**NATIONAL TRANSPORTATION SAFETY BOARD**

Office of Highway Safety
Washington, D.C. 20594

## Group Chairman's Factual Report

# TECHNICAL RECONSTRUCTION

HWY22FH008

## A. ACCIDENT

| | |
|---|---|
| Location: | Intersection of Oklahoma State Highway 22 (SH 22) and U.S. Highway 377 (US 377) / State Highway 99 (SH 99)<br>Tishomingo, Johnston County, Oklahoma |
| Date: | March 22, 2022 |
| Time: | 12:19 pm CDT |
| Vehicle 1: | 2015 Chevrolet Spark |
| Vehicle 2: | 1994 Peterbilt Truck Tractor<br>in combination with a 2017 Travis semitrailer |

## B. TECHNICAL RECONSTRUCTION GROUP

| | |
|---|---|
| Group Chairman | Robert Squire<br>National Transportation Safety Board<br>490 L'Enfant Plaza, SW<br>Washington, D.C. 20594 |

## C. SUMMARY

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

## D. DETAILS OF TECHNICAL RECONSTRUCTION GROUP INVESTIGATION

The Technical Reconstruction Group convened to assist with the interpretation and analysis of documentation acquired for this crash and to assist with an analysis of the events and potential causal factors. In support of these tasks the group relied upon information, data and documentation provided by the Oklahoma Highway Patrol (OHP) and other NTSB investigative groups. Factual reports prepared by other NTSB investigative groups should be consulted for information related to specific aspects of the investigation, including information referenced within this report.

## 1.0 Introduction, Crash Location and Documentation

The crash involved two vehicles that collided at the intersection of U.S. Highway 377 (US-377)/State Highway 99 (SH-99) and State Highway 22 (SH-22) within the city of Tishomingo, Johnston County, OK.[1] The crash occurred when a 2015 Chevrolet Spark, while attempting to turn left from eastbound SH-22 onto northbound US-377, entered the path of, and was struck by a Peterbilt truck and semitrailer combination. **Figure 1** depicts a boundary map for the city of Tishomingo.

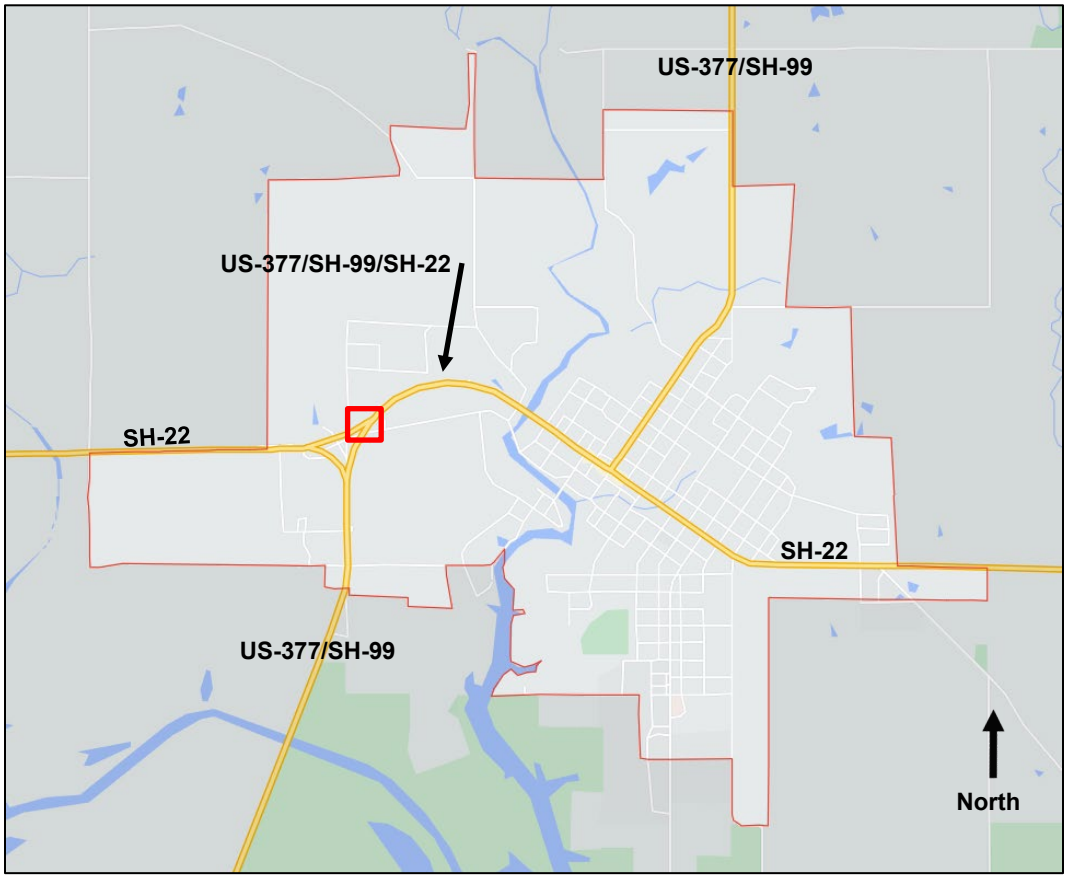


**Figure 1:** Tishomingo, OK, city boundary map with highway route designations and area of crash as indicated by red-colored square.

SH-22 is an east-west highway with a single travel lane in each direction on approach to and within the city limits. While US-377 and SH-99 are a concurrent north-south highway through Tishomingo, a portion of that highway exhibits an east-west orientation east of the crash site. As depicted in the Figure 1 map, US-377/SH-99 are also concurrent with SH-22 between the crash intersection and eastern end of Tishomingo. The concurrent highways exhibit a northwest-southeast orientation and then begin an arcing or curved heading that transitions about 70° until SH-22 diverges into a westward heading. The heading change of US-377 is about 125° along the

[1] US-377 and SH-99 are concurrent. A concurrency in a road network is an instance of one physical roadway bearing two or more different route numbers and share the same right-of-way.

apparent curve that covers an estimated distance of 4,700-4,900 feet.[2] Similar to SH-22, US-377 features single opposing lanes of travel. As noted in the NTSB *Highways Factors Factual Report*, the speed for both highways approaching the intersection was 50 mph at the time of the crash.

**Figure 2** is a modified Google Earth image, approximately scaled, that illustrates the arcing characteristic of the highway eastward from the crash location.


**Figure 2:** Modified Google Earth image approximately scaled to illustrate the arcing characteristic of the highway eastward from the crash location. The crash location is highlighted by the red box.

At the intersection, westbound SH-22 exhibits a tangential departure from the concurrent highway about two-thirds the distance through the apparent curve. From there SH-22 exhibits a change in orientation from northeast/southwest to a west/east heading. At the intersection, SH-22 exhibits a wide pavement interface (~230 feet as measured between pavement edges) with US-377. Pavement striping is used to designate travel lanes and create a gore area.[3] In the westbound direction, SH-22 diverges along a tangent. In the eastbound direction, pavement markings are used to create a short, curved approach that decreases an otherwise significant skew for eastbound traffic. At the intersection, eastbound SH-22 also widens to approximately 22 feet (as measured from site documentation).

The intersection is controlled by a stop sign posted for eastbound SH-22. Right turns onto southbound US-377 were prohibited for eastbound SH-22 at the intersection (another roadway further west facilitates eastbound SH-22 to southbound US-377 movements).[4] As observed in scene photographs, highway signage was unobstructed and appeared in good condition. Pavement

[2] Limited data indicate that while the change in highway orientation appears as continuous curve, it is likely comprised of multiple curved segments.
[3] The length of the gore contiguous with US-377 was about 86 feet.
[4] A "No Right Turn" sign (MUTCD R3-1) was erected approximately 150 feet in advance of the intersection "Stop" sign.

striping appeared visible, albeit faded at various locations. The NTSB *Highway Factors Factual Report* should be consulted for specific intersection and highway metrics.

## 1.1 Post-Collision Scene Documentation and Roadway Evidence

Following the crash, investigators with the Oklahoma Highway Patrol (OHP) photo-documented the scene using sUAS and terrestrial methods.[5] Using similar methods, NTSB investigators conducted additional site documentation. The sUAS images were rendered through the Pix4DMapper software to create a three-dimensional point cloud project for use in analysis.[6] The OHP sUAS project captured images of the post-crash positions of rest for the two vehicles, roadway evidence and evidence markings applied by OHP investigators. Overall, the OHP project documented approximately 790 feet of US-377 and 580 feet of SH-22 about the intersection. **Figure 3** depicts a screen capture image of the 3D point cloud rendered from the ariel photograph project.

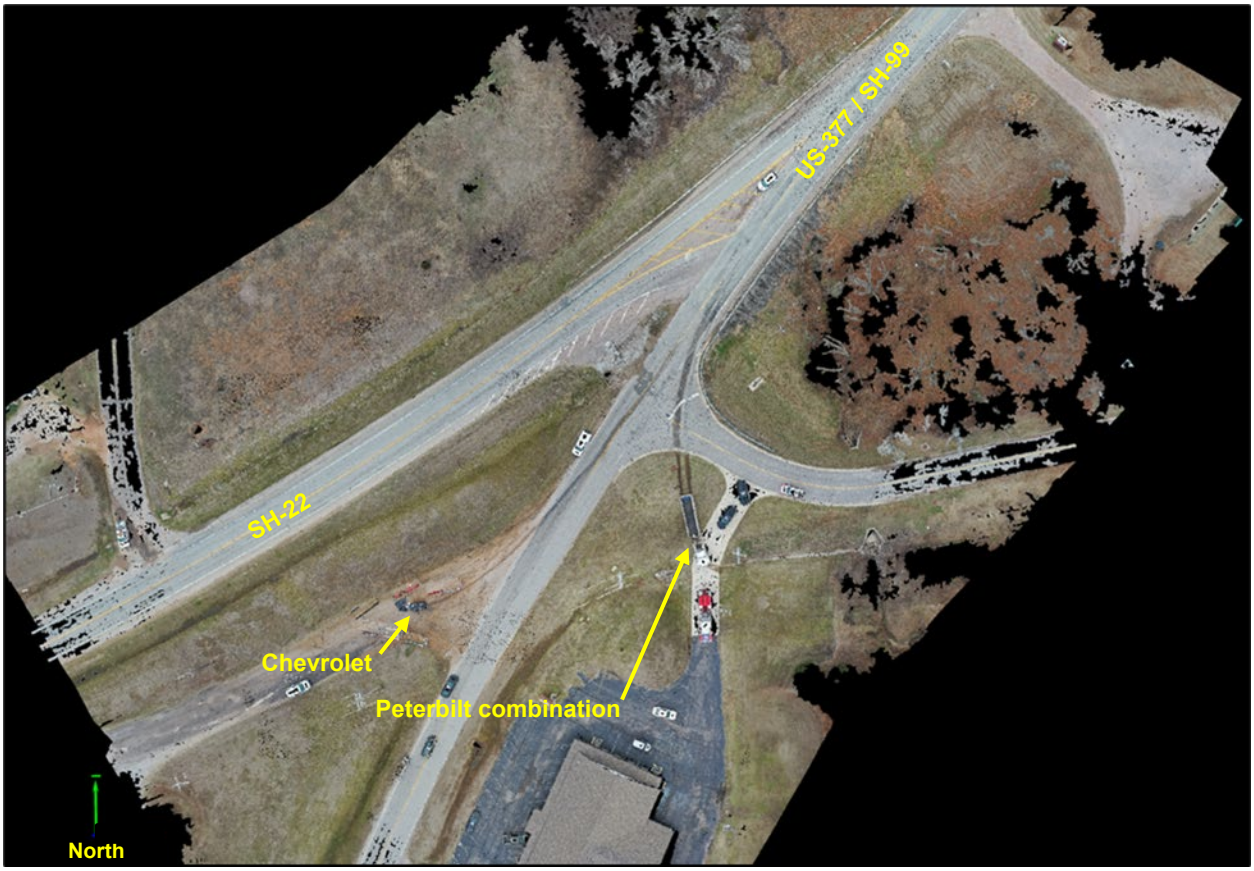


**Figure 3:** Screen capture image of the 3D point cloud rendered from the ariel photograph project depicting the roadway and vehicle positions of rest.

[5] sUAS – small unmanned aerial system (i.e., drone).
[6] Pix4DMapper is a photogrammetry software package designed to use overlapping photographic images to generate 3D point clouds. Additional outputs from the generated point cloud include 3D models (textured mesh), digital surface and terrain models, and 2D orthomosaic maps.

Roadway evidence of the collision exhibited characteristics of pavement scars (surface scrapes and shallow gouges), tire friction marks, fluid debris and off-pavement soil furrowing. Roadway evidence of the collision was within the lanes of US-377 and confines of the SH-22 and US-377 intersection, as defined by the extension of pavement curb lines. Relative to the eastbound SH-22 roadway - as defined by pavement markings - the onset of a cluster of pavement scars was observed at the northern end of an extension of the left edge line. The parallel pavement scars were clustered between the approximate middle of the southbound travel lane of US-377 and about one to one and half feet into the opposing northbound travel lane. The cluster of scars extended southward about 6-7 feet. The approximate midpoint of the cluster was about 48 feet from the painted stop line on SH-22.[7]

The onset of two parallel linear tire friction marks was observed about 63 feet north of the roadway scars. The parallel marks were characteristic of a dual tire configuration. At their onset, the marks were within the southbound travel lane of US-377 inboard of the centerline. As the marks overlapped the area of pavement scars, they crossed the centerline into the northbound travel lane. South of the pavement scar area, these tire marks became interspersed with other tire friction marks, vehicle debris and fluid debris. The fluid debris paralleled the tire friction marks to the west. The tire marks and debris exhibited an arced path toward the southeast and terminated at the final rest position for the Peterbilt combination. The front of the Peterbilt combination was stopped at the end of the arcing debris path about 244 feet south of the pavement scars. The combination unit came to rest off the pavement surface with soil furrows continuing from the pavement edge to the vehicle's position of rest.

Additional tire friction marks originated around the pavement scars and similarly continued southward. Beginning about the area of the pavement scars additional tire friction marks were observed. Many of these marks were lighter in intensity or intermittent, with some exhibiting an arcing or serpentine orientation. Beginning about 86 feet south of the (onset of) pavement scars, an apparent trail of fluid debris tracked along the highway centerline. The fluid debris trail then arced toward the western road edge and reached the pavement edge about 249 feet south of the pavement scars. Soil furrows continued about 110 feet to final rest position for the Chevrolet. The Chevrolet came to rest about 359 feet southwest of the pavement scars as measured along the debris path to the vehicle's approximate center of mass.

Using available site photographs and the site point cloud project, the sightline from the eastbound SH-22 stop line northward along US-377 was observed to be physically unobstructed except for the changes in alignment which included the eastward curvature and ascending vertical grade. Estimates are that the line of sight extended toward approaching southbound traffic was at least 1,000 feet.

[7] Note that the stop line is oriented at an angle to the US-377 roadway with measurements taken from the most prominent portion of the painted stop line. Measurements were taken from an approximate midpoint in the lane.

## 2.0 Vehicles

The crash involved two motor vehicle – a 2015 Chevrolet Spark subcompact sedan and a 1994 Peterbilt truck tractor in combination with a dump body semitrailer. Post-crash vehicle photographs were provided by both OHP and NTSB investigators.

## 2.1 Passenger Vehicle

The vehicle is identified as a model year 2015 Chevrolet Spark M300 four-door subcompact passenger vehicle. Certain vehicle manufacturing specifications are identified in **Table 1**.

**Table 1:** Certain vehicle specification data.

| Parameter | Feet | Inches |
|---|---|---|
| Overall length | 12.08 | 145 |
| Overall width | 5.25 | 63 |
| Wheelbase | 7.75 | 93 |
| Curb weight | 2303 lbs. | |
| Engine | 1.2-liter gasoline | |
| Transmission | Automatic | |
| Tire Pressure Monitoring | Direct | |

A review of the NHTSA safety recall database indicated no unfulfilled safety recalls for this vehicle preceding the crash.[8] A safety recall regarding corrosion of the secondary hood latch lever was announced in August 2022. This reported safety defect would have no detrimental influence on the circumstances related to this crash.

*August 25,2022*
*Manufacturer Recall Number:* *A222359300*
*NHTSA Recall Number:* *22V640*
*Recall Status:* *Recall Incomplete, remedy not yet available*
*Summary:*
*General Motors has decided that a defect which relates to motor vehicle safety exists in certain 2013 – 2015 model year Chevrolet Spark and 2014 – 2015 model year Spark EV vehicles. The secondary hood latch lever in these vehicles may prematurely corrode at the pivot. If severely corroded, the secondary latch striker may become stuck out of position and fail to properly engage.*
*Remedy:*
*Dealers will replace the hood striker assembly and hood latch assembly.*

[8] U.S. Department of Transportation, National Highway Traffic Safety Administration vehicle identification number (VIN) look up tool. (www.nhtsa.gov/recalls)

An additional VIN review identified the installation of certain supplemental airbag restraints that included first row driver and passenger frontal and knee airbags, and first and second row side airbags and side curtain airbags.

### 2.1.1 Vehicle Damage

Post-collision vehicle damage was photographically documented by OHP and NTSB investigators. Scene photographs depict the removal of the roof, rear hatch and passenger side front and rear doors with evidence of removal by emergency responders. Vehicle examination photographs taken later depict the additional removal of driver side front and rear doors as well as the B-pillar.

While post-collision dimensions were not provided, photographic imagery depict evidence of substantial contact damage at the driver side front of the vehicle. As depicted, evidence of direct contact encompassed the driver side front fender and A-pillar with some overlap of the left frontal surface. Similar structural displacement was observed to the driver side rocker panel. Photographs depict rearward displacement of the driver side floor pan that compromised apparent leg occupant leg room. On scene photographs depict substantial outward bowing of the driver's door.

Rearward displacement of the vehicle engine with the accompanying destruction of numerous engine compartment components were evident. The forward portion of a frontal structure identified as the engine cradle cross member protruded from the front of the vehicle. The structures above the cradle cross member, which included the engine and frontal body appeared to be displaced rearward relative to this structure. The right edge of the cradle exhibited evidence of override contact.

The passenger side front fender and body structure about the A-pillar and forward exhibited a displacement toward the driver side of the vehicle.

Post-collision photographs depict the seat belt latch plate for the front passenger seat still engaged with latch. A length of belt webbing ran through the latch plate loop. Belt webbing for the driver's seating position was observed to be spooled out but was cut or torn at some distance from the B-pillar spool. The latch plate remained attached to the webbing. Both rear seating position belts appeared intact with the webbing stowed against the seat backs/C-pillars. The latch plates were visible and attached to the webbing. **Figure 4** depicts a photograph of the Chevrolet during the post-collision examination by investigators.

**Figure 4**: Post-collision photograph depicting the frontal damage exhibited by the Chevrolet. The vehicle roof and driver's side B-pillar had been removed by emergency response personnel. Source: NTSB

## 2.2 Truck Tractor and Semitrailer Combination

The heavy vehicle involved was identified as a 1994 Peterbilt 397, three axle truck tractor. coupled to a 2017 Travis S/96 end dump body semitrailer. The Peterbilt was a conventional truck tractor configured with a day cab that exhibited a wheelbase of about 24 feet as measured from axle 1 to a midpoint between axles 2 and 3 post-collision. A photograph of the instrument cluster depicted a displayed mileage of 348,580 miles.

The trailer was further described as a quarter frame, end dump body, 30 feet in length. The trailer exhibited a three-axle configuration with the leading axle being a pneumatically operated lift axle. The VIN plate indicated a gross vehicle weight rating of 68,000 pounds.

Using sUAS photogrammetry project, the combination measured just under 52 feet in overall length.

### 2.2.1 Vehicle Damage

The truck tractor exhibited contact damage across the entire width of the vehicle front end, primarily at bumper height. The appearance of substantial contact deformation began near the right (passenger) side frame rail attachment point and extended laterally across the bumper face to the

left side. The contact damage created deformation to the face of bumper and displaced the lower edge (bottom) rearward. The frame attachment on the left side limited rearward displacement at that location. Additional contact damage and body deformation was observed to the right side of the hood's vertical face (just above the headlamps) and to the leading surface of the right front fender. **Figure 5** depicts a photograph of the Peterbilt post-collision.

While post-collision photographs depict the left steer axle tire as being deflated, the remaining nine tires on the Peterbilt appear intact and in operational condition.


**Figure 5**: Post-collision photograph depicting damage exhibited by the Peterbilt.
Source: NTSB

The trailer exhibited no evidence of damage or collision-related contact with the Chevrolet. Post-collision photographs depicted no detrimental structural concerns.

### 2.2.2 Vehicle Weight

At the time of the crash, the Peterbilt combination was reportedly transporting gravel. OHP investigators acquired axle end weights during their post-collision examination and reported the gross vehicle weight, absent the driver, was reported as 81,750 pounds. **Table 2** lists the individual axle end, and total axle weight for each of the six axles.

**Table 2:** Total axle weight for Peterbilt combination vehicle.

| Axle Location | Left (Driver) Side | Right (Passenger Side) | Total |
|---|---|---|---|
| Steering – 1 | 4,850 lbs. | 4,450 lbs. | 9,300 lbs. |
| Tractor Drive – 2 | 8,400 lbs. | 8,300 lbs. | 16,700 lbs. |
| Tractor Drive – 3 | 6,750 lbs. | 9,300 lbs. | 16,050 lbs. |
| Trailer Lift – 4 | 3,750 lbs. | 4,300 lbs. | 8,050 lbs. |
| Trailer – 5 | 7,800 lbs. | 8,600 lbs. | 16,400 lbs. |
| Trailer – 6 | 7,450 lbs. | 7,800 lbs. | 15,250 lbs. |
| Total | 39,000 lbs. | 42,750 lbs. | 81,750 lbs. |

On roadways other than interstate highways, Oklahoma regulates truck weight using the Federal Bridge Formula as provided in 23 U.S.C., Section 127.[9] Other restrictions include limitations on single axle weight to 20,000 pounds and a tandem axle limit of 34,000 pounds. Application of the Bridge Formula table, as also conveyed in Oklahoma Statute 47 §14-109, would limit the Peterbilt combination to a gross vehicle weight of 82,000 pounds.[10] As the vehicle was a truck tractor and dump semitrailer combination it was excepted from the Bridge Formula table that establishes weight limits based on axle spacing and number of axles.[11] No additional information regarding the cargo or its loading within the vehicle was available. As observed in the sUAS photographs, the load was covered by a tarp and otherwise could not be observed despite the open top trailer.

[9] Grandfathered exceptions may exist for certain highways that are part of the National Highway System.

[10] The permissible gross vehicle weight corresponds to the maximum axle spacing between the steer axle and last trailer axle. On-scene NTSB investigators measured the distance at 46.67 feet (rounded to 47 feet), which corresponds to 82,000 lbs. OHP investigators later conferred a measured distance of 47.08 feet (rounded to 48 feet), which would correspond to a permissible gross vehicle weight of 83,000 pounds.

[11] 47 O.S. § 14-109B - Except as to gross limits, the table in subsection A of this section shall not apply to a truck-tractor and dump semitrailer when used as a combination unit. In no event shall the maximum load in pounds carried by any set of tandem axles exceed thirty-four thousand (34,000) pounds for vehicles exempt from the table; however, any vehicle operating with split tandem axles or tri-axles shall adhere to the table. (As conveyed in paragraph A)

## 3.0 Electronic Data – Chevrolet

### 3.1 Airbag Control Module Event Data Recorder

With limited exceptions, light duty vehicles (GVWR of 3,855 kg/8,500 pounds or less) manufactured on or after September 1, 2012, if equipped with an event data recorder must comply with rules promulgated under 49 Code of Federal Regulations Part 563. As defined by Part 563, an event data recorder (EDR) means a device or function in a vehicle that records the vehicle's dynamic time-series data during the time period just prior to a crash event (e.g., vehicle speed vs. time) or during a crash event (e.g., delta–V vs. time). The regulation defines data elements, sample rate, range, accuracy, and resolution. In most all cases, the light duty EDR function is contained within the supplemental restraint system (SRS) control module – typically the airbag control module (ACM). EDR records are typically written when the ACM interprets that an event threshold is met based on data received by sensors within or connected to the module. ACM EDR data can generally be read by commercially available equipment although not all vehicles can be accessed by the same equipment. For this crash, police investigators were able to image data from the Chevrolet's airbag or sensing and diagnostic module (SDM).[12]

Most ACM EDRs are capable of recording multiple events depending upon timing, event thresholds and magnitude and recording priority. Events not reaching a threshold for being "locked" can be overwritten by subsequent events of greater magnitude. When data is "locked," subsequent events may not be recorded. As a result, data depicting multiple events may not include all events in the chain of events and may not completely describe the chronology of a multiple event crash.

One event record, classified as a deployment event, was recovered from the Chevrolet.[13] System status data indicated the occurrence of one event. The seat belt buckle status was monitored only for the two front seats – driver and passenger – and indicated that both belts were buckled (latch plate inserted into buckle). One diagnostic trouble code (DTC) was recorded indicating that an SRS deployment command had been issued.

The event was consistent with observed vehicle damage and collision configuration. A reported maximum longitudinal change in velocity of -55 mph (160 milliseconds after time 0) was consistent with a frontal impact.[14] A reported maximum lateral change in velocity of 25 mph (132 milliseconds after time 0) was consistent with a left (driver to passenger) side impact. Deployment commands were issued for the driver and front passenger side seat belt pretensioners and frontal airbags (1st stage) at 3 milliseconds after time 0. At 4 milliseconds a deployment command was issued for side airbags on both the driver and passenger side of the vehicle. At 5 milliseconds a command was issued for deployment of the frontal airbags 2nd stage.

---

[12] Sensing and Diagnostic Module (SDM) is the term used by General Motors Company to identify their airbag control module.

[13] Technical Reconstruction Attachment - Chevrolet SDM/EDR Report – Bosch Crash Data Retrieval System.

[14] "Time zero" is defined as "beginning of the crash event" and is the time at which the ACM algorithm is activated, a specific Delta-V is exceeded, or a non-reversible restraint device is deployed. Time zero may be defined differently for front, side, rear, and roll-over events. All the precrash, event, cumulative change in velocity data, deployment times etc., are relative to "time zero".

Five (5) seconds of precrash data (up to time zero) that reported multiple vehicle performance parameters were also retrieved. The data was reported at a rate of 2Hz (twice per second).[15] Time 0 or impact occurred within the final ½ second of the reported precrash record.[16] Precrash data is summarized in **Table 3**.

**Table 3**: Chevrolet EDR precrash data table

| Time (seconds) | Speed-Indicated (mph) | Accelerator Pedal[17] (% full) | Engine Throttle[18] (% full) | Engine RPM | Service Brake-Brake Switch |
|---|---|---|---|---|---|
| 5.0 | 1 | 17 | 30 | 1408 | Off |
| 4.5 | 3 | 25 | 39 | 1920 | Off |
| 4.0 | 6 | 0 | 33 | 2176 | Off |
| 3.5 | 7 | 0 | 22 | 1856 | On |
| 3.0 | 7 | 47 | 30 | 1728 | Off |
| 2.5 | 9 | 54 | 75 | 2624 | Off |
| 2.0 | 12 | 54 | 83 | 3264 | Off |
| 1.5 | 15 | 58 | 99 | 3840 | Off |
| 1.0 | 17 | 99 | 99 | 4480 | Off |
| 0.5 | 21 | 99 | 99 | 4928 | Off |

As illustrated by the precrash data, for the approximate 5 seconds before the crash the Chevrolet was in motion with only evidence of a momentary brake application at about 3.5 seconds before impact.[19] The data then exhibit notable changes at the 4- and 2.5-second samples. At about 4 seconds precrash, the accelerator pedal reports 0% application. This data is repeated at the 3.5 second sample concurrent with the brake application. In contrast, the 2.5 second sample depicts a sharp increase in both the accelerator pedal and engine throttle percent data. Between about 1.5 and 1.0 seconds before impact, both the accelerator pedal and engine throttle percentage depict an increase to 99%. At the final data sample, the reported vehicle speed was 21 mph. **Figure 6** provides a graphical depiction of the precrash data.

[15] Recorded asynchronously and reported to nearest interval.
[16] The 0.5 second Pre-crash data value (most recent recorded data point) is the data point last sampled before Time Zero. That is to say, the last data point may have been captured just before Time Zero but no more than 0.5 second before Time Zero. All subsequent Pre-crash data values are referenced from this data point.
[17] Indicates the position of the position of the accelerator as a percent of full application.
[18] Indicates the actual position of the engine throttle blade as a percent of full application.
[19] Brake switch circuit Status indicates the open/closed state of the brake switch circuit.

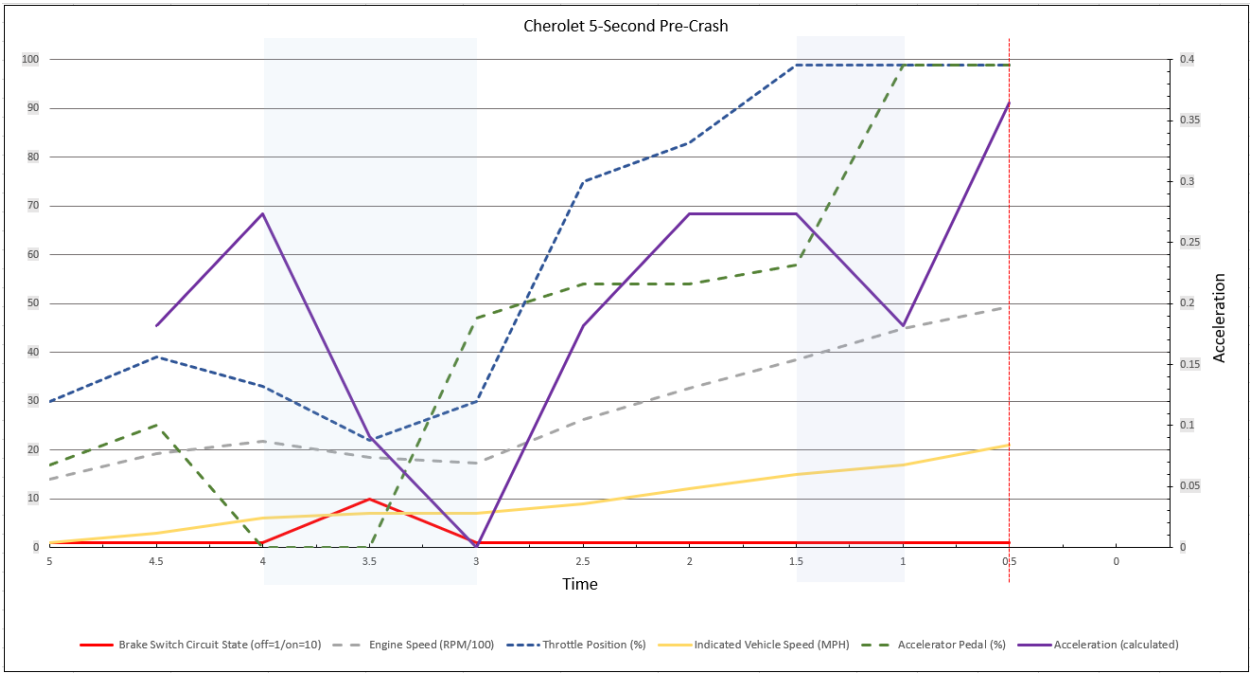


**Figure 6**: Precrash data depicted in graphical format

## 3.2 Chevrolet OnStar® Track Data

During the investigation, OHP investigators provided NTSB investigators with a .kml file that was identified as vehicle track log data from the Chevrolet's OnStar application.[20,21] The file included a total of 96 track logs which when opened in the Google Earth application mapped tracks along numerous highways. Of the tracks identified in the file, four (4) were dated the day of the crash.

Regarding the track logs on the day of the crash, the first indicated a stationary position that mapped to a residence near US-377 approximately 15 miles north of the city center at 9:04 am. The start of the second track was time stamped at 9:33:12 am on US-377 about 2.9 miles north of the SH-22 intersection. This second track, as mapped, terminated at the Tishomingo High School parking lot (adjacent to S. Chisholm Ave) at time stamp 9:41:51 am. The third track initiated at the terminating point for the second track at the high school with a start time of 11:29:52 am. The third track continued west on SH-22 and then approximately 1.3 miles north on S. Bullet Prairie Road where it terminated at a residence at 11:43:31 am. The fourth and final track initiated at 12:12:53 pm, beginning at the terminus for track three, and backtracked to eastbound SH-22. This fourth track, indicating eastward movement, terminated at time stamp 12:16:23 pm on SH-

[20] "kml" - Keyhole Markup Language is an XML notation for expressing geographic annotation and visualization within two-dimensional maps and three-dimensional Earth browsers. KML was developed for use with Google Earth.
[21] OnStar Corporation is a subsidiary of General Motors that provides subscription-based communications, in-vehicle security, emergency services, turn-by-turn navigation, and remote diagnostics systems.

22 approximately 0.62 miles west of (before) the crash location. The final time stamp was about three minutes before the reported time of the crash.

## E. DOCKET MATERIAL

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

- Chevrolet SDM/EDR Report – Bosch Crash Data Retrieval System

END OF REPORT

Robert J. Squire
Highway Accident Investigator