March 19, 2025 HIR-25-01

Combination Vehicle Rollover, Fire, and Interstate 95 Overpass Collapse

Philadelphia, Pennsylvania
June 11, 2023

On June 11, 2023, about 6:17 a.m., a 2017 International truck-tractor in combination with a 2004 Heil Specification Package 406AL tank trailer (truck) was exiting northbound Interstate 95 (I-95) at the Cottman Avenue exit in Philadelphia, Pennsylvania.[1] At this location, I-95 is an eight-lane divided highway with four lanes each in the northbound and southbound directions. In the area of the Cottman Avenue exit, the posted speed limit on I-95 is 55 mph with an advisory speed limit of 25 mph for the exit ramp. The truck, operated by Penn Tank Lines, was transporting about 8,500 gallons of gasoline from Wilmington, Delaware, for delivery to a convenience store in Philadelphia. As the truck traversed the exit ramp at an estimated speed of 44–54 mph, the driver lost control on the decreasing-radius, leftward curve, causing it to roll onto its right (passenger) side and strike the adjacent concrete barrier. A subsequent fire destroyed the truck and caused the collapse of the northbound overpass lanes of I-95. The truck driver was fatally injured as a result of the crash and postcrash fire. The southbound I-95 lanes adjacent to the northbound overpass collapse were also damaged by the postcrash fire and deemed unsafe after the Pennsylvania Department of Transportation (PennDOT) conducted a postfire inspection.

[1] (a) In this report, all times are eastern daylight time. (b) Visit ntsb.gov to find additional information in the public docket for this NTSB investigation (case no. HWY23FH014). Use the CAROL Query to search safety recommendations and investigations.

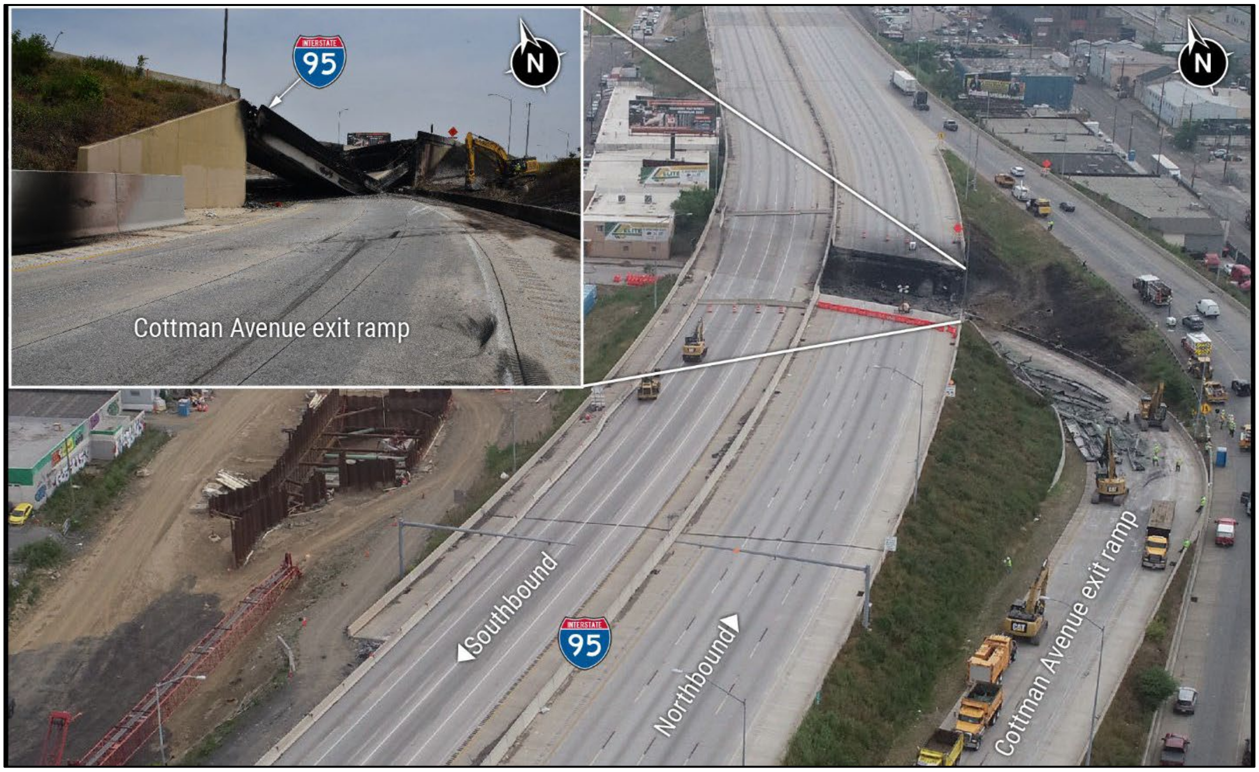

Figure 1. View of crash location on Cottman Avenue exit ramp and I-95 in vicinity of crash.

Location	Interstate 95, on northbound Cottman Avenue (Exit 30) exit ramp
Date	June 11, 2023
Time	06:17 a.m. eastern daylight time
Involved vehicles	1 (2017 International truck-tractor in combination with 2004 Heil Specification Package 406AL tank trailer)
Involved people	1 (truck driver)
Injuries	1 fatal (truck driver)
Weather	Dry, clear, and daylight
Roadway information	Interstate highway exit ramp, two travel lanes with usable right shoulder, descending-grade roadway with sharp left curve under the interstate

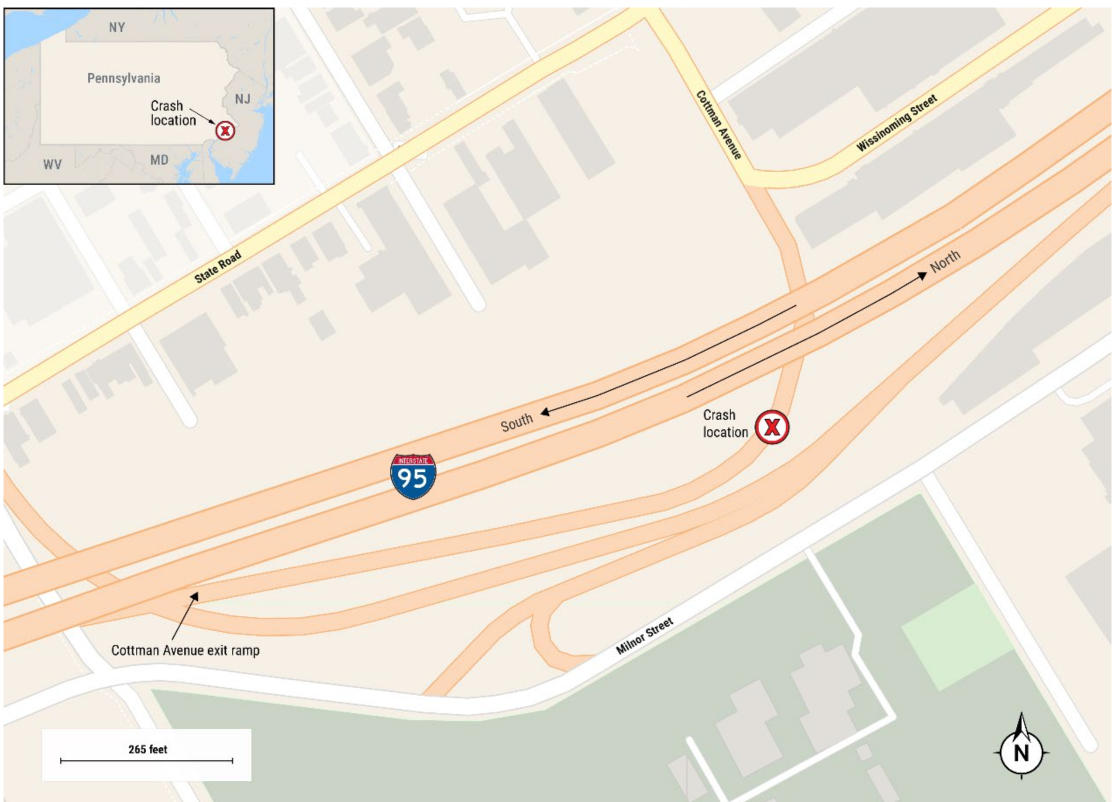

Figure 2. Map showing crash location. (Source: Google Maps; annotated by NTSB)

1. Factual Information

1.1 Background

1.1.1 Roadway Design and Signage

The crash occurred on the exit ramp connecting northbound I-95 to Cottman Avenue in Philadelphia City/County, Pennsylvania. The exit ramp consisted of two marked lanes with a usable right shoulder.[2] The exit ramp had a negative (downhill) grade of approximately 2.3% that led to a decreasing-radius, leftward curve underneath I-95. The leftward curve was about 567 feet long with a radius of about 300 feet. The right shoulder varied in width between 8 and 14 feet and was constructed with an approximate negative (downhill) cross-slope of 2.0% from left to right in the direction of travel.[3] The left lane of the ramp was constructed with an approximate positive (uphill) cross-slope of 6.0%, meaning that the ramp was banked to assist drivers in navigating the leftward curve. The cross-slope break from the exit ramp onto the right shoulder was 8.0%, conforming with American Association of State Highway and Transportation Officials (AASHTO) guidance, which advises that the maximum cross-slope break between the traveled roadway and usable shoulder should not exceed 8.0% (AASHTO 2018). Grooved longitudinal rumble strips were present along the roadway edge lines in both the right and left shoulders along the exit ramp. Concrete traffic barriers were located on each shoulder and were approximately 3 feet high.[4] At the time of the crash, it was daylight, the weather was clear, and the roadway was dry.

The speed limit on northbound I-95 just before the exit ramp was 55 mph. At the onset of the exit ramp on the right, approximately 733 feet south of the collision area, an exit speed sign was posted, advising motorists to travel no faster than 25 mph. About 500 feet south of the collision area was a truck rollover warning sign accompanied by an advisory speed plaque also indicating the recommended speed of 25 mph. Near the area where the rollover occurred, three chevron alignment signs were located along the outside of the horizontal curve, emphasizing the change in horizontal alignment.

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[2] The American Association of State Highway and Transportation Officials defines a *usable shoulder* as a portion of a roadway shoulder that a vehicle can use to pull over or stop in an emergency.

[3] The cross-slope break was determined by finding the algebraic difference in the grades between the travel lane and shoulder.

[4] These barriers conformed with *Manual for Assessing Safety Hardware* test levels capable of redirecting a 22,000-pound single unit at a speed of 56 mph and an impact angle of 15 degrees. For more information, see AASHTO 2011, Chapter 5—Roadside Barriers.

Figure 3 shows the Cottman Avenue exit ramp and the positions of the signs in relation to the area of the crash.

Figure 3. Overhead view of I-95 and Cottman Avenue exit ramp with signage identified. (Source: Google Earth; annotated by NTSB)

1.1.2 Traffic Volume and Crash History

The most recent average daily traffic volume for the Cottman Avenue exit ramp was calculated by PennDOT in 2019.[5] The volume was gathered from the beginning of the exit ramp to the I-95 overpass. In 2019, the average daily traffic was 15,544 vehicles. Of these vehicles, 1,587 were large trucks, constituting 10.2% of the total traffic volume.

In the 5 years leading up to the crash, PennDOT documented 16 total crashes that occurred on the Cottman Avenue exit ramp. Of these crashes, three involved a large commercial truck; none of these trucks experienced a rollover event. Four crashes involved a vehicle driving too fast for conditions; one of these four vehicles was a large truck. None of the 16 crashes involved fatalities.

[5] Traffic volume data were retrieved from PennDOT's Traffic Information Repository. For more information, see TMS Site 15591 Traffic Report | PennDOT Traffic Information Repository.

1.2 Event Sequence

The truck driver began work around 10:41 p.m. on June 10, the night before the crash, when he picked up his trailer in Pennsauken, New Jersey, at a lot belonging to TK Transport Incorporated, his employer and an affiliate of Penn Tank Lines. The driver's schedule for this shift consisted of three distinct trips, each of which involved picking up gasoline from a loading facility and dropping it off at a convenience store. The driver completed the first two of these trips and was completing the third trip when the crash occurred. The third trip started in Wilmington, Delaware, and was scheduled to conclude with the driver delivering his whole load of gasoline to a Wawa convenience store on Oxford Avenue in Philadelphia, located approximately 5 miles northwest of the crash location. As the truck traversed the Cottman Avenue exit ramp's downward-sloping, leftward curve at an estimated speed of 44–54 mph, the driver initiated a leftward turn to negotiate the curve but lost control of the truck, which rolled over one quarter turn (90°) onto its right (passenger) side.[6] The truck then struck the concrete barrier at the edge of the right shoulder of the exit ramp. A postcrash fire erupted, and the truck skidded beneath the I-95 overpass, where it came to rest. The fire burning beneath the overpass caused all four northbound lanes to collapse onto the exit ramp below, including onto the left (driver) side of the truck. The southbound I-95 lanes adjacent to the northbound overpass collapse were also damaged by the postcrash fire and deemed unsafe after PennDOT conducted a postfire inspection. The truck driver was fatally injured in the crash and postcrash fire.

1.2.1 Roadway Evidence

Based upon on-scene observations of the crash area as well as aerial photographs provided by the Pennsylvania State Police (PSP), the National Transportation Safety Board (NTSB) documented roadway evidence including two parallel tire friction marks that were lighter in color where they first appeared and became darker leading to the curve in the exit ramp. In total, the marks extended about 176 feet. At their termination, the marks were dark, and the right outer mark widened and angled toward the right shoulder of the roadway. About 4.5 feet south of the final friction mark were scrape marks on the roadway surface that extended to the right concrete barrier in the area where the exit ramp began to curve sharply before crossing under I-95. Black scorched areas were also observed on the roadway, concrete barrier, grassy area beyond the concrete barrier, and overpass bridge structure. Recovery operations were underway during the evidence documentation, and some roadway evidence had been covered up by debris or obscured by heavy equipment being used to clean up and remove the

[6] For more information about how the truck's speed was determined, see section 1.7.

collapsed bridge. Figure 4 shows the friction marks, scrape marks, and concrete barrier scorching.

Figure 4. Tire friction marks, scrape marks, and scorching on the Cottman Avenue exit ramp roadway and concrete barrier.

1.2.2 Video Evidence

The PSP obtained and provided to the NTSB video footage from a surveillance camera located on a business building southeast of the crash site that showed the Cottman Avenue exit ramp. The footage showed the truck traveling north on the ramp. As the truck negotiated the left horizontal curve, it overturned onto its right side, after which a fire erupted. The NTSB used this video to conduct a speed and simulation study for the truck. The study is discussed in detail in section 1.7.

The NTSB also obtained separate video footage of the truck at three of the driver's previous stops: two Wawa convenience stores in South Hampton Township, Pennsylvania, and Landsdale, Pennsylvania, where he dropped off gasoline; and a loading facility in Wilmington, Delaware, where he picked up gasoline. At each of these three locations, the footage showed that one of the four manhole covers located at the top of the truck's cargo tank was improperly open when the vehicle arrived, remained open while there, and was still open when the truck departed the location.[7] These manholes are used for cleaning, inspection, or top-loading of certain commodities; for the cargo tank involved in this crash, the gasoline was loaded through the loading lines

[7] 49 *CFR* 177.834(j)(1) requires that all manhole covers be closed and secured while in transport.

at the bottom of the tank.[8] Figure 5 includes a still image from video footage at the Wilmington, Delaware, loading facility showing the tank's forwardmost manhole cover in an open position.

Figure 5. Loading facility video footage showing open manhole cover atop cargo tank. (Source: Buckeye Terminal, Wilmington, Delaware)

Other surveillance video footage showed the driver walking back and forth and at times standing next to the cargo tank near the open manhole. In the footage that the NTSB reviewed, the driver did not appear to notice that it was open at any time. The NTSB also spoke with several company officials from Penn Tank Lines; each of them stated that the driver should have been able to hear air being displaced from the open compartment while he was filling it with gasoline from below, with one official stating that this displacement would have sounded like a "tornado."

[8] Although the video footage showed that the manhole cover remained open throughout the truck driver's shift, the NTSB was not able to determine when or why it was first opened.

1.2.3 Postcrash Fire

The Philadelphia Fire Marshal's Office and the Philadelphia Arson and Explosives Task Force completed an investigation into the origin and cause of the postcrash fire that occurred after the truck's quarter-turn rollover. The investigation determined that the fire originated near the front of the trailer and was likely fueled by gasoline as it escaped from the open manhole and spread throughout the exit ramp and underpass area. Although less likely, gasoline could also have been released if the truck's fuel tank were breached during the crash sequence. Because of the severe damage sustained by the trailer during the postcrash fire, the NTSB was unable to determine whether such a breach occurred.

The burning gasoline that spread throughout the rollover area also entered storm drains near and along the underpass that ran southeast toward the outlet at the Delaware River, approximately 800 feet away. The fires in the stormwater system resulted in a series of recurring explosions that ejected storm drain covers along the path of the system and continued for several hours. No pedestrians, vehicles, or buildings were exposed to the explosions along this path.

1.3 Injuries, Occupant Protection, and Emergency Response

The truck driver was fatally injured in the rollover and postcrash fire. The autopsy report listed the cause of death as blunt trauma of the head and inhalation and thermal injuries. The NTSB's examination of the burned truck cab interior showed that the truck was equipped with a lap/shoulder belt for the driver and front passenger seat positions. The NTSB found the driver's seat belt latch-plate still inserted into the driver's seat belt buckle, an indication of seat belt usage.

Philadelphia Police Department dispatchers were notified of the crash through the 911 system at 6:17 a.m. The 911 call was transferred to a PSP operator, who contacted PennDOT at 6:18 a.m. The first two PSP units were dispatched at 6:18 a.m., followed by more than 12 other PSP units.[9] At 6:26 a.m., one unit that was en route to the crash was assigned to close the I-95 entrance ramps near the Cottman Avenue exit. At 6:31 a.m., two PSP units arrived on scene and positioned their vehicles near the Cottman Avenue overpass to close northbound I-95. At 6:32 a.m., another PSP unit arrived and helped close northbound I-95. At 6:39 a.m., a PSP unit closed the southbound travel lanes of I-95. Except for the truck, no vehicles were affected by the rollover, postcrash fire, or

[9] The dispatch time was not recorded in the PSP logs due to the volume of 911 calls that dispatch operators were initially handling. The NTSB determined the dispatch time using the arriving PSP troopers' dashboard cameras, which displayed travel times of 13 minutes.

collapse of the northbound I-95 lanes, or by the damage to the southbound I-95 lanes near the northbound overpass.

The Philadelphia Fire Department was dispatched at 6:20 a.m., and the first engine unit arrived on scene at 6:25 a.m. The Philadelphia Hazardous Materials Task Force was dispatched at 6:54 a.m. to respond to the storm drain covers being displaced by explosions. The task force used its engine and truck as well as air monitoring devices to detect hydrocarbon levels near some of the exploding covers. The task force also instructed first responders not to park near the storm drains for safety reasons.

1.4 Driver Factors

1.4.1 Licensing, Experience, and Driving History

The 53-year-old male driver was the owner-operator of the crash-involved truck. The truck was leased to TK Transport, which in turn leased it to Penn Tank Lines. The driver began working for TK Transport in October 2021. He held a Pennsylvania Class A commercial driver's license with tank and hazardous materials endorsements that was last issued in June 2019 and set to expire in June 2023.[10] Based on his application to TK Transport, he had worked as a truck driver for at least 12 years. One of the previous positions listed on the application indicated some experience operating a fuel truck. In an interview with the NTSB, TK Transport's operations manager described the truck driver as being highly regimented, doing his work, and never complaining. Based on his driving logs, the truck driver did not have any speeding events during the time he worked at TK Transport.[11] The truck driver's files included a May 2022 recognition for "awareness to surroundings and attention to the road ahead in reacting to several deer crossing his path on [a] rural road," based on dashboard camera video evidence of the event.[12]

[10] A Class A license is required to operate any combination of vehicles with a gross vehicle weight rating of 26,001 pounds or more. The driver also held the appropriate commercial endorsements authorizing him to operate vehicles transporting hazardous materials, drive tank vehicles, and pull double and triple trailers. For more information about Pennsylvania driver's license categories and commercial endorsements, see License Types & Restrictions | Driver and Vehicle Services | Commonwealth of Pennsylvania.

[11] The truck's electronic logging device was programmed to trigger a speeding event if a driver exceeded 68 mph for more than 30 seconds.

[12] According to Penn Tank Lines, vehicles in operation for the company are equipped with a telematics system, including a dashboard camera. The truck driver's truck was equipped with an Omnitracs system.

The Commercial Driver License Information System (CDLIS) included 30 years of records for the truck driver.[13] In the most recent 10 years, the truck driver had four traffic-related convictions. One of these convictions, reported in 2016, was for speeding. None of the convictions were for traffic offenses while driving a commercial vehicle. The driver was involved in two commercial vehicle crashes in the 2 years before the June 11, 2023, crash. The CDLIS did not identify the truck driver as being at fault in either of these crashes.

1.4.2 Medical Certification, Health, and Toxicology

The driver underwent two commercial motor vehicle (CMV) driver medical examinations in August and October 2021. At the August examination, the driver reported a history of high blood pressure. No medication use was documented. The examiner determined that the driver met physical qualification standards and qualified him for a full 2-year medical certificate without restriction. At the October examination, which was required for his employment with TK Transport and Penn Tank Lines, the driver reported being unsure whether he had a history of high blood pressure. He reported no medication use. The examiner determined that the driver met physical qualification standards and qualified him for a full 2-year medical certificate without restriction.

At the request of the NTSB, the Federal Aviation Administration Forensic Sciences Laboratory performed toxicological testing of postmortem specimens from the driver.[14] This testing detected diphenhydramine, a sedating over-the-counter antihistamine, in his body cavity blood and liver tissue. The diphenhydramine concentration in the cavity blood specimen was below the measurement method's 25-nanograms-per-milliliter lower limit of quantitation and below the typical treatment concentration in a living person's plasma of 25–100 nanograms per milliliter.

1.4.3 Work Schedule and Precrash Activities

The truck driver's regular weekly work schedule was from Sunday to Thursday. He was paid by the number of trips taken and generally made three trips per day. In the

[13] The CDLIS is a nationwide computer system, administered by the Federal Motor Carrier Safety Administration, that enables state driver licensing agencies to ensure that each commercial driver has only one driver's license and one complete driver record.

[14] The Federal Aviation Administration Forensic Sciences Laboratory can test for about 1,000 substances including toxins, prescription and over-the-counter medications, and illicit drugs.

2 weeks before the Sunday, June 11, crash, the truck driver typically worked from 10:00 p.m. until 8:00 a.m., a schedule that can be classified as shift-work.[15]

According to the driver's logs, he started his shift at TK Transport's lot in Pennsauken, New Jersey, about 10:41 p.m. on June 10, when he picked up his trailer. On the first trip of his shift, he picked up gasoline from a facility in Paulsboro, New Jersey, and delivered it to a convenience store in South Hampton Township, Pennsylvania, about 1:27 a.m. on June 11. On his second trip, he picked up gasoline in Philadelphia and delivered it to a convenience store in Landsdale, Pennsylvania, about 3:47 a.m. On the third trip of the shift, he picked up gasoline from a loading facility in Wilmington, Delaware, and was driving to a convenience store in Philadelphia to deliver it when the crash occurred about 6:17 a.m. The truck driver had completed this route at least 30 times in 2023 alone.

The truck driver's cell phone records showed that from June 8–10, his days off, he registered calls and text activity between the hours of 8:00 a.m. and 6:00 p.m. (see figure 6). This suggests that on his days off, the truck driver reverted to a daytime schedule.

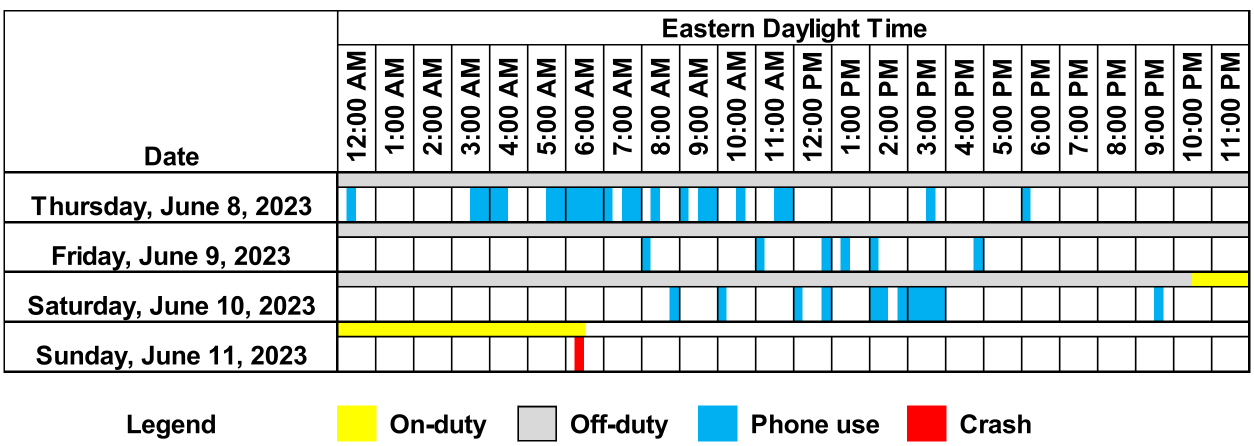

Figure 6. Graphical representation of truck driver's phone use (calls/texts) and on-duty times during the 72 hours before the crash. Phone use is shown as a contiguous block if the time between outgoing texts or phone calls was less than 15 minutes.

Based on his phone records, on the night of June 8, the truck driver had more than 13 hours of sleep opportunity. On the night of June 9, he had more than 15 hours of sleep opportunity. On the evening of June 10, before starting his shift, he had an additional 5.5 hours of sleep opportunity. These records include the truck driver's calling and texting functions but do not reflect any additional third-party applications that he

[15] *Shift work* denotes a work schedule occurring outside of traditional daytime hours, such as an evening, rotating, or on-call shift.

may have used. According to the phone records, the truck driver was not using his phone for a call or text at the time of the crash.

1.5 Vehicle Factors

1.5.1 General

The 2017 International truck-tractor was manufactured in May 2016 and had a gross vehicle weight rating (GVWR) of 52,350 pounds.[16] The truck also included a 2004 Heil Specification Package 406AL cargo tank trailer. The truck was not equipped—and was not required to be equipped—with electronic stability control (ESC) because its manufacture date preceded the August 2019 effective date of Federal Motor Vehicle Safety Standard (FMVSS) 136, "Electronic Stability Control," which requires ESC to be installed on vehicles with a GVWR over 26,000 pounds. ESC is designed to reduce crashes caused by rollover or loss of control. When installed on a vehicle, ESC can detect a loss of traction and apply braking force to individual wheels to assist a driver in maintaining vehicle control.

1.5.2 Damage

Any damage that the truck sustained from the quarter-turn (90°) rollover was obscured by the collapse of the overpass onto the left side of the cab while it rested on its right side and was consumed by fire. The truck-tractor exhibited oxidation of exterior metal surfaces including the frame, cab, and engine. All combustible surfaces on the exterior of the cab were consumed, including the plastic components, tires, and rubber engine components. The postcrash fire also consumed almost the entire interior of the cab, with only the metal components—such as the seat frames, dashboard, and steering wheel—remaining. Only pieces of aluminum remained from the truck's cargo tank.

Due to the extensive crash and fire damage, the NTSB was not able to perform a functional inspection of the truck's steering system. The rear axles were identified at the crash site underneath the collapsed bridge; however, the NTSB could not inspect the axles due to their location during the bridge cleanup process. Brake pad measurements were obtained by PSP investigators. The brake shoe thickness measurements were recorded to be one-half inch.

[16] *Gross vehicle weight rating* is the total maximum weight that a vehicle is designed to carry when loaded, including the weight of the vehicle plus fuel, passengers, and cargo.

1.6 Motor Carrier Factors

The truck driver was an owner-operator who worked for TK Transport. TK Transport began as an independent company in 1990 but became an affiliate of Penn Tank Lines in 2001 and was operating under Penn Tank Lines' US Department of Transportation (USDOT) number at the time of the crash. As such, TK Transport used the hiring, training, and safety policies and procedures of Penn Tank Lines, and Penn Tank Lines was the motor carrier responsible for regulatory compliance and the safety of its leased carriers and vehicles.[17] Penn Tank Lines was headquartered in Chester Springs, Pennsylvania, and it operated as an interstate, for-hire carrier of building materials, liquids/gases, intermodal containers, paper products, and bulk flammable and combustible hazardous materials loads.

In accordance with Penn Tank Lines' internally developed training process for driver trainees, the crash-involved driver received 80 hours of training including classroom instruction, instructional videos, meetings with terminal management, and on-the-job training observed by a lead driver trainer. The truck driver also passed a background check, a road test that included driving a tank trailer, and a hazardous materials transportation course. He received training and signed off on several policies, including a speed policy and two policies addressing manhole covers and the inspection of the manhole cover area. The latter policies included guidance on checking to ensure that all lids are down and secured. The driver acknowledged that he received training on the use of a retractable mirror to inspect manhole covers as part of the routine pretrip inspection process completed at the beginning of each shift. Before the crash occurred, Penn Tank Lines had begun transitioning from a paper-based process to an electronic process for drivers to complete their pretrip inspections. The electronic process includes a manhole inspection checklist item. To successfully complete the inspection, a driver must indicate for each checklist item that there is no defect. As of October 2023, all truck-tractors owned and leased by Penn Tank Lines have been equipped with and require an electronic pretrip inspection.

The truck driver submitted to a pre-employment controlled substance test on October 13, 2021, which was negative for tested-for substances. Penn Tank Lines also queried the Drug and Alcohol Clearinghouse and found no open violations for the driver.

Penn Tank Lines used a tablet-based, Federal Motor Carrier Safety Administration (FMCSA)-approved electronic logging device (ELD) provided by Omnitracs to account for drivers' hours of service. Hours of service were verified through an electronic transmission of ELD data and confirmed by the carrier. The FMCSA conducted a total of

[17] 49 *CFR* 376.12 explains the leasing process and contents of a lease.

eight compliance reviews of Penn Tank Lines' operations between the date that Penn Tank Lines entered the motor carrier industry and the date of the on-site, focused review that occurred as a result of the crash.[18] None of these reviews resulted in an unsatisfactory safety rating.

1.7 NTSB Video and Vehicle Performance Study

The NTSB used the surveillance video from a Hanwha QNO-8010R security camera located at a warehouse near the crash location to conduct a video study of the truck as it traveled down the exit ramp.[19] The goals of this study were: (1) to estimate the truck's speed as it approached the curve in the exit ramp, and (2) to evaluate the effectiveness of an ESC system in preventing the rollover, had such a system been installed. The NTSB reviewed a portion of the video consisting of about 5 seconds before the truck entered the curve.[20]

The study determined that the truck was traveling between 44 and 54 mph at the time of the crash, which was 19–29 mph above the posted advisory speed limit of 25 mph. When ESC was added to the simulated tractor-trailer, the rollover was prevented over this entire range of speeds (44–54 mph).

[18] The FMCSA conducts compliance reviews to examine motor carriers' operations, including drivers' hours of service, maintenance and inspection, driver qualification, commercial driver's license requirements, financial responsibility, accidents, and hazardous materials. The purpose of a compliance review is "to determine whether a motor carrier meets the safety fitness standard" in 49 *CFR* Part 385. For more information, see 49 *CFR* 385.3.

[19] For more information, see the *Video/Speed Study Factual Report* in the public docket for this investigation (case no. HWY23FH014).

[20] The first part of the study used SynthEyes, a brand of camera tracking/match moving software. SynthEyes can examine an image sequence and determine the speed and location of objects visible in the video relative to landmarks in the external environment. The second part of the study used the vehicle dynamics software TruckSim. This software can use vehicle and roadway data to conduct three-dimensional simulations that model tractor-trailer dynamics in cornering situations such as this crash. The NTSB used TruckSim to conduct a series of simulations to evaluate the effectiveness of ESC in preventing the crash.

2. Analysis

The roadway design and signage did not contribute to the truck rollover, crash, or postcrash fire on the Cottman Avenue exit ramp. The 8.0% cross-slope break on the exit ramp met AASHTO guidance. The signage on the exit ramp included two 25-mph advisory speed limit plaques, a truck rollover warning sign, and three chevron signs. This level of signage was appropriate and sufficient to warn drivers of the approaching downward and leftward curve. Further, the concrete barrier located in the right shoulder showed no evidence of deformation, indicating that it properly prevented the truck from exiting the roadway after the rollover event and collision occurred.

The truck's mechanical condition and the driver's licensing, experience, and training also did not contribute to the crash. Although the postcrash fire consumed all combustible materials throughout the truck and prevented the NTSB from conducting detailed examinations of some systems, the damage that the truck sustained was consistent with the details of the event sequence and did not suggest any mechanical deficiencies that caused or contributed to the severity of the crash.

The driver possessed a valid Class A commercial driver's license, medical certificate, and tank/hazardous materials endorsement. He had several years of experience driving a tractor with a tank trailer. He was familiar with the exit ramp where the crash occurred, as it was part of his regular route. The motor carrier responsible for overseeing the vehicle's operations, Penn Tank Lines, had no record of unsatisfactory safety performance as evaluated by the FMCSA's compliance reviews and had a robust driver safety, training, and evaluation program that included a speed policy and two separate policies relating to manhole cover inspection. The crash-involved driver was trained—and signed off on having received training—on each of these policies.

During the postcrash examination, the driver's latch-plate was found to be inserted into his seat belt buckle, indicating that he was wearing his seat belt when the crash occurred. His phone records showed that he was not talking or texting on his phone at the time of the crash. His postmortem toxicology results indicated that he did not have alcohol in his system. Low levels of diphenhydramine were detected in his cavity blood and liver tissue, but no other tested-for drugs were detected. The truck driver took steering action to try to negotiate the left horizontal curve at the end of the exit ramp in the moments leading up to the crash, indicating that he was awake and that a medical event or interference of symptoms of his high blood pressure was unlikely.

Emergency responders attended to the postcrash fire and its aftereffects in a timely and adequate manner. The Philadelphia Fire Department arrived on scene shortly after being notified of the fire and took command of its suppression. The PSP coordinated with the Philadelphia Police Department to close the exit and entrance ramps to I-95 and control traffic until PennDOT was able to set up barricades and directional signage for the detour. The issue of the burning gasoline in the stormwater system was identified and monitored appropriately, and no persons or property were exposed to the fires or ejecting storm drain covers.

2.1 Truck Driver Actions

2.1.1 Speeding

Speeding—exceeding a speed limit or driving too fast for conditions—is one of the most common factors associated with motor vehicle crashes in the United States (NCSA 2023). The results of the NTSB's video analysis indicated that the truck was traveling between 44 and 54 mph, which was well above the posted advisory speed limit of 25 mph. The tire friction marks observed on the exit ramp indicated a shift in weight that caused the right-side tractor tires to scrape against the roadway as the vehicle negotiated the left horizontal curve. The scraping—which left darker marks as the weight continued to shift—and ultimately the rollover occurred as a result of the high speed at which the truck entered this curve.

The NTSB has investigated many other speeding-related crashes, similar to this crash, in which the driver was traveling far above the posted speed limit (NTSB 2019, 2022, 2023a, 2023b, and 2023c). The National Highway Traffic Safety Administration (NHTSA) reports that in 2021, 29% of the total traffic fatalities involved speeding behavior (12,330 fatalities from crashes where at least one driver was speeding) (NCSA 2023). This represents a substantial increase from 2019 (9,592 fatalities from speeding-related crashes).

2.1.2 Driving with an Open Manhole Cover

The NTSB reviewed the FMCSA's documented manhole cover violations over the past 10 years (2013–2023) and determined that an average of about 19 such violations occur per year. In 2023, the FMCSA completed 167,997 roadside inspections on CMVs transporting hazardous materials.[21] The purpose of securing manhole covers is to prevent the leaking or release of contained hazardous material into the atmosphere. Federal regulation requires closing and securing manhole covers, and the Commercial Vehicle Safety Alliance constitutes missing or unsecured manhole covers as an out-of-service violation.[22] In this crash, when the truck rolled over onto its right (passenger) side, the open manhole cover enabled gasoline to quickly spill throughout the environment, likely initiating the postcrash fire and enabling it to spread quickly. Video evidence from

[21] FMCSA roadside inspection data were retrieved from A&I online – Motor Carrier Analysis and Information Resources Online (dot.gov).

[22] For more information, see Out-of-Service Criteria (cvsa.org).

each of the truck driver's three trips before the crash showed that the manhole cover for the forwardmost compartment of the truck's cargo tank was open when he arrived to pick up or deliver gasoline and remained open when he departed.

After the crash occurred, Penn Tank Lines transitioned from a paper-based process to an electronic process for drivers to complete pretrip inspections. Although this updated process does not completely prevent a driver from skipping an inspection step, it requires the driver to make an entry signifying that all manhole covers are secured.

2.2 Truck Driver Fatigue Assessment

The truck driver's regular work schedule was from 10:00 p.m. until 8:00 a.m. on Sunday through Thursday. The NTSB examined the driver's cell phone records, which showed calling and texting activity between the hours of 8:00 a.m. and 6:00 p.m. on his days off prior to the crash. This suggested that the driver reverted to a daytime schedule on days that he did not work. Research has shown that performing shift work, in this case driving between 10:00 p.m. and 8:00 a.m., is associated with an increase in fatigue-related crashes (Lee and others 2016; Bharadwaj and others 2021; Stutts and others 2003; Åkerstedt and Wright 2009). Individuals engaged in shift work experience more sleepiness and disturbed sleep than daytime workers, because their sleep time is out of synchronization with the body's circadian rhythms (Rosa and Colligan 1997; Drake and others 2004; Monk 2005; Wickwire and others 2017). The body's physiological processes, such as hormone secretion, body temperature regulation, and metabolism, are all regulated by the circadian rhythms. When the body is exposed to irregular work hours, it can struggle to adjust and maintain a healthy balance.

Environmental and societal synchronizers (such as sunlight and family activities, respectively) can further exacerbate difficulties shift workers face in sleeping during the day (Shen and others 2006). The likelihood that the driver reverted to a traditional sleep schedule during his days off may indicate that he did not adjust or establish a consistent rhythm for obtaining quality sleep. He had more than 13 hours of sleep opportunity on June 8, more than 15 hours of sleep opportunity on June 9, and about 5.5 hours of sleep opportunity on June 10 (the day before the crash). However, sleep opportunity is not identical to sleep; it simply indicates the windows of time when the truck driver could have slept based on the absence of evidence that he was performing other activities (such as using his phone).

The driver's lack of alertness to the exit ramp advisory speed and loss of control of his vehicle suggest that he may have been fatigued when the crash occurred. His neglect of the task of securing the open manhole at the front of the cargo tank—despite being adjacent to it on multiple occasions while picking up and dropping off gasoline during his shift—also suggests potential fatigue, particularly because the noise caused by air exiting the manhole compartment while he was loading it with fuel would have been obvious to a driver who was fully alert.

The truck driver's toxicology results indicated that he had used the antihistamine medication diphenhydramine, which has the potential to cause cognitive and psychomotor slowing and drowsiness. Whether he had used diphenhydramine as a sleep aid was unknown. The diphenhydramine levels in his cavity blood and liver tissue were low, but interpreting a diphenhydramine level measured in postmortem cavity blood is unreliable. Therefore, it was unknown whether the driver was experiencing impairing effects from his use of diphenhydramine at the time of the crash or during the pretrip inspection.

2.3 Electronic Stability Control

Speeding can cause catastrophic crashes with high likelihood of fatalities. One potential countermeasure relevant to this crash is the availability of ESC. The crash-involved truck was not equipped with ESC. It was manufactured in 2016 and thus predated the 2019 effective date of FMVSS 136, which requires ESC to be installed on vehicles with a GVWR greater than 26,000 pounds. The results of the NTSB's simulations indicated that an ESC system could have helped to prevent the rollover in this crash at any of the speeds in the 44–54 mph range at which the truck was traveling. In the simulations, ESC rapidly slowed the truck as it entered the curve, which reduced the lateral acceleration and prevented the rollover. The catastrophic postcrash fire, which led to the fatal injury of the crash-involved truck driver and the collapse of the I-95 overpass, demonstrates the importance of ESC, especially for vehicles transporting hazardous materials.

Although ESC is now legally required for the heaviest vehicles (those weighing more than 26,000 pounds GVWR), lighter commercial vehicles and buses would also benefit from this technology. In 2011, following its investigation into a rollover and subsequent fire involving a cargo tank semitrailer carrying liquified petroleum gas in Indianapolis, Indiana, the NTSB issued recommendations to NHTSA to develop performance standards for ESC systems for all CMVs over 10,000 pounds and to require the installation of ESC on all newly manufactured CMVs over 10,000 pounds (NTSB 2011; Safety Recommendations H-11-7 and -8). These recommendations have been classified Open–Unacceptable Response and have been reiterated several times following the NTSB's investigations of subsequent crashes that could have been prevented if these technologies had been installed.

In 2023, NHTSA and the FMCSA issued a notice of proposed rulemaking in which they proposed to amend FMVSS 136 to require nearly all heavy vehicles over

10,000 pounds to be equipped with ESC systems.[23] In its response, the NTSB affirmed its support for this rulemaking while also disagreeing with NHTSA's stated timeframe for vehicle compliance, which would give some manufacturers 4 or 5 years to meet the ESC requirements.[24] The NTSB urged the USDOT to oversee the implementation of this rulemaking effort and identify opportunities to quickly complete and implement the final rule.

3. Conclusions

3.1 Probable Cause

The National Transportation Safety Board determines that the probable cause of the Philadelphia, Pennsylvania, combination vehicle rollover crash, postcrash fire, and subsequent Interstate 95 overpass collapse was the driver's failure to slow the vehicle as he exited the interstate onto the exit ramp well above the posted advisory speed limit, due to inattention to the roadway potentially associated with fatigue. Contributing to the severity of the postcrash fire was the driver's failure to secure the vehicle's manhole cover during his pretrip inspection, which enabled the gasoline that was being transported to quickly enter the environment and spread throughout the crash area.

3.2 Lessons Learned

3.2.1 The Importance of Mitigating Fatigue

Shift work is an essential part of commercial trucking; however, drivers and employers must be aware of its risks and manage fatigue to prevent hazardous driving and crashes. Because driving outside of daytime hours has been shown to increase the risk of fatigue-related crashes, it is critical for shift-work drivers to develop strategies for mitigating fatigue. In this crash, the truck driver's phone records suggested that he reverted to a daytime schedule on his days off and therefore did not develop a consistent schedule for obtaining quality sleep.

For more than 15 years, the NTSB has advocated for and promoted fatigue management programs, such as the North American Fatigue Management Program (NAFMP), and their use by motor carriers to reduce fatigue-related crashes (NTSB 2008, 2010, 2012a, 2012b, 2023c, and 2024). The NAFMP is a free, interactive, web-based

[23] Automatic Emergency Braking Test Devices: Heavy Vehicle Automatic Emergency Braking. Notice of proposed rulemaking. 88 *Federal Register* 43174. July 6, 2023.

[24] NPRM response, August 28, 2023.

educational and training program designed to help commercial truck and bus companies increase awareness among drivers, safety managers, shippers/receivers, and family members of factors contributing to fatigue and its effects on performance. In 2024, following our investigation of a collision in Louisville, New York, in which a fatigued truck driver crossed over a highway centerline and struck a bus traveling in the opposite direction, the NTSB issued Safety Recommendations H-24-30 and -31, asking major trucking trade associations and unions to inform their members about the crash and to urge them to develop fatigue management programs based on the NAFMP (NTSB 2024).[25] Among the many strategies that a robust fatigue management program can promote, the Philadelphia, Pennsylvania, crash highlights the importance of drivers adopting sleep schedules that do not change substantially between their workdays and their days off.

3.2.2 The Benefits of Electronic Stability Control

FMVSS 136, "Electronic Stability Control," began mandating in August 2019 that vehicles above 26,000 pounds GVWR be equipped with ESC. The fact that this mandate was not applicable to the truck involved in this crash, which weighed more than 26,000 pounds but was manufactured in May 2016, highlights the need for continued progress in ensuring that ESC is installed on commercial vehicles. Although the primary cause of the truck's rollover was the driver's excessive speed on the exit ramp, the NTSB's simulations suggested that ESC would have prevented the rollover from occurring, even with the truck traveling at an unsafe speed of 19–29 mph over the advisory speed limit.

NTSB Safety Recommendations H-11-7 and -8 call on NHTSA to develop ESC performance standards for CMVs above 10,000 pounds and to require the installation of ESC on these vehicles once the standards have been developed. NHTSA and the FMCSA have indicated in a 2023 notice of proposed rulemaking that they are working on a final rule that would require nearly all commercial vehicles to have ESC systems. However, the final rule has not yet been published, and even after it appears, the agencies plan to give some manufacturers as many as 4 or 5 years to comply with the regulations. The Philadelphia, Pennsylvania, crash provides another example of the benefits of ESC, which could have prevented a rollover event for even the heaviest class of vehicle traveling up to 29 mph over the speed limit. It remains critical that the USDOT identify opportunities to expedite the deployment of this technology to lighter commercial vehicles as well, where its capability of preventing a catastrophic outcome is even more assured.

[25] Safety Recommendation H-24-30 was issued to the American Trucking Associations and National Private Truck Council. Safety Recommendation H-24-31 was issued to the Amalgamated Transit Union, International Brotherhood of Teamsters, Owner-Operator Independent Drivers Association, and Transport Workers Union of America.

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