

Virginia Commonwealth University
Transportation Safety Training Center
Virginia Multi-disciplinary Crash Investigation Team

Report Number 213 – September 2010

ABSTRACT

After entering heavy fog while driving on the interstate, the driver of a tractor and semi-trailer slowed. A second tractor and semi-trailer struck the first trailer in the rear. The two vehicles travelled from the right lane into the left lane. The passenger in the second tractor exited the vehicle. A Hyundai Elantra approached the second trailer. A third tractor and semi-trailer struck the Elantra, overriding the rear and pushing it into the rear of the second trailer, killing both occupants in the front seats. The passenger of the second tractor was caught in these collisions and killed. Corrosive liquid from the third trailer spilled onto the roadway and into the median ditch. The Elantra and the third tractor were consumed by an ensuing fire. The interstate highway was closed for over 16 hours due to the involvement of hazardous material.

This crash illustrates the critical importance of being attentive to roadway conditions and adjusting driving speeds and following distances when visibility is limited. The life saving potential of seat belt use is discussed, as well as hazardous material spill response, post-crash scene and traffic management.

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SYNOPSIS

Day, Time, Season: Monday, 11:34 p.m., Spring

Road/Weather: Interstate highway; fog and damp roadway

Vehicles Involved: 2005 Kenworth T600 Tractor and 1999 Lufkin semi-trailer (TT1)
2006 International 9200i Tractor and 2001 Lufkin semi-trailer (TT2)
1999 Hyundai Elantra
2006 Sterling AT9500 Tractor and 2008 Trailmobile semi-trailer (TT3)

Individuals Involved:

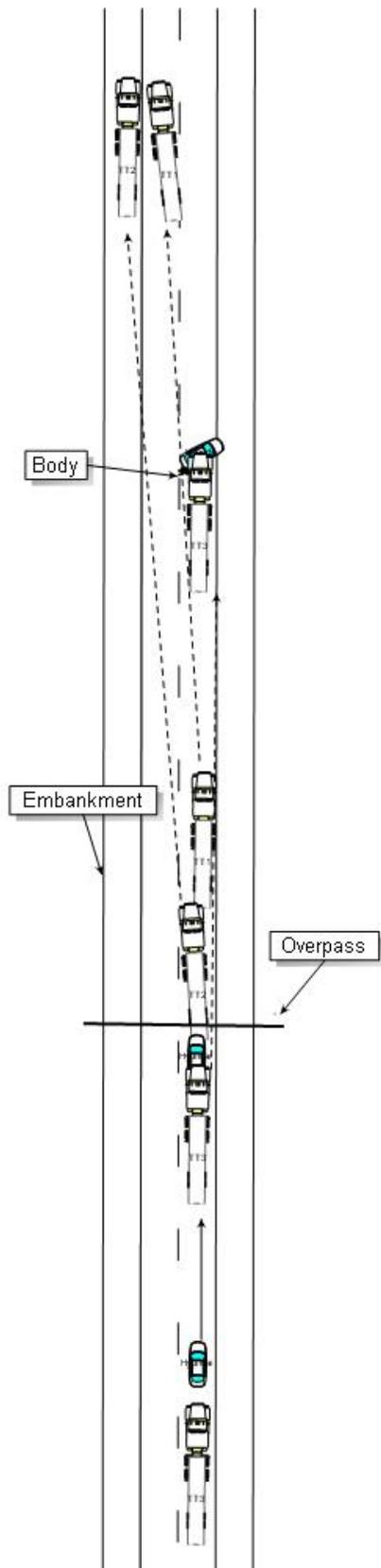
Kenworth:	52 year old male driver, not injured
International:	29 year old male driver, minor injury
	51 year old male front seat passenger, fatality
Hyundai:	35 year old male driver, fatality
	27 year old male, front seat passenger, fatality
Sterling:	44 year old male driver, moderate injury

Summary: A series of rear-end collisions resulted when the first tractor and semi-trailer slowed.

Severity: Three fatalities, 1 person with moderate injuries and one with minor injury, extensive property damage to three vehicles and two trailers

Probable Cause: Limited visibility, driving too fast for conditions, failure to maintain safe following distances

Significant Points: Driving in fog and limited visibility, failure to maintain safe following distances, pavement markings for inclement weather, failure to use safety restraints, hazardous material spills and public safety, crash scene and traffic management



Virginia Multi-Disciplinary
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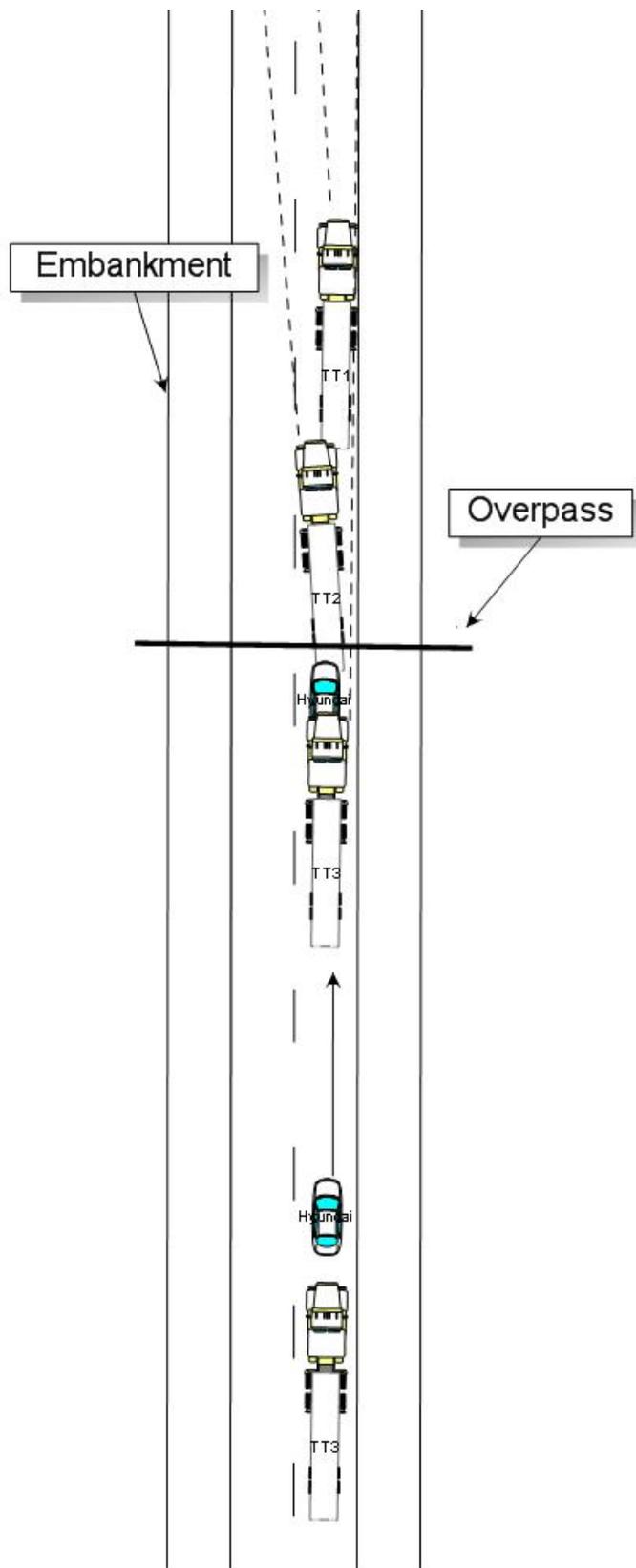
2005 Kenworth T600 Tractor
and 1999 Lufkin semi-trailer (TT1)

2006 International 9200i Tractor
and 2001 Lufkin semi-trailer (TT2)

1999 Hyundai Elantra

2006 Sterling AT9500 Tractor
and 2008 Trailmobile semi-trailer (TT3)

Not to Scale



ENLARGEMENT of COLLISIONS

CRASH DESCRIPTION

At about 11:30 p.m. on a damp Monday night in spring, a 2005 Kenworth T600 tractor (Tractor 1) pulling a 1999 Lufkin semi-trailer (Trailer 1, TT1 combined) was travelling south, in the right lane on an interstate highway, when it encountered heavy fog. The 52 year old driver, who was alone and wearing his lap/shoulder belt, reduced the speed of his vehicle because his visibility was limited. This interstate highway is a major four lane north-south route located in a rural area. The road is asphalt and is in good condition. Each lane is approximately 12 feet wide. There is an approximately 11 foot asphalt shoulder adjacent to the right side of the southbound lanes; a three foot asphalt shoulder is adjacent to a grass median on the left. There are rumble strips on both shoulders. The northbound and southbound lanes are separated by a grass median. At the location of the crash, the median drops off to a shallow ditch, then rises in the center to a bank approximately 10 feet high. The road is straight and on an approximately 2 percent downgrade. The road is controlled by signs and pavement markings which are in good condition. In addition, snow plowable reflective pavement markers are installed to help delineate the roadway at night and during inclement weather. The reflective elements on these markers are in poor condition. There is no overhead lighting. The speed limit is 65 MPH.

The TT1 driver was about four hours into an approximately 10 hour trip. He had picked up a load of freight in a northeastern state and was to deliver the trailer of wood and general freight to a location approximately 350 miles away, in a state bordering Virginia.

A second tractor and semi-trailer was travelling an unknown distance behind TT1, also in the right lane. The driver of this vehicle, a 29 year old male, was driving a 2006 International Tractor (Tractor 2) pulling a 2001 Lufkin semi-trailer (Trailer 2, TT2 combined). He was accompanied in the passenger seat by his driving partner, a 51 year old male. The pair had left a northern state and driven approximately 465 miles, hauling mail. They had about 780 miles more to reach their final destination, a major city in a neighboring state. Neither man wore safety restraints. As he approached the slower TT1, the TT2 driver observed the trailer's tail lights and realized he was close to a collision. He began braking and turned to his left in an evasive maneuver. However, he was unable to avoid the collision, striking the rear of the Trailer 1 with the right front of Tractor 2 in an offset configuration. The impact pushed Trailer 1 forward and to the right, and Tractor 1 pivoted to the left into a jackknife situation. The TT1

driver, realizing that he had been struck, began braking and attempting to stop. Tractor 2 continued into the left lane and alongside TT1. The initial impact jostled both the driver and his driving partner inside the cab. While TT2's driver was still attempting to stop, the co-driver exited the cab through the passenger's side door.

Several other vehicles were just north of this location, also travelling south on this section of highway. A 1999 Hyundai Elantra was travelling in the right lane. This vehicle was operated by a 35 year old male with a 27 year old male in the front passenger seat. They were commuting home from a job in a nearby town. They had completed the majority of their trip (about 29 miles) and were less than five miles from home when the crash occurred. Both wore their lap/shoulder restraints.

Behind the Hyundai, a 44 year old male, also restrained with a three point belt system, drove a 2006 Sterling tractor (Tractor 3) pulling a 2008 Trailmobile semi-trailer (Trailer 3, TT3 combined) that contained corrosive liquids in drums, as well as stacks of paper brochures and catalogues on pallets in the front area of the trailer. This driver had picked up his load about two hours earlier in a state just north of Virginia. He had travelled approximately 110 miles and had about 140 miles to go before he would reach his final destination.

Upon seeing events unfolding ahead, the Hyundai driver began braking (an uninvolved witness reported seeing the brakes lights illuminate just prior to the crash). The TT3 driver, who did not report seeing the car, indicated that he saw the lights of Trailer 2 and began to brake as he realized a collision was imminent. Although the exact sequence of the collisions is unknown, Tractor 3 impacted and overrode the back of the Hyundai, striking the car in an offset rear-end collision and pushing it forward. The Hyundai's front end struck the right half of the Trailer 2's rear end, under-riding it at an angle. The force of these collisions pushed the front end of Trailer 2 against the semi connection while the underriding Hyundai lifted the trailer's rear end up. The right side of the trailer's roof, about midway down the length of the trailer, struck the underside of the overpass. As it was pushed forward into the concrete, the right side of the roof peeled and buckled back, from mid-section to the back end of the trailer. Tractor 3 continued moving forward, pushing the car before it. Crushed between Trailer 2 and the Tractor 3, the two Hyundai occupants died instantly from massive head injuries. This sequence of events happened within seconds of the first collision. The co-driver of TT2 was caught in the midst of this collision and killed.

A driver in a Toyota sedan travelling in the left lane was a short distance behind the tractor trailers. He did not report seeing the car, but he had to move his vehicle onto the left shoulder when the last tractor entered his lane while striking the Hyundai. He witnessed Tractor 3 collide with the Trailer 2 as he brought his own vehicle to a stop by the guardrail. A fourth tractor trailer driver also witnessed these collisions.

The impact of the last collision pushed TT2 forward and to the left, disengaging Trailer 2 from the car. The driver of TT 2 was thrown around the cab again by this second impact. Tractor 2 moved past the left side of TT1 onto the left shoulder, then rolled down to the bottom of the ditch line and partially back up the rising embankment in the median. Tractor 2 came to rest with all axles in the median, facing south. The rear axle of Trailer 2 came to rest in the grass median south of the overpass. Tractor 1 came to final rest in the grass median adjacent to Tractor 2. The rear axles of Trailer 1 came to final rest mostly in the left lane with the right side rear axles just over the lane line in the right lane of the southbound interstate. The Hyundai and TT3 came to final rest in the right travel lane of the southbound interstate, with the rear axle of Trailer 3 just south of the overpass. The Hyundai caught on fire.

The TT2 driver exited his truck on the passenger side, and saw Tractor 3 on top of the burning car. He and the witnesses ran to assist the Tractor 3 driver, who had fractured a leg. They removed him from the cab and, as they moved to the shoulder, flames engulfed that vehicle also. The fire consumed the Hyundai, the Tractor 3 cab and the front part of the semi-trailer it hauled.

Witnesses and those involved called emergency personnel to report the crash. Members of a local all-volunteer fire and rescue department were first on scene. Members of local law enforcement agencies, state police and multiple fire and rescue (volunteer and paid) personnel arrived within minutes. They took control of the southbound lanes of travel, which were blocked by the crashed vehicles, and notified the nearest Virginia Department of Transportation (VDOT) office to request assistance with traffic management. VDOT notified their maintenance contractor, who dispatched trucks and set up electronic message boards and traffic control devices. Approaching southbound traffic was diverted onto a parallel primary route to bypass the crash area. One northbound lane of the interstate was closed to allow emergency responders access to the site.

Due to the fog and smoke billowing from the burning vehicles, the “corrosive” placard on Trailer 3 was not immediately identified. Approximately 30 minutes after the crash, the contents

of the trailer were positively identified as hazardous, changing the approach emergency personnel used to manage the situation. Citizen safety became the fire and rescue chief's immediate priority. The 42 occupants of vehicles stopped on the interstate north of the crash site were asked to evacuate the area. Sheriff's deputies and other law enforcement officers walked among the stopped vehicles, explaining the situation and coordinating the effort. The stranded motorists cooperated willingly. Using a local county school bus, these individuals were moved to a county emergency shelter, where they were assisted by members of the local Red Cross agency and auxiliary members of the fire department. One house in the path of the smoke was also evacuated.



***Photo #1: Final rest of TT1(left) and TT2 in the southbound lanes.
Part of Trailer3 and the Hyundai are visible in the background.***

In the meantime, those dealing with the burning TT3 were attempting to determine exactly how much and what types of materials were contained in the trailer. The manifest burned in the tractor and the injured driver did not know what he was hauling, but State Police personnel were able to contact the carrier and get a copy of the manifest sent via facsimile machine, showing that it carried both caustic and corrosive cleaning liquids. Over 5000 gallons of fluid, including fuel and cleaning fluid had spilled onto the highway and median. The fluid was diked to contain the spill until the fire was put out and it could be assessed and cleaned up. Initial sample testing showed that the liquid was a highly caustic base (pH of 14, with 1 being the most acidic level and 14 being the highest base level). The regional hazardous material team from a nearby city was contacted and personnel dispatched to help manage that aspect of the situation. Emergency personnel were given personal protective equipment, mainly boot coverings to protect footwear from the corrosive effects of the fluid. A State Trooper set up air quality monitoring devices in four quadrants around the perimeter of the area. The tests revealed that the air was not contaminated and breathing apparatus were not required. A bridge inspector for VDOT was also dispatched to assess the damage due to the overpass strike.

The tractor drivers were transported by ambulance to a local hospital. The first tractor driver was not injured. He was checked and released, and then a trooper drove him to the shelter that had been set up for evacuees. He was later transported back to the scene to be interviewed by investigators. The TT2 driver was treated and released by the hospital but the third driver was admitted for treatment of his serious leg injuries.

Within 45 minutes of the crash, the local Medical Examiner was apprised of at least one fatality in the car. The co-driver from TT2 was counted as missing. Several hours later, investigators located this man's body and confirmed that there was a deceased passenger in the car as well. A total of three were killed. Crime scene technicians were requested to assist in documenting and collecting evidence, since two of the bodies had been dismembered. All three had been burned beyond recognition, but they had all died of blunt force injuries during the collisions.

The fire in Trailer 3 continued to burn throughout the night and into the next morning. The flames would die out under the chemical foam, but the material would smolder, then reignite. The fire was not completely extinguished until approximately 13 hours after the crash. Crime scene technicians removed the bodies from the wreckage and they were transported by funeral home personnel to the nearest Office of the Chief Medical Examiner for autopsy and

toxicological studies. State Police investigators, reconstructionists and motor carrier specialists documented the vehicle positions and physical evidence. Then, heavy equipment movers were brought in to move the tractors and trailers. TT1 was inspected by the State Police motor carrier specialists and released to the owner. TT2 was towed from the scene, while Tractor 3 and the Hyundai were placed on flat bed trucks and transported to different locations for storage. Trailer 3 was moved a short distance from the crash site, to a staging area off the highway. Material that survived the fire was removed and repackaged for later transport. The empty trailer was hauled to the same storage facility that housed the burned remnants of Tractor 3 and TT2. Once the scene was cleared and the roadway cleaned, members of the hazardous materials team took samples of soil to identify the level of contamination and to determine, from that, whether removal or further treatment would be required. No actions beyond those already taken were deemed necessary. The southbound lanes of the interstate were reopened 16 hours after the crash occurred.



Photo #2: Hyundai and TT3 at final rest.

REMARKS

The Virginia Multi-disciplinary Crash Investigation Team (VMCIT) first learned of this horrific event through media reports. After contacting State Police officers involved in the investigation and learning about the fatalities, the weather conditions and the hazardous material spill, the Team decided to research this crash.

The night of the crash, the weather was foggy, a frequent occurrence on this stretch of interstate, which transitions from foothills to a mountainous region. The roadway was damp but it was not raining. The fog was not consistently thick and visibility for both roadway placement and other vehicles varied with the density. The snow plowable markers in the centerlines are in poor condition as a result of wear and prolonged, heavy use. Consequently, they do not provide much reflective visual feedback to drivers under adverse conditions. In these types of inclement weather situations, driver safety organizations such as the American Automobile Association (AAA), suggest that drivers increase following distances. Many of these organizations indicate that a 3 second following distance is recommended for passenger vehicles on clear days with high visibility. With larger vehicles, 4 to 5 seconds is recommended on clear days with high visibility. During inclement weather situations, increasing time and distance increases the chances of stopping safely.

The 52 year old TT1 driver reported that he slowed when his visibility was obscured as he entered the fog bank, an appropriate action under these conditions. He held a valid Class A commercial driver's license that had been issued by a southern state, where he made his home. This 130 pound man was reported to be 5 feet 11 inches tall and he was required to wear corrective lenses while driving but had no other restrictions. The brief driving history supplied by his home state showed that he had been convicted of driving while intoxicated in 1994 (offense occurred in 1992), but the conviction was not related to driving a commercial motor vehicle (CMV). In 2003, he was convicted of a CMV related violation and he was involved in a non-injury crash in 2005. The record did not show that he was charged with any violations in that crash, and he had no further incidents or violations on the last four years of the report. The FR300P Police Crash Report indicated that he had no impairments and had not been drinking prior to the crash. According to the report, the investigating officer did not request or perform any tests to determine alcohol or drug use. The Federal Motor Carrier Safety Administration (FMCSA) requires the operator's company to ensure that such tests are conducted after a fatal

crash and that the results are kept in confidential files by the company. However, these results are not released to law enforcement investigators unless through subpoena. The TT1 driver had been driving for about four hours, having picked up a load about 230 miles northeast, in another state. It is unknown if he stopped at any time between his point of origin and the location of the crash. This driver's log book information was not reported as reviewed by the motor carrier specialist who inspected his tractor and trailer after the crash, so there is no way to know if he might have exceeded the maximum hours of driving he was allowed under FMCSA regulations.

The 29 year old TT2 driver, who held a valid Class A commercial driver's license that had been issued just over a year earlier, was licensed by another southern state. His home state verified his license status and indicated that he had one restriction, although the specific restriction was not identified. No driver history was provided. This man was six feet tall and weighed 210 pounds, according to his license. He was not impaired at the time of the crash; he was not reported as under the influence of alcohol or drugs. A State Police motor carrier specialist inspected his driver log the following day at the lot where the tractor and trailer had been impounded. The specialist reported that this driver was within the maximum allowable hours of driving at the time of the crash and there were no indications that he was fatigued. Since the investigating officer had no reason to suspect that this driver was under the influence of alcohol or drugs, he did not request blood or breath tests.

The passenger in Tractor 2 was a co-driver. Since neither man was restrained, they were both thrown about the cab when their tractor struck Trailer 1. The lower part of the windshield had a small "spider web" type crack, but the cause was not determined. Autopsy results showed that the passenger suffered fractures of the right shoulder, elbow and forearm, but these injuries could have occurred during the second collision when he was struck as a pedestrian.

The driver of TT2 reported to the investigating trooper that his passenger ended up in his lap after the first collision. He stated that the passenger moved back to his seat and then "jumped out of the cab" on the passenger side, while the vehicle was still in motion. This action seems inexplicable; a more likely scenario is that he was ejected and/or fell from the cab during the initial collision. As TT1 and TT2 moved past him, he was caught in the second collision between TT2, TT3, and the Hyundai.

Blood and tissue were found on the lower left rear corner of TT1 and it is unlikely that this matter was from either of the victims in the Hyundai. VMCIT members were told by one law enforcement officer at the scene that samples of the tissue were gathered by crime scene

technicians so that the DNA could be tested and matched to the victims. However, no additional information about these samples was sent to the investigating trooper or the reconstructionists, so VMCIT members were unable to confirm that this tissue belonged to the passenger from TT2. Autopsy results showed that this man died of blunt chest and abdominal trauma, including laceration of the heart, lungs, liver and intestines. He suffered multiple fractures, including extensive pelvic fractures and separation of the thoracic vertebrae. Toxicology tests revealed that he was not under the influence of alcohol or drugs at the time of his death.

FMCSA regulations (§392.16) require that “A commercial motor vehicle which has a seat belt assembly installed at the driver’s seat shall not be driven unless the driver has properly restrained himself/herself with the seat belt assembly.” The driver of Tractor 2 was not restrained and, consequently was tossed about the cab each time his trailer was struck. FMCSA regulations are silent with respect to requiring a passenger to wear safety belts; however, the Code of Virginia requires all front seat passengers to wear safety belts (§ 46.2-1094). If the passenger had been belted, he would have remained in his seat and is likely to have survived this crash.

The 35 year old Hyundai driver, who was not the owner of the car, did not have a valid driver’s license. He was an illegal immigrant from Guatemala and was related to his passenger. Little is known about this driver, although he was not impaired at the time of the crash. The two men had been working in a nearby city and travelled about 29 miles, on their way home. They were less than five miles from their destination when the crash occurred. When they did not arrive home, the driver’s wife and a cousin went to the sheriff’s office to file a missing persons report. Although the men had not been identified at that time, as soon as their identities were confirmed, the sheriff’s office sent an officer to notify the family. Toxicology tests for both Hyundai occupants revealed that they had no alcohol or drugs in their bodies at the time of the crash. The driver died immediately of blunt head, chest and abdominal trauma, while his passenger also died instantly of blunt head trauma.

The 44 year old TT3 driver held a valid Class A commercial motor vehicle license from his home state, which borders Virginia. No active suspensions or revocations were cited on the driving record received from his home state, but no other information about his driving history was included. His height was listed as six feet and his weight was listed as 235 pounds. According to the FR300P, this man had no physical defects that would have impaired his driving ability, and he was not under the influence of drugs or alcohol at the time of the crash. No

toxicology tests were conducted or requested by the investigating officer because he had not observed any behaviors indicative of impairment. This driver was about two hours into a trip of approximately 250 miles. Even though his tractor burned, his employer had a computerized log of his recent driving schedule, which was provided to the specialist heading up the motor carrier part of the crash investigation. The log showed that this driver had not driven in excess of the maximum hours allowed by the FMCSA. There was no other evidence to determine whether or not he was fatigued. Because he wore his safety belt, this driver's injuries were confined mainly to his lower extremities. He did not suffer serious chest or head injuries, which would have been likely had he not been restrained. He was conscious immediately after the collision and able to alert others to his position and condition, so that they knew to attempt to remove him from his tractor before the fire spread.

Damage to TT1 was focused completely on the rear of the trailer. The left side of the rear impact guard was buckled and pushed forward under the trailer. The motor carrier trooper conducted a post crash inspection of this tractor and semi trailer, finding the side marker lights on the rear sides of the trailer to be inoperable. The tractor also had an inoperable taillight, turn signal, and brake light. He also noted an audible air leak in the service line glad hand (air brake line connector) at the connection to the trailer. No other damage or defects were noted on TT1.

Damage to TT2 was extensive in nature. The rear of the trailer sustained major damage. The rear impact guard was pushed against the bottom floorboard of the trailer. The rear tandem axles were broken from the leaf assemblies and the brake chambers on the rear most axle were destroyed. The rear third of the trailer was torn and buckled at the top. The motor carrier trooper's post crash inspection of the trailer indicated that the left rear tail lights and both rear side marker lights were inoperable due to the crash. The tractor suffered contact damage to the right front half. The hood was broken and buckled. The motor carrier trooper's post crash inspection of the tractor indicated the right side windshield was broken (he did not attribute this to the crash), right side windshield wiper was inoperable, the left side front tire tread depth was less than 4/32nd of inch, the left Anti-lock Braking System (ABS) wire was cut, and there was an audible air leak coming from the air relief valve at the front drive axle (axle #2). He met with U.S. Postal workers the next day so that they could remove the mail from Trailer 2 and return it to the postal system.



Photo #3: Front view of Tractor 2, showing damage from collision with rear of Trailer 1. Burned remains of Trailer 3 are visible to the left.

The Hyundai Elantra was completely destroyed by both contact damage and fire. The trunk was buckled forward and intruded into the rear passenger compartment. The engine compartment was pushed rearward and down, intruding into the front passenger compartment. The overall length of the vehicle was reduced by approximately 6 ½ feet from the manufacturer's original vehicle specifications. No inspection information was available for this vehicle due to the fire damage.

Damage to TT3 was extensive to the tractor and the front of the trailer. They were both damaged by contact damage and extensive fire damage. The tractor was destroyed by the fire, with the steer tires and first drive axle tires melted. The interior was burned extensively. The motor carrier trooper's post crash inspection of the tractor indicated the clamp brakes on the front drive axle (axle #2) were out-of-adjustment and the automatic airbrake adjustment system failed to compensate for wear. Both of these he indicated were not crash related. The front portion of the trailer was damaged by fire. This was where the hazardous materials had been

loaded. The hazardous materials list provided by the company indicate the trailer was carrying sodium hydroxide, hypochlorite solution, formic acid, phosphoric acid, ethanolamine, ferrous chloride, inorganic corrosive basic corrosive liquids, inorganic acidic corrosive liquids, and oxidizing solution. The total weight of the hazardous materials was approximately 8000 pounds. The motor carrier trooper's post crash inspection of the trailer indicated no defective equipment that was not related to the crash and ensuing fire damage.

When this crash was reported, local agencies worked together and implemented an emergency action plan. VDOT staff as well as leaders from local agencies indicated they had learned a great deal from assessing their responses to major crashes that had shut down the interstate for extended times during the past several years. As soon as the severity of the crash and the possibility of hazardous material involvement were identified, local school personnel were notified and the schools were declared closed. This measure was taken to reduce traffic on the alternate routes and to ensure that school children were not trapped in traffic for extended periods of time, as they had been on previous occasions. The hazardous material team from a nearby city was called in to help assess and deal with contamination at the scene.

Emergency planning personnel within local and state levels worked with the VDOT Traffic Operations Center to manage traffic and maintain the safety of those working at the crash site. The southbound lanes were closed at 11:38 p.m. and traffic diverted onto a primary route that runs parallel to the interstate. Electronic message signs were displayed well in advance of the crash site to warn approaching drivers and give them the opportunity to take alternate routes. One of the northbound lanes was closed at 11:45 p.m. and re-opened at 2:31 p.m. Due to concerns about the hazardous materials and the length of time required to control, document and then clear this scene, occupants of the vehicles parked in the southbound lanes close to the scene were evacuated at 12:01 a.m. Both northbound lanes were closed at 3:27 a.m. and traffic was diverted to a nearby interchange in order to allow backed up southbound traffic that had not been evacuated to use the crossover to help alleviate the queue. This traffic was also diverted to the nearby parallel primary road.

In addition to managing traffic flow around the scene, VDOT worked with other agencies to plan the removal of the crashed vehicles. Once State Police investigators and reconstructionists had finished documenting evidence and measuring the scene, heavy duty tow trucks were called in and all but the car and TT3 were removed. Once the fire was extinguished, the bodies were extricated from the wreckage and sent to the nearest district office of the Chief

Medical Examiner. A contractor “over-packed” and offloaded materials from Trailer 3. Over-packing involves placing the containers into larger containers and then double checking to ensure nothing is leaking. These containers were removed to a staging location less than a mile south of the site, at the gore area of an interstate exchange. They were then loaded onto another trailer and moved from the area. The burned Trailer 3 was the last vehicle removed from the scene.

Members of the hazardous material response team initially focused on identifying the exact nature of the spill, the types of chemicals involved and the quantities. Once they had determined that highly caustic chemicals had contaminated the area, they worked to dike the fluid and neutralize it. They added acidic chemicals to counteract the alkaline fluids, as well as water to dilute them, and then performed bio-remediation by introducing microbes to eat the fuels that had leaked. The team also monitored the perimeter of the spill, identifying various zones which required differing levels of personal protective equipment. Although air quality monitoring indicated that there was no immediate threat from airborne hazardous materials emanating from the smoke plume, the road surface and the ditch were wet. Shoe coverings were given to many of those walking through the crash area and others had to be washed down.

One of the concerns later mentioned by both VDOT staff and state and local agency personnel was the lack of protection at the site. The geography was open and a closed perimeter was difficult to maintain. One issue identified for future incidents was the need for first responders to clearly delineate the hazard zones and demarcate them with colored tape (red, yellow, or blue, depending on the safety threats within a particular zone). This would create exclusion areas, so that unsuspecting investigators or emergency responders did not walk through a contaminated area without wearing appropriate protective equipment.

Different agencies had differing purposes at the scene, which led to differing priorities. From previous serious incidents, however, these groups had learned that they needed to have at least one person from each agency in a single room or “command center” to maintain the accuracy of information and allow clear back-and-forth communication. While their ability to direct and control all the activities on the scene was not possible, the overall management appears to have been very efficient.

Those who had been evacuated were returned to their vehicles at 6:32 a.m. They were allowed to move their vehicles, follow the detour around the crash site, and resume their trips. The northbound lanes were opened to traffic at 8:14 a.m. After the crash scene had been completely cleared, the southbound lanes were opened to all traffic at 3:22 p.m. using a “slow

roll” technique. This technique has been found to be highly effective in getting all traffic back to normal travel speeds as quickly as possible. In the past, it often took three to four hours to achieve normal interstate speeds after a crash of this magnitude. Using the “slow roll” technique, the congestion cleared at 4:31 p.m., in just over an hour.

The annual average daily traffic is 22,000 vehicles for this section of roadway (Virginia Department of Transportation, 2008). For the period August 27, 2008 to June 30, 2009 the VDOT reported that there were 378 incidents over a 150 mile stretch of this interstate highway in Virginia. Fifty-eight of these incidents involved tractor trailers, 219 were vehicle incidents and 101 involved congestion or other factors. The reporting system had just been implemented in August of 2008, so a full year of data was not available for the first report. From July 1, 2009 through June 30, 2010, there were 526 reported incidents, including 37 total road closures. Ninety-eight of the incidents involved tractor trailers, 345 were vehicle incidents and 83 were reported as congestion or “other” types of incidents.

Because of the higher speeds involved and the mix of vehicles with immensely differing size, this type of interstate crash often has tragic results. In this case, at least one fatality could have been avoided if all occupants had been belted and rode down the crash sequence within the confines of the vehicles. The only way to prevent future rear end collisions, however, requires greater vigilance and caution on the part of drivers, so that they have time to respond when travelling under adverse conditions or when unexpected slowing or stopping occurs.

RECOMMENDATIONS

1. Those associated with transportation safety and training use the findings in this report to reinforce that:
 - a. Motor vehicle operators must, at all times, pay attention to the driving task.
 - b. Motor vehicle operators driving under adverse conditions or where visibility is limited must be especially vigilant with regard to unexpected situations. They should adjust their vehicle speeds to ensure they are not “overdriving” their sight distance and increase lead times and distances when following other vehicles.

2. The Virginia Department of Transportation (VDOT), the Virginia Department of Motor Vehicles (DMV), the Virginia Department of State Police (VSP), local law enforcement agencies, and both public and private agencies associated with transportation safety and training should continue to educate drivers on proper actions to take when crashes occur or when vehicles are stopped on the roadway. It is important to provide approaching traffic with as much information as possible regarding the danger ahead—such as pressing brake lights when slowing or activating flashers when stopped and placing flares or emergency triangles behind vehicles stopped on roadway shoulders. All drivers stopped on the interstate should be vigilant with respect to traffic approaching from the rear, since distracted or inattentive drivers may not identify the situation soon enough to stop safely.

3. All occupants of motor vehicles should wear the safety restraints provided in their vehicles.
 - a. The DMV and those associated with transportation safety and training should continue to stress the life-saving properties of seat belts.
 - b. VSP and local law enforcement officers should continue to enforce safety restraint laws.
 - c. Companies that employ commercial drivers should, as a matter of policy, require that all occupants of all vehicles used for business purposes wear the installed safety restraints.

4. VDOT should conduct a review of the snow plowable reflective pavement markers and replace all the damaged reflective elements along this stretch of interstate highway.

5. VSP, VDOT and local law enforcement and emergency services agencies should continue to evaluate and improve their emergency action plans. Lessons learned from past emergency events provide invaluable insight into approaches that were effective as well as those that could be improved. The outcome of improved safety and efficiency provides benefits for everyone, from the responders and their agencies, to the citizens at large.

6. VSP and local law enforcement agencies should continue to stress the importance of thorough evidence collection for crash investigations, including commercial motor vehicle crashes. Even if the crash causative factors are quickly identified, information that may not appear immediately relevant may become important in the full disposition of the case. This includes evidence such as vehicle inspection, vehicle maintenance information, materials being hauled, and drivers' hours of service for "not at fault" drivers and vehicles.

REFERENCES

Virginia Department of Transportation (2008). *Average Daily Traffic Volumes with Vehicle Classification Data on Interstate, Arterial and Primary Routes*. Richmond, VA.