



**VEHICLE FACTORS GROUP CHAIRMAN'S
FACTUAL REPORT**

Williston, Florida

HWY16FH018

(11 pages)

**NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF HIGHWAY SAFETY
WASHINGTON, D.C.**

**VEHICLE FACTORS GROUP CHAIRMAN'S
FACTUAL REPORT**

A. CRASH INFORMATION

Location: US 27-Alt, milepost 29, near Williston, Levy County, Florida
Vehicle #1: 2015 Tesla Model S 70D
Operator #1: Private operator
Vehicle #2: 2014 Freightliner Cascadia truck tractor in combination with a 2003
Utility 3000R refrigerated semi trailer
Operator #2: Okemah Express, LLC
Palm Harbor, FL
Date: May 7, 2016
Time: 4:36 PM EDT
NTSB #: HWY16FH018

B. VEHICLE FACTORS GROUP

Jerome F. Cantrell, Vehicle Factors Group Chairman
NTSB, Office of Highway Safety
490 L'Enfant Plaza S.W., Washington, DC 20594

Tesla Motors Inc. Group Member
Matthew Schwall, Ph.D.
Director, Field Performance Engineering
3500 Deer Creek Road
Palo Alto, California 94304

C. CRASH SUMMARY

For a summary of the crash, refer to the *Crash Summary Report* in the docket for this investigation.

D. DETAILS OF THE VEHICLE FACTORS INVESTIGATION

The 2015 Tesla Model S sedan was examined by NTSB staff on July 14, 2016. All major mechanical systems were examined, which included the powertrain, steering, braking, and suspension systems. Overall collision damage, along with any damage or anomalies within major vehicle mechanical systems were documented. Supporting photographs, vehicle specifications, and available maintenance records were reviewed.

A level 1, post-accident inspection was conducted on the Freightliner truck-tractor and the Utility semi-trailer on May 12, 2016, by the Florida Highway Patrol (FHP). This inspection did not uncover any violations on the truck-tractor. The damages noted for the semi-trailer were identified as broken lower frame rails, missing or bent frame crossmembers, inoperable intermediate side marker lamps, and an air leak at a proper connection.¹

By the time staff arrived in Florida,² the truck tractor and semi-trailer were no longer in Williston, FL. The semi-trailer was no longer owned by Okemah Express LLC, but had in fact been used to help purchase a newer semi-trailer. Staff was able to locate the 2003 Utility semi trailer that had been involved in the crash and the new owner allowed staff to scan it for reconstruction purposes. The truck tractor along with the newer semi trailer were no longer in the state of Florida and they were not expected to return to Florida for an unreasonable period of time.

1. Vehicle #1 – 2015 Tesla Model S 70D Sedan, Passenger Vehicle

1.1. General information

| | |
|-----------------------|---|
| Make/Model: | 2015 Tesla, 4-Door Sedan / Model S 70D |
| VIN: ³ | 5YJSA1S26FFXXXXXX |
| Date of Manufacture: | June 2015 |
| GVWR: ⁴ | 5,732 lbs |
| GAWR (front axle): | 2,813 lbs |
| GAWR (rear axle): | 3,307 lbs |
| Dual Electric-Motors: | AC Induction Motor, Liquid-Cooled, with variable Frequency Drive, 329 Combined HP |
| Battery: | 70 kWh |
| Transmission: | Single Speed Fixed Gear |

1 Neither the truck tractor nor semi-trailer were mechanically inspected by NTSB staff due to their unavailability.

2 The crash happened on May 7, 2016 and NTSB launched to the crash location on July 7, 2016.

3 Vehicle Identification Number (VIN).

4 Gross Vehicle Weight Rating (GVWR) is the total maximum weight that a vehicle is designed to carry when loaded, including the weight of the vehicle itself plus fuel, passengers, and cargo.

1.2. Damage Description

The front of the Tesla sustained major damage to the left-front. The leading edge and top of the hood sustained superficial scratches and scrapes. The leading edge of the left side of the hood was damaged and crushed rearward. The left headlamp assembly was missing. The plastic bumper cover was missing and the left side of the bumper was displaced rearward. The air conditioning condenser fins were damaged. The left side of the air conditioning condenser was bent and separated from the mounting brackets. Wiring to the various sensors located in the front bumper and grill area were exposed, damaged and hanging down in front of the bumper. The windshield was broken and most of it was missing. The “A” pillars were displaced rearward and the roof had been torn from the top of the “A” pillars and was folded rearward to the trunk area.

The left side of the Tesla sustained substantial damage. The left-front fender was displaced rearward, collapsing the wheel well, trapping the left-front tire. The left-front wheel was cracked and the tire was deflated. The left-side rearview mirror was broken from its respective mount and hanging by its electrical wires. The left-side rearview mirror also housed the external cell phone antenna. The driver’s door sustained superficial scratches. The leading edge of the left-rear passenger door was dented at approximately the top hinge area and was displaced rearward, and was unable to close and latch. The rear windshield was shattered. There were no side windows left intact.⁵

The rear of the Tesla sustained major damage. The trunk lid was crushed. The left and right tail lamp assemblies, mounted in the trunk lid, were missing the clear outer lenses. The third brake light assembly, mounted at the top of the rear windshield, was displaced, but was still hanging in its respective mounting location. The right side of the trunk lid was displaced forward. The right side of the trunk lid was askew and lifted. The trunk was unable to be latched closed. The right side of the plastic bumper covering sustained scratches.

The right side of the Tesla sustained moderate damage. The front fender, front passenger door, and the rear quarter panel sustained scrapes and scratches. The rear passenger door was crushed downward and trapped closed. The top of the “B” pillar was displaced rearward into the rear passenger compartment. The right-side rearview mirror was slightly damaged, but still mounted. The rearview mirror mount sustained major abrasion damage at the base of the “A” pillar.

The condition of the interior of the Tesla at the time of the crash was unknown because the electronics had been removed sometime prior to this inspection. The instrument panel to the right of the driver and in front of the passenger, along with the center stack console, had all been removed. The interior contained a lap top computer stand mounted to the right-front passenger floor board, forward of the passenger seating position.⁶

The driver supplemental restraint system deployed during the sequence of the crash. The driver and front passenger knee bolster airbags, the driver’s front airbag, and driver’s side airbag deployed during the sequence of the crash. The driver and passenger seating positions were equipped with a Type 2 (three-point, continuous loop lap/shoulder) occupant restraint system. The

5 See Vehicle Photograph #1 – Left front of Tesla.

6 See Vehicle Photograph #2 – Instrument panel of Tesla.

webbing for the driver's restraint system had been cut by recovery personnel at the crash scene, to extricate the driver.

The webbing was trapped in the extended position and the latch plate was located locked in the buckle.⁷ The passenger's restraint system was drawn taut against the "B" pillar in the stowed position.

The seatbacks of the front passenger seats were deformed rearward. The forward portion of the driver's headrest sustained multiple cuts and abrasions. Biological material was documented on the left side of the headrest. The left side of the seat was sliced through the outer covering. The left side of the passenger's headrest was torn at the bottom, approximately at shoulder height. Biological material was down the left side of the driver's seat.

The rear passenger compartment was full of debris from the crash and was not inspected.

1.3. Vehicle Recorded Event Data

The Tesla was not equipped with an Event Data Recorder. The Tesla was equipped with an Air bag Control Module, however; this control module did not have an event data recorder. Any data that would have been recorded by the computer had been removed from the Tesla sometime prior to this inspection by NTSB staff. Refer to the Recorder Group Chairman's factual report for any data obtained from the vehicle manufacturer.

1.4. Driver Controls

The driver control instrument panel and gauge display were all digital. The main instrument panel display screen, located in the center stack of the Tesla, had been removed and was not located with the vehicle at the time of this inspection.

A single lever, mounted to the left side of the steering wheel column, operated the wipers, high/low beam, and turn signals. The bottom lever, mounted to the left side of the steering wheel column controlled the position of the steering wheel, such as, forward and backward and up and down. The single lever mounted to the right side of the steering column operated the transmission and electronic parking brake.

The steering wheel had three spokes, two with operational buttons. The buttons located on the left spoke of the steering wheel could be used to change radio stations, control volume, and navigate the left side of the instrument panel. The buttons located on the right spoke of the steering wheel could be used to operate cell phone applications, to navigate the right side of the instrument panel, and voice commands.

1.5. Tires and Wheels

According to the VIN plate, mounted on the lower portion of the "B" pillar in the driver's door opening, the Tesla was specified to be equipped with P245/45R19 tires, mounted on 19x8 rims.⁸ The tires were specified to be inflated to 45 psi for both axles. **Table 1** includes the tire and wheel information documented at the time of inspection.

⁷ See Vehicle Photograph #3 – Driver's Seat Belt Latch Plate and Buckle.

⁸ Hereafter referenced as wheel.

Tread depth measurements were taken from the outboard tire shoulder, to the inboard tire shoulder, and in three separate locations within the major tread grooves of a given tire. The measurements taken are documented in **Table 1**. All tread depths measured were within the minimum tread depth regulation for passenger vehicle tires, which is 2/32 of an inch for all axles.⁹

Table 1. Tesla Tire Information

| Axle I | Left | Right |
|----------------|---|------------------------------------|
| Make | GOODYEAR | MICHELIN |
| Model | EAGLE RS-A2 | PRIMARY MXM4 |
| DOT # | M67V JE1R 1615 | B9Y9 005X 2315 |
| Size | 245/45R19 (98V) | 245/45R19 (98W) |
| Load Rating | 1,653 lbs @ 51 psi | 1,653 lbs. @ 51 psi |
| Tread Plies | 2 plies polyester, 2 plies steel, 1 nylon | 2 plies polyester, 1 ply polyamide |
| Sidewall Plies | 2 plies polyester | 2 plies polyester |
| Pressure | DEFLATED | 44 psi |
| Tread Depth | 7/32, 6/32, 6/32, 6/32 inch | 4/32, 4/32, 4/32, 4/32 inch |
| Axle II | Left | Right |
| Make | MICHELIN | MICHELIN |
| Model | PRIMARY MXM4 | PRIMARY MXM4 |
| DOT # | B9Y9 005X 2315 | B9Y9 005X 2315 |
| Size | 245/45R19 (98W) | 245/45R19 (98W) |
| Load Rating | 1,653 lbs. @ 51 psi | 1,653 lbs. @ 51 psi |
| Tread Plies | 2 plies polyester, 1 ply polyamide | 2 plies polyester, 1 ply polyamide |
| Sidewall Plies | 2 plies polyester | 2 plies polyester |
| Pressure | 44 psi | 44 psi |
| Tread Depth | 6/32, 5/32, 5/32, 5/32 inch | 6/32, 5/32, 5/32, 6/32 inch |

All four tires were mounted on alloy wheels held in place with five lug nuts each. A clock face reference (1:00 – 12:00) was used to describe locations on each tire and wheel. The valve stem was used as the 12:00 position. Tire and wheel damage observed during the inspection is described in the following bullets. The tires and wheels not listed, exhibited no damage.

- Axle I Left Wheel
 - The alloy wheel sustained a circumferential crack from approximately the 11:00 to 1:00 positions, approximately 6-inches in chord length. The inboard side of the wheel sustained a radial collapse from the 4:30 to 7:30 positions, approximately 12-inches in chord length.
- Axle II Left Tire
 - The outboard tire sidewall contained a bulge, at approximately the 11:30 position.

⁹ Measured in two adjacent tread grooves at any location on the tire (49 CFR 570.9(a)).

1.6. Steering

The Tesla was equipped with electric power-assisted rack and pinion steering gear.

All of the steering arm linkages from the steering wheel down to the rack and pinion steering gear remained intact and connected. It was possible to rotate the steering gear from stop-to-stop by turning the steering wheel. All ball joint connections remained intact and free of excessive wear or play.

1.7. Suspension

Axle I of the Tesla was equipped with an independent suspension system, which consisted of lower control arms, air springs/telescopic dampers, a stabilizer bar, and stabilizer bar connecting links.

The forward, lower control arm, ball joint mounting bolt was broken at the steering knuckle. No other damage was noted.

Axle II of the Tesla was equipped with an independent suspension system, which consisted of multiple linkages, air springs/telescopic dampers, a stabilizer bar, and stabilizer bar connecting links. No damage was observed to axle II suspension components.

1.8. Braking

The Tesla was equipped with a hydraulic, Anti-Lock Braking System (ABS) with Electronic Brake Force Distribution, Integrated Advanced Stability Control, Automatic Emergency Braking (AEB), and Electronic Accelerator pedal actuated regenerative braking system. There were disc brake assemblies on both axles. The brake calipers were fixed, with four pistons each.

Brake functional check for the Tesla was accomplished by applying the brake pedal and attempting to rotate the brake assemblies with a pry bar. When the brake master cylinder was actuated, all brakes assemblies locked from hand rotation, and released when the brake master cylinder was released. Brake measurements are recorded in **Table 2**.

Table 2. Tesla Brake Measurements

| Brake Location | Axle I | | Axle II | |
|-------------------------------|--------------------|--------------------|--------------------|--------------------|
| | Left | Right | Left | Right |
| Brake Type | Disc | Disc | Disc | Disc |
| Measured Lining Thickness | Top: 13/32 inch | Top: 13/32 inch | Top: 13/32 inch | Top: 13/32 inch |
| | Bottom: 13/32 inch | Bottom: 13/32 inch | Bottom: 13/32 inch | Bottom: 13/32 inch |
| Measured Rotor/Drum Thickness | 1.248 inches | 1.248 inches | 1.098 inches | 1.098 inches |

| | | | | |
|---|-------------|-------------|-------------|-------------|
| Manufacturer's Specification – Rotor/Drum Thickness | 1.18 inches | 1.18 inches | 1.02 inches | 1.02 inches |
|---|-------------|-------------|-------------|-------------|

The fluid in the brake master cylinder was at the full mark embossed on the side of the reservoir.

1.9. Maintenance History

The maintenance records were obtained from Tesla. The only maintenance issues identified between July 2015 and May 7, 2016, were three tire issues. The first tire issue occurred on December 21, 2015, and involved the left-front tire. The documented problem was stated as a flat tire and the wheel was damaged as well. The second tire issue occurred on February 13, 2016, and involved the left-rear tire. It was unknown what issues were addressed with the left-rear tire. The third tire issue occurred on March 3, 2016, and involved the left-front tire. It was unknown what issues were addressed with the left-front tire at this time.¹⁰

2. 2015 FREIGHTLINER TRUCK TRACTOR AND 2003 UTILITY SEMI TRAILER

2.1. GENERAL INFORMATION

TRUCK TRACTOR:¹¹

Make/Model: 2014 Freightliner Cascadia
 VIN: 3AKJGHV4ESXXXXXX
 Company Unit #: 14
 Date of Manufacture: February 2013
 GVWR:¹² 52,350 lbs
 GAWR (front axle):¹³ 12,350 lbs
 GAWR (middle axle): 20,000 lbs
 GAWR (rear axle): 20,000 lbs
 Engine: Detroit Diesel DD13, Inline Six-Cylinder, 470 hp
 Transmission: Allison, 6-speed, Automatic
 Additional equipment and specifications are included in the Freightliner Combined Vehicle Specs and Chassis Final Vehicle Record.¹⁴

¹⁰ See Vehicle Attachment # 1 – Tesla Tire Pressure Information.

¹¹ The specifications for the Freightliner were taken from the Freightliner Vehicle Specs and Chassis Final Vehicle Record.

¹² Gross Vehicle Weight Rating (GVWR) is the total maximum weight that a vehicle is designed to carry when loaded, including the weight of the vehicle itself plus fuel, passengers, and cargo.

¹³ Gross Axle Weight Rating (GAWR) is the maximum distributed weight that a given axle is designed to support.

¹⁴ See Vehicle Attachment # 2 – Freightliner Vehicle Specs and Chassis Final Vehicle Record.

SEMITRAILER:
Make/Model: 2003 Utility, 3000R, Refrigerated Semi-Trailer
VIN: 1UYVS25303UXXXXXX
Company Unit #: 2004
Date of Manufacture: November 2002
GVWR: 65,000 lbs
GAWR (per axle): 19,000 lbs

2.2. DAMAGE DESCRIPTION

The truck tractor was not available for NTSB staff to inspect and the semi-trailer had already been sold to a third party therefore; only a visual walk around to document the damage sustained by the semi-trailer was conducted by NTSB staff. A post-crash mechanical inspection was conducted by the FHP on May 12, 2016 and is included as Attachment 3.¹⁵

The FHP post-crash inspection of the truck tractor did not reveal any mechanical issues. The FHP post-crash inspection of the semi-trailer identified missing and broken frame crossmembers and inoperable intermediate marker lamps. There was also an air leak at a proper connection between axle IV and V.

On July 13, 2016, a visual walk around was conducted by NTSB staff on the semi-trailer. The rear of the semi-trailer sustained no collision damage.

The right side¹⁶ of the semi-trailer had abrasions and scuff marks along the reflective tape, for approximately 18 feet, above the sliding tandems. Between approximately 20 to 26 feet from the front of the semi-trailer, there were two broken locations in the trailer frame. The forward location contained some chrome trim material. The sheet metal between the broken frame locations contained a half-moon impression. The direction of the damage appeared to flow from the right side of the semi-trailer to the left side of the semi-trailer. Multiple crossmembers were bent and one crossmember was missing. The intermediate side marker light was missing.¹⁷

On the front of the semi-trailer was the refrigeration unit. No damaged from the crash was identified on the front of the semi-trailer.

The left side of the semi-trailer had some minor scuff marks along the first 6 feet of the siding. At approximately 24 feet from the front, the lower semi-trailer frame was broken and was protruding outward. At approximately 6 feet from the broken section, the semi-trailer frame was bent, also protruding outward. The intermediate side marker light was broken, but still attached. The intermediate side marker light mounting bracket was bent outward and upward.¹⁸

¹⁵ See Vehicle Attachment #3 – FHP Post-Crash Inspection.

¹⁶ Orientation of the trailer for right and left sides, is from the rear looking forward.

¹⁷ See Vehicle Photograph #4 – The Right Side of the Semi-Trailer.

¹⁸ See Vehicle Photograph #5 – The Left Side of the Semi-Trailer.

2.3. BRAKING

The truck tractor had disc brakes on all axles. Therefore, there were no brake push-rod stroke measurements documented in the FHP post-crash report for the truck tractor.

The semi-trailer was manufactured with an ABS type 30/30 clamp brake chambers on both axles. The FHP documented the brake push-rod stroke measurements. There were no brakes out-of-adjustment. A visual inspection of the brake linings, airlines, and foundation brake components was conducted by NTSB staff. All brake linings were in excess of the minimum requirements of ¼ inch.¹⁹ The thermoplastic emergency brake airline attached to the right side of the axle was worn through the outer layers to the inner or second color. This is an out-of-service condition according to the North American Standard Out-of-Service Criteria.²⁰ The rubber, emergency brake hose, forward of the front axle, contained an improper splice (non-DOT approved fitting).

2.4. SUSPENSION

The suspension of the semi-trailer consisted of air springs, shock absorbers, cantilever arms, and solid axles. No damage was identified to the semi-trailer suspension.

2.5. MAINTENANCE HISTORY

Maintenance and inspection records for the Freightliner truck tractor and Utility semi-trailer combination were obtained from Okemah Express LLC, via a subpoena from the NTSB to his lawyer.

The most recent annual inspections for the Freightliner truck tractor and Utility semi-trailer combination, occurred in January 2016, in Clearwater, FL.

E. DOCKET MATERIAL

The following attachments and photographs are included in the docket for this investigation:

LIST OF ATTACHMENTS

Vehicle Attachment #1 – Tesla Tire Pressure Information - *Official Use Only*

Vehicle Attachment #2 – Freightliner Vehicle Specs and Chassis Final Vehicle Record

Vehicle Attachment #3 – FHP Post-Crash Inspection

¹⁹ 49 CFR Part 393.47(d) states 1/4 inch minimum for air-braked non-steering axles, or 3/16 inch minimum for air-braked front steering axle brakes

²⁰ North American Standard Out-of-Service Criteria, Part II 1 h (1)

LIST OF PHOTOGRAPHS

Vehicle Photograph #1 – Left front of Tesla

Vehicle Photograph #2 – Instrument panel of Tesla

Vehicle Photograph #3 – Driver's Seat Belt Latch Plate and Buckle

Vehicle Photograph #4 – The Right Side of the Semi-Trailer

Vehicle Photograph #5 – The Left Side of the Semi-Trailer

END OF REPORT

Jerome F. Cantrell

Vehicle Factors Investigator