage you to submit your response electronically to correspondence@ntsb.gov.

[Original Signed]

By: Robert L. Sumwalt, III
Acting Chairman