National Transportation Safety Board
Office of Highway Safety
Washington, DC 20594

HWY23MH017

TECHNICAL RECONSTRUCTION

Group Chair's Factual Report

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A. CRASH INFORMATION

Location: Teutopolis, Effingham County, Illinois
Date: September 29, 2023
Time: 8:41 p.m. CDT

B. TECHNICAL RECONSTRUCTION GROUP

Group Chair	Eric Gregson National Transportation Safety Board
Group Member	Trooper Jeremy S. Mueller Illinois State Police

C. CRASH SUMMARY

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

D. DETAILS OF THE INVESTIGATION

The Technical Reconstruction Group Chairman's Factual Report is based on a collection of information from the Illinois State Police (ISP) which included photographs, reports, documents, and data. Further support was provided through the examination and documentation of the crash scene, the combination vehicle, and the utility trailer involved in the crash.

The report begins with a description of the crash event and location, continuing with the documentation of the scene which involved terrestrial photography, small, unmanned aircraft system (sUAS) aerial photography, and three-dimensional scanning.[1] Photographs were taken in digital format and scanning was accomplished using a combination of terrestrial laser scanning and the Recon3D scanning application.[2] The aerial photographs were gathered using a DJI Phantom 4 Professional V2. The report concludes with a description of the damage to the combination vehicle and parked utility trailer associated with the crash event and a discussion of the electronic data obtained from the combination vehicle.

[2] Recon3D is a scanning application that utilizes the Lidar on the Iphone. The application uses the Everypoint engine and combines the lidar with video frames. The combination provides a photogrammetry plus lidar model.

The crash involved a 2005 International 9900ix truck-tractor in combination with a 1978 Mississippi Tank Company MC331 cargo tank semitrailer (combination vehicle), traveling west on US Route 40, and a 2021 Sure-Trac utility trailer (utility trailer) that was parked approximately 27 feet north of the westbound travel lane. At the time the combination vehicle departed the roadway a 2013 Toyota Sienna was overtaking it within a marked no passing zone. The combination vehicle traveled off the roadway, overturning, and colliding with the front of the parked utility trailer.

E. FACTUAL INFORMATION

1.0 Location

The crash events began on U.S. Route 40 in Teutopolis, Effingham County, Illinois, at the Global Positioning System (GPS) coordinates of 39.141005° latitude and 88.438401° longitude. U.S. Route 40 consisted of two travel lanes, one westbound and one eastbound with adjoining shoulders. Approximately 529 feet east of where the combination vehicle exited the roadway began a no passing zone for westbound vehicles. The shoulders were constructed of asphalt and aggregate and measured approximately 3 feet wide where the combination vehicle exited the roadway. A drainage channel paralleled the westbound lane. At the end of the drainage channel was a non-commercial driveway. Beneath the non-commercial driveway was a corrugated metal pipe which provided drainage under the driveway. Figure 1 depicts a photograph of US Route 40 and the drainage channel looking westbound, direction the combination vehicle was traveling. Figure 2 is a map depicting the location of the crash.

Figure 1. Photograph depicting US Route 40 and drainage channel. Photograph is looking westbound.

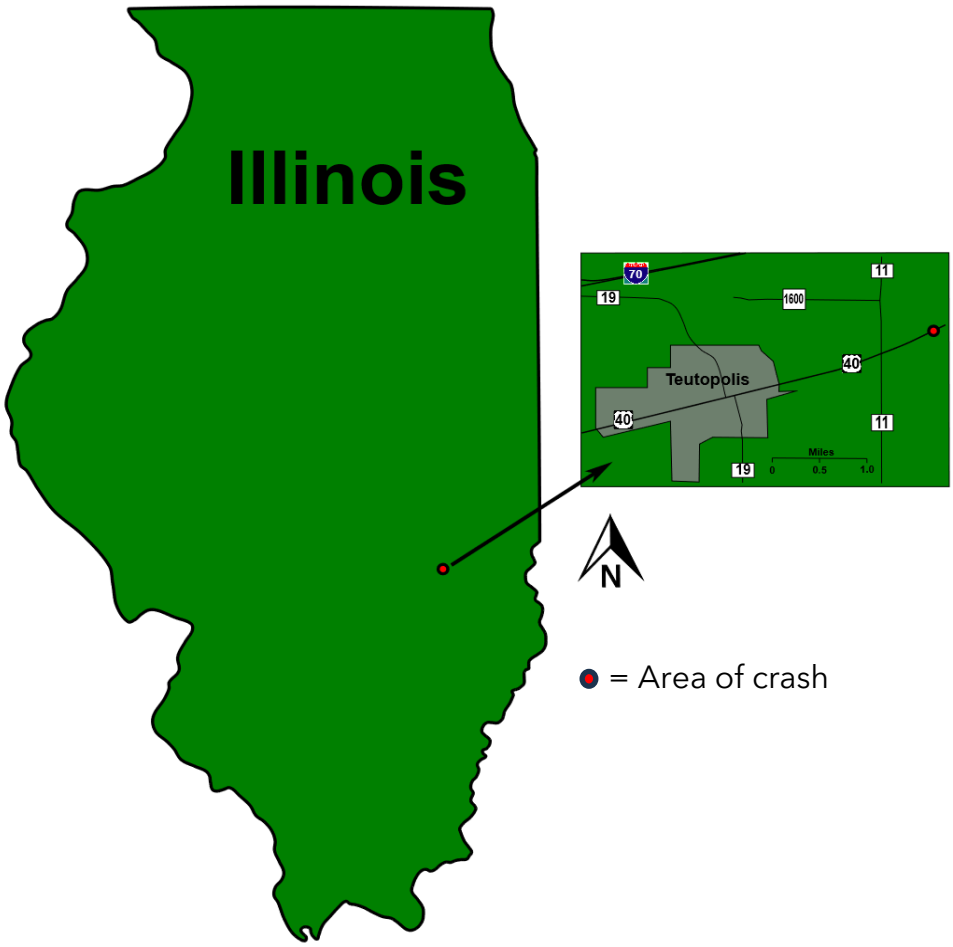

Figure 2. Map showing the approximate location of the crash.

2.0 Post-Collision Site Documentation and Evidence

On October 1st, 2023, NTSB investigators conducted a detailed examination and documentation of the crash scene. During the examination, the roadway layout, design, markings, and physical evidence were all documented utilizing digital photography, which included aerial photographs obtained with an sUAS. The sUAS images were processed using Pix4DMapper photogrammetry software from which three-dimensional point clouds and two-dimensional orthomosaic images were rendered for analysis.[3]

[3] 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. An orthomosaic is an image with high detail and resolution made by combining many smaller images and is corrected for lens distortion, camera tilt, perspective, and topographic relief.

During their on-scene investigation, ISP investigators had marked, with yellow and orange marking paint, six ground control points (GCPs), numbered 1 through 6, beginning west of the crash scene, progressing eastward, and concluding east of the crash scene.[4] ISP electronically documented the GCPs utilizing a Leica Robotic Total Station and a sUAS, providing NTSB investigators with the GCP data in an electronic file.

NTSB investigators identified a tire mark (A) on the westbound shoulder consistent with the direction of travel of the combination's front axle. The single tire mark was approximately 283 feet east of the impact with the corrugated metal pipe and transverse slope, area of impact (AOI). The mark began at the pavement edge and continued for approximately 45 feet at an angle of about 2.0° relative to the roadway. The tire mark continued along the gravel shoulder increasing to an angle of approximately 3.0° for approximately 85 feet where it then transitioned to the grass. Here the combination vehicle experienced a change in topography. The combination vehicle transitioned from the relatively level shoulder to the approximate 11° foreslope of the drainage channel.

As the right side of the combination vehicle entered the grass, two additional tire imprints (B) were identified in the grass, consistent with the right side of axles two and three. The imprints continued, together, northwestward traversing the foreslope of the drainage channel. As the combination vehicle continued traveling northwestward an additional tire mark (C) was identified being consistent with the left side of the front axle; the tire mark appeared on the westbound gravel shoulder about 156 feet east of the AOI and approximately 145 feet west of the onset of the right-side tire mark. As the right-side of the combination vehicle entered the bottom of the drainage channel it turned left, traveling west parallel to the roadway. The imprints, which were approximately 12 feet north of the westbound travel lane, continued westward along the bottom of the drainage channel, transitioning to furrows, for about 130 feet until terminating at the transverse slope on the eastern side of the non-commercial driveway.[5] The 12-inch diameter metal corrugated pipe extruded out into the drainage channel exposing approximately 3 feet of pipe. The entire right side of the exposed pipe was collapsed inward with a puncture about midway down the exposed pipe. A soil scuff mark was identified beginning approximately 38 feet northeast of the AOI along the back slope of the drainage channel. The disturbed area measured approximately 40 feet in length by 2.5 feet wide and extended westward parallel with the drainage channel and furrows. The mark was consistent with being created by the side of the cargo tank semitrailer. Figure 3 is an image of the two-dimensional orthomosaic depicting the evidence described above.

[4] Ground control points – points on the surface that have known coordinates. The points are then utilized to geo-reference the points with the rendered three-dimensional point cloud.
[5] See Highway Group Chair's Factual Report for additional drainage channel details.

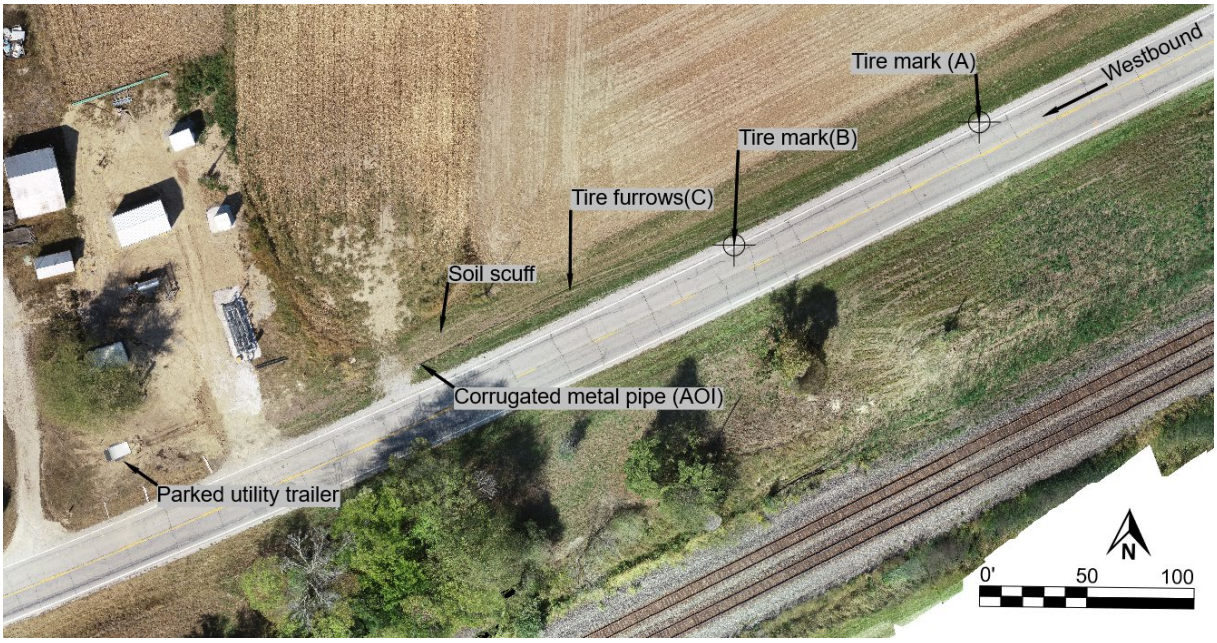

Figure 3.Cropped image of the two-dimensional orthomosaic identifying the areas of evidence discussed above.

Continuing westward, after the approximate 24-foot-wide non-commercial driveway, was an open area of dirt and grass, ending at a commercial driveway. The commercial driveway was about 24 feet wide, which led to another area of open dirt ending at a residential driveway. Figure 4 is an image from the two-dimensional orthomosaic depicting the layout of the three described driveways.

Figure 4. Cropped image from the two-dimensional orthomosaic depicting the layout of the three driveways.

Vehicle parts and debris were scattered around the drainage channel and across the non-commercial driveway in a westward direction. The grass/dirt area between the

commercial and non-commercial driveways was furrowed with areas of grass displaced westward. The surface evidence continued west across the commercial driveway transitioning into the dirt area west of the commercial driveway. There was a furrow in the dirt beginning at the west edge of the driveway extending westward, approximately 99 feet west of the AOI, measuring about 37 feet in length by 2.5 feet in width. The end of the furrow was cylindrical and consistent with the shape of the cargo tank semitrailer. At the end of the furrow was an area approximately 29 sq-ft consisting of deep furrows and disturbed dirt. Another area approximately 167 sq-ft was just south of the furrow and consisted of disturbed dirt with four separate smaller areas of fluid-soaked dirt.

Continuing westward, three parallel furrows were identified. The middle of the three furrows began approximately 8 feet west of the smaller area of disturbed dirt and measured about 19 feet in length. The outer two furrows began about 6-feet west of the middle furrow and measured approximately 17 feet in length. The distance between the two outer marks was about 8 feet which was consistent with the width of the utility trailer. Figure 5 below is an overhead view of the crash scene. Labeled on the image are the identified areas of evidence described above.

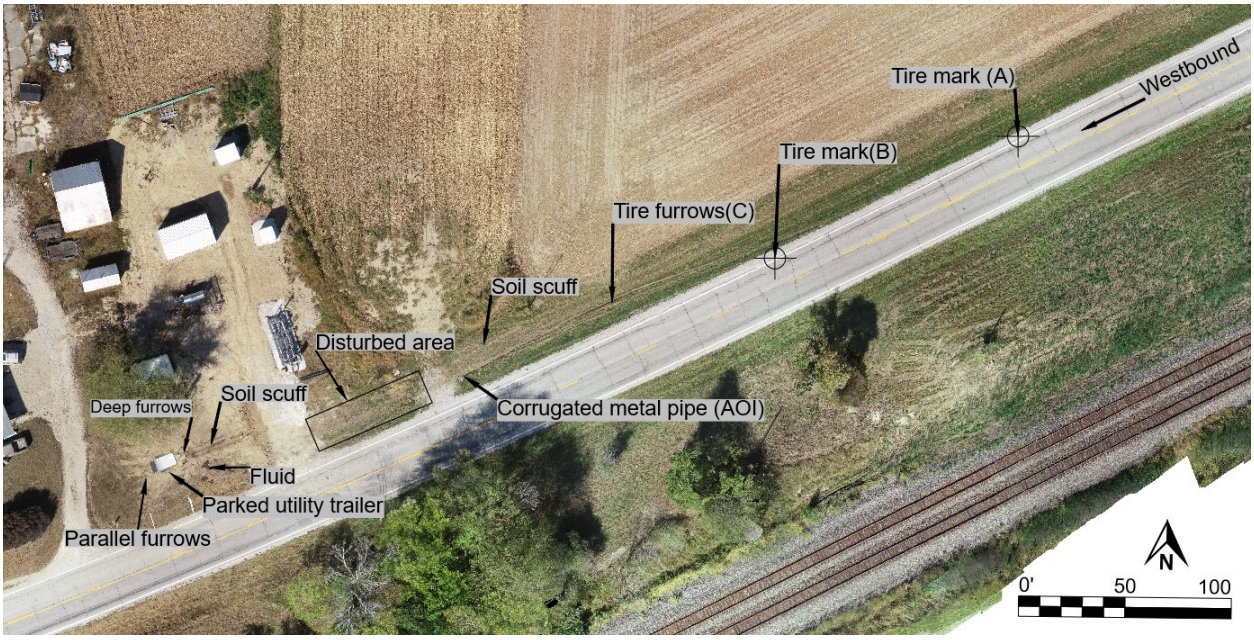

Figure 5. Cropped image from the two-dimensional orthomosaic depicting all described evidence.

3.0 Vehicle Documentation

One commercial combination vehicle and a parked loaded utility trailer were involved in the crash. At their final rest positions, both vehicles were located off the westbound side of the roadway in the area between the residential driveway and the

commercial driveway. It should be noted that two passenger vehicles and two additional commercial combination vehicles were involved in post-crash events resulting from the hazardous material release.[6] The involved combination vehicle and utility trailer were inspected at Heartland Towing and Recovery, located in Effingham, Illinois, between October 1st and October 4th, 2023.

3.1 2005 International 9900ix truck tractor in combination with a 1978 Mississippi Tank Company MC331 cargo tank semitrailer

At final rest, the International combination was off the roadway in the dirt area between the residential driveway and commercial driveway approximately 22 feet north of US Route 40. The cargo tank semitrailer was aligned with the roadway and lying on its right side. The truck tractor remained coupled with the cargo tank semitrailer. The truck tractor had rotated approximately 155-degrees and was facing southeast relative to the cargo tank and was on its left side. The combination vehicle traveled approximately 422 feet after leaving the westbound travel lane. Figure 6 depicts the combination vehicle in its position of rest.

Figure 6. Overhead image of the combination vehicle at final rest. (Source: ISP edited by NTSB)

[6] Refer to Vehicle Factors Group Chair's Factual Report for additional vehicle information.

The truck tractor exhibited contact damage around the entirety of the vehicle. The hood with integrated fenders and roof had been torn from the vehicle. The cab portion was broken from the frame and displaced rearward. The windshield was shattered with the top of both "A" pillars pushed inward. Along the left side (driver's side) the corner of the front bumper was bent and displaced outward from the wheel. There was dirt in the air cleaner, "A" pillar, driver's door, exhaust stack and along the left side of the sleeper birth coupled with linear scrapes/scratches. The rear wall of the sleeper cab was separated from the sides of the sleeper cab with the top displaced rearward.

The right-side (passenger side) dual tire set on axle two and axle three were displaced rearward. Continuing forward along the right-side, the side of the sleeper cab separated from the rear wall and the top was displaced inward and downward. Longitudinal scrape and scratch marks were observed along the length of the saddle tank and the cover for the storage box above the side-step was missing. The right-side air cleaner had been torn from the "A" pillar and dirt had accumulated in the front cowl. The bottom of the front bumper was displaced rearward. Figure 7 are two images of the generated three-dimensional point cloud of the International truck tractor. The images depict the damage sustained during the crash event.

Figure 7. Three-dimensional point cloud images of the of the International truck tractor depicting the damage sustained from the crash.

3.2 1978 Mississippi Tank Company Cargo Tank

The damage to the cargo tank was concentrated to the front and right-side. Beginning just aft of the tank head, longitudinally along the center line of the cargo tank, were scrape/scratch marks coupled with soil that had accumulated along the side. The scratch marks and accumulation of soil extended rearward for approximately 24 feet. An additional scrape/scratch mark was identified that extended from the top of the cargo tank rearward terminating just above the centerline. The scrape mark measured about 32 feet long and was at an approximate 3.4-degree angle in relation to the center line of the cargo tank. The hose tube, along the right side, was displaced down and inward. The front of the fender was displaced rearward, and the rear of the fender was displaced upward. The right-side of the bumper was bent and displaced

rearward. The damage was characteristic of a ½ turn rollover event. Figure 8 is an image of the right-side of the cargo tank depicting the scrape/scratch marks, soil accumulation, and damage sustained.

A puncture was identified on the tank head located at approximately 11 o'clock, when looking directly at the front of the tank. The puncture measured approximately 7-inches in length and 4-inches wide. A metal frame located above the puncture was broken and displaced upward.

Figure 8. Image of the right-side of the cargo tank semitrailer.

Figure 9. Image of the cargo tank semitrailer head depicting puncture.

Figure 9 above is a photograph of the front of the cargo tank semitrailer depicting the puncture and damage to the metal frame. The inset image in the lower right corner is a close-up of the puncture.

3.3 2021 Sure-Trac Utility Trailer

The second vehicle involved in the collision was identified as a 2021 Sure-Trac Utility Trailer that was 16-feet long and 8-feet wide. The utility trailer was positioned in the dirt area between the commercial and residential driveways. At its position of final rest, the trailer was approximately 33 feet west of and in line with the combination vehicle. The right-side trailer tongue support rail was displaced inward while the lunette ring and plate was displaced to the right. The trailer jack was collapsed with the foot bent to the right. The right front corner sustained damage to the sheet metal, internal wooden structure, and frame rails exposing the interior of the trailer. Figure 10, below are two images of the utility trailer showing the damage to the right front corner and the trailer tongue and lunette ring.

Figure 10. Photograph depicting the damage to the right front corner of the trailer. Right photograph shows damage to the tongue and lunette ring (Source: ISP).

4.0 Electronic Data

4.1 2005 International 9900ix

The International truck tractor was equipped with a Cummins ISX-500 diesel engine. The engine is controlled by several controllers which are generally referred to as electronic control modules (ECM). The ECM may be capable of recording and storing engine data relating to engine and vehicle parameters. Depending on engine and vehicle setup, the data may be recorded and stored on a single module or multiple modules. As mentioned in the NTSB Vehicle Factors Group Chair report, imaging of the Cummins ECM was conducted by ISP investigators.[7] The imaging process was observed by NTSB investigators. Copies of the imaged data were provided by ISP investigators.[8]

Aside from engine management and operation, the ECM processes certain electronic data related to engine usage and information, fault codes, electronic and sensor programming, and event data that may be stored and later accessed. Event data consists of acceleration-triggered events including sudden decelerations. The event data is reported in time-series format for a period before and after the triggering event. In the event of a crash, the data associated with triggered and recorded events may be useful in the analysis of the pre-crash vehicle movements and driver actions.

The ECM on the Cummins engine was identified as a CM870, with the capability of recording an acceleration triggered event (e.g., sudden deceleration). A sudden deceleration is typically set by a change in vehicle speed of ±9 mph/sec and when recorded, data is reported for 59 seconds before and 15 seconds after the trigger at 1 second intervals. Parameters with this data may include vehicle speed (mph), engine speed (rpm), engine load (%), throttle (%), brake status (on/off), clutch status (on/off),

[7] See Vehicle Factors Group Chair's Factual Report for imaging process.
[8] See Technical Reconstruction Attachment – Cummins ISX-500 ECM Report

cruise status (on/off), and lamp status (on/off). The ECM can record up to three sudden decelerations each individually identified with the ECM run time at occurrence (HH:MM:MM) and occurrence distance (miles).[9]

The imaged data revealed three records or "Sudden Vehicle Speed Deceleration Report Record". Each separate record reported the distance and ECM run time at occurrence which can be seen in Table 1.

Table 1. ECM times and distances at each occurrence.

Record Name	ECM Run Time	Distance
Sudden Deceleration Record #1	2341:37:31	1,699,057.7
Sudden Deceleration Record #2	2694:33:26	1,708,066.5
Sudden Deceleration Record #3	2951:13:12	1,714,159.9

The data also included other attributes which included a Trip Detail Report. The Trip Detail Report included numerous parameters, including the total engine distance at the time of imaging, which was reported at 1,715,338.03 miles.[10]

4.2 Samsara DriveCam

The International truck tractor was equipped with a Samsara model CM31 forward-facing camera that was capable of recording video. NTSB investigators were provided with a short video that depicted the operation of the combination vehicle leading up to the crash events. The video was approximately one-minute in length. In the upper right corner was the date and time stamp (YYYY MM DD, HH:MM:SS) in central daylight time. Below the date and time was the reported speed of the combination and the speed limit. Figure 11 is an image from the start of the forward-facing camera video. In the image the front of the truck tractor hood and US Route 40 are visible. Also visible is the light projected onto the roadway from the truck tractors illuminated headlights. The date and time as well as the reported vehicle speed and roadway speed limit are visible.[11]

[9] ECM run time is the amount of time the ECM has been under power for the life of the ECM. The ECM run time includes idle time.
[10] The most recent event "Sudden Deceleration Record #3" was recorded approximately 1,178.13 miles prior to the ECM imaging.
[11] See Technical Reconstruction Attachment – Samsara Forward-Facing Video

Figure 11. A screen capture from the forward-facing video showing the view from the combination.

Approximately 8 seconds later (08:41:28) the combination continued westbound, in the distance is the residence and commercial property where the crash event occurred. The speed was reported at approximately 60 mph. Figure 12 below is a screen capture at this time.

Figure 12. A Screen capture at time 08:41:28.

At approximately 08:41:32, as the combination continued westbound, illuminated headlights became visible in the eastbound lane. Also visible is the "No Passing Zone" sign located off the eastbound side of the roadway. The reported speed was approximately 60 mph. Figure 13 is a screen capture at this time.

Figure 13. A screen capture at time 08:41:32.

Prior to 08:41:45 the combination was observed to be travelling within the westbound travel lane. At this time the combination began a rightward movement toward westbound shoulder and had slowed to approximately 59 mph. Approximately two seconds later at 08:41:47 the right front of the combination crossed the shoulder and entered the grass slowing to approximately 56 mph; at the same time the right front headlight of another westbound vehicle is visible to the left of the combination. The vehicle was overtaking the combination with a vehicle traveling within the eastbound lane. Figure 14 is a screen capture taken at 08:41:47.

The combination continued rightward off the roadway, as the taillights of the overtaking vehicle, occupying both the east and westbound lanes, became visible. The eastbound vehicle is clearly visible as depicted in Figure 15 below.

Figure 14. A screen capture of time stamp 08:41:47.

Figure 15. A second screen capture at time 08:41:47.

Figure 16 below is an additional screen capture from 08:41:47. It shows the overtaking vehicle in the westbound lane narrowly avoiding a collision with the eastbound vehicle.

Figure 16. Additional screen capture from time 08:41:47.

As seen in Figure 17 below at the time of 08:41:49 the overtaking vehicle has reestablished their position within the right lane and the right side of the combination is in the drainage channel. The combination continued westward in the drainage channel and had slowed to approximately 53 mph.

Figure 17. Screen capture from time stamp 08:41:49.

Figure 18 below is a screen capture from one second later at 08:41:50. The combination had fully entered the drainage channel, began to overturn, and impacted the transverse slope of the drainage channel. Also visible in the is the parked utility trailer that was impacted by the cargo tank trailer.

Figure 18. A screen capture from time stamp 08:41:50.

4.3 Samsara Telemetry Data

The cargo tank was equipped with a Samsara fleet tracking device that transmitted telematic data to Samsara Inc. and the Detailed Vehicle Activity Report was provided to NTSB investigators by Samsara Inc. The activity report provided parameters that depicted elements of vehicle position and time. The data covered the date of September 29th, 2023, beginning at 7:18 a.m. and concluding at 8:42 p.m. central daylight time. The table identified the cargo tank as TR18 and included date/time, speed (mph), speed limit (mph), latitude, longitude, status, and location reported in one-minute intervals. The last location data point was approximately 0.70 mile west of the crash location. Samsara also provided an area map depicting the vehicle position as derived from the telematic data which can be seen in Figure 19.

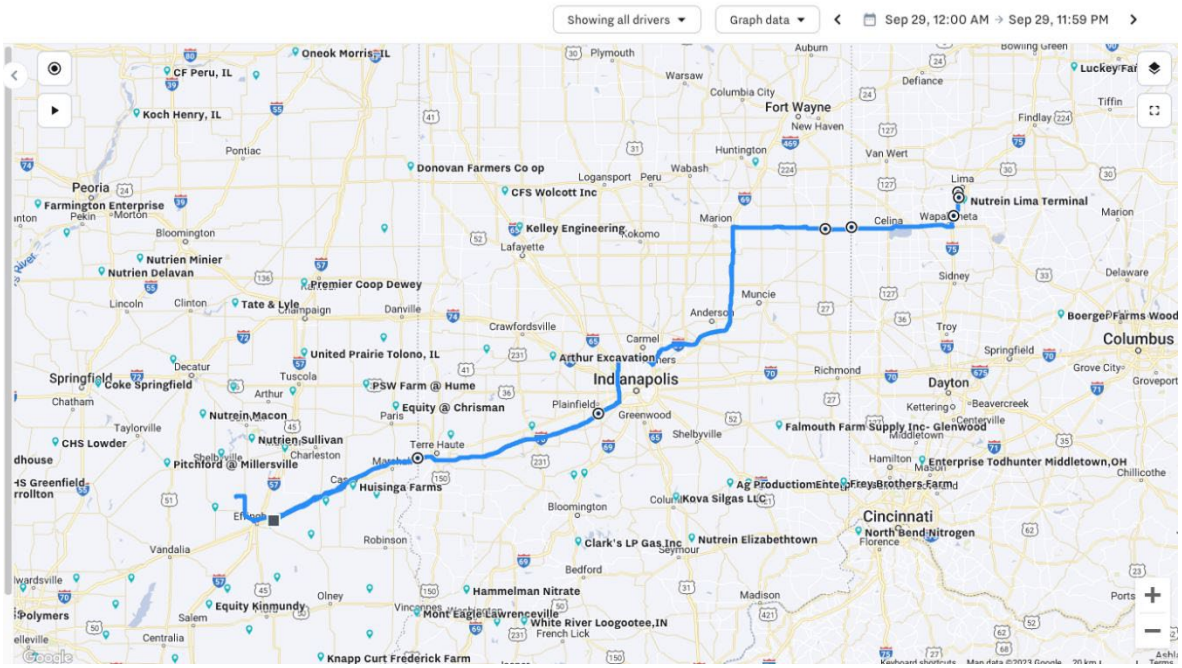

Figure 19. Map image provided by Samsara depicting cargo tank position as derived from the telematic data.

Because the system continuously provides geographic positions (GPS), when integrated with time, the GPS can be utilized to determine an average speed. Figure 12 is a graph showing the reported speed of the cargo tank as well as the reported speed limit for the 16-minutes leading up to the collision event.[12]

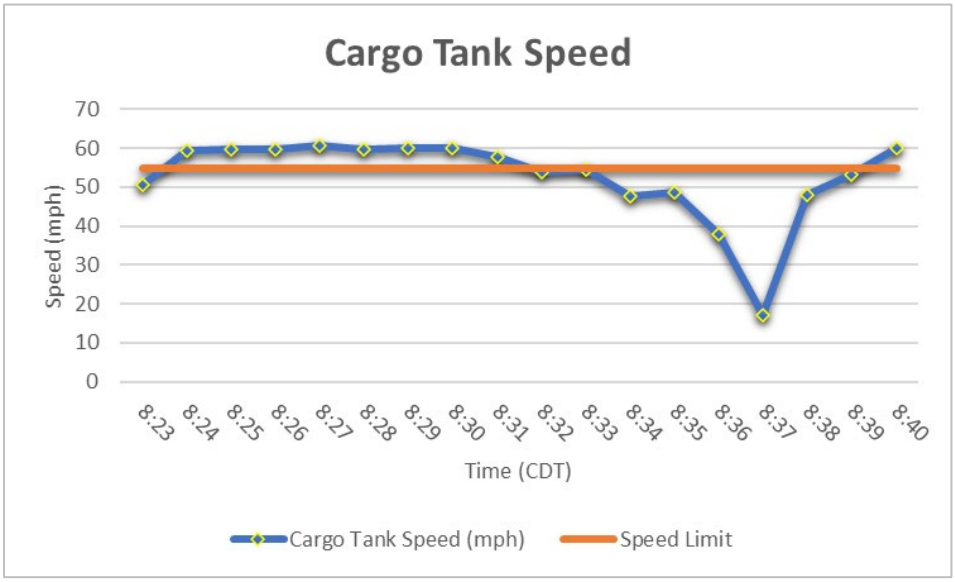

Figure 20. Graph representing the average cargo tank speed and roadway speed limit.

[12] See Technical Reconstruction Attachment – Detailed Vehicle Activity Report

F. REFERENCES

NTSB Vehicle Factors Group Chair's Factual Report
NTSB Motor Carrier Group Chair's Factual Report

G. DOCKET MATERIAL

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

Technical Reconstruction Attachment: Cummins ISX-500 ECM Report

Technical Reconstruction Attachment: Samsara Forward-Facing Video

Technical Reconstruction Attachment: Detailed Vehicle Activity Report

Submitted by:

Eric Gregson
Highway Crash Investigator