Law Enforcement Officer
Motor Vehicle Crash Investigation

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LEO 2016-02
February 9, 2018

Trooper Crashes on Roadway While Responding to Reckless Driver Complaint—Kentucky

EXECUTIVE SUMMARY

On June 23, 2015, a 23-year-old state police trooper was fatally injured when he lost control of his vehicle in a curve and was struck by an oncoming tractor trailer.

The trooper was responding to a complaint of a reckless driver whom Dispatch had advised was traveling ahead of him. Using his cell phone, the trooper called Dispatch to get an update on the location of the reckless driver. As the trooper entered a curve in the road, he lost control of his patrol car, which rotated counterclockwise, and crossed into the path of oncoming traffic. Seeing the out-of-control patrol unit, the driver of an oncoming tractor trailer applied his brakes and steered toward the shoulder in attempt to avoid crashing into the trooper. The patrol unit had spun approximately three-fourths of a full rotation, placing the driver's side door in front of the oncoming tractor trailer as the collision occurred. The trooper died on impact.

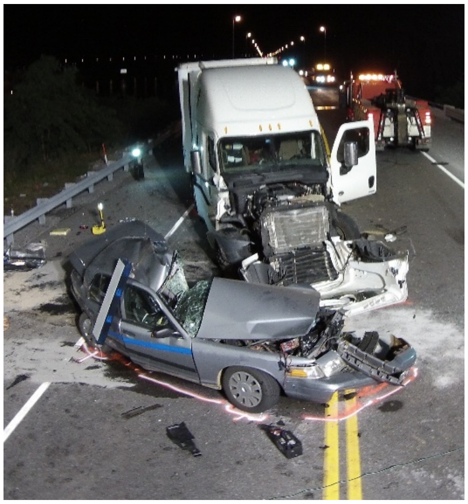
Photo taken at scene of crash.
(*Photo courtesy of Kentucky State Police.*)

CONTRIBUTING FACTORS

Key contributing factors identified in this investigation include:

- Vehicle speed
- Use of a cell phone while driving
- Roadway conditions and/or weather

KEY RECOMMENDATIONS

NIOSH investigators concluded that, to help prevent similar occurrences:

- Law enforcement agencies should establish and enforce standard operating procedures for the use of onboard vehicle equipment and other electronic devices, such as cell phones, when operating vehicles.
- Law enforcement agencies should establish and enforce standard operating procedures for the maximum miles per hour over the posted speed limit a law enforcement officer may use when responding to a call.
- Law enforcement agencies and training academies should emphasize the driving skills of matching vehicle speed with roadway and environmental conditions.

- Law enforcement agencies and training academies should consider including in the training curriculum techniques for managing adrenaline surge.
- Departments of transportation should consider the use of supplemental traffic control devices in addition to the minimum specified by the *Manual of Uniform Traffic Control Devices (MUCTD)* to warn motorists of upcoming curves.

NIOSH Law Enforcement Officer Investigations

The National Institute for Occupational Safety and Health (NIOSH), an institute within the Centers for Disease Control and Prevention (CDC), is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. Through an interagency agreement, the National Institute of Justice funded a NIOSH pilot program to investigate line-of-duty deaths of law enforcement officers resulting from vehicle crashes and being struck by vehicles while responding to roadside emergencies and making traffic stops. These NIOSH investigations are intended to reduce or prevent occupational deaths and are completely separate from the rulemaking, enforcement and inspection activities of any other federal or state agency. NIOSH does not enforce compliance with State or Federal occupational safety and health standards and does not determine fault or assign blame. Participation of law enforcement agencies and individuals in NIOSH investigations is voluntary. Under its program, NIOSH investigators interview persons with knowledge of the incident who agree to be interviewed and review available records to develop a description of the conditions and circumstances leading to the death(s). Interviewees are not asked to sign sworn statements and interviews are not recorded. The agency's reports do not name the deceased officer, the law enforcement agency or those interviewed. The NIOSH report's summary of the conditions and circumstances surrounding the fatality is intended to provide context to the agency's recommendations and is not intended to be definitive for purposes of determining any claim or benefit. The NIOSH report is not intended as a legal statement of facts. This summary, as well as the conclusions and recommendations made by NIOSH, should not be used for the purpose of litigation or the adjudication of any claim.

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INTRODUCTION

On June 23, 2015, at approximately 1748, a trooper from the Kentucky State Police (KSP) was fatally injured when the patrol unit he was driving was struck by a tractor trailer. The trooper had received a complaint of a reckless driver and was attempting to locate the vehicle when his patrol unit spun out of control, after entering a curve, and into the path of an oncoming tractor trailer. After learning of this incident, and enlisting the cooperation of the KSP, an investigation team consisting of staff from the NIOSH Division of Safety Research and the Kentucky Fatality Assessment and Control Evaluation Program met with the KSP collision analysis officer who had investigated and created a reconstruction of the incident, as well as a dispatcher who was on duty when the crash occurred. NIOSH investigators reviewed the KSP collision analysis report, photographs, and witness statements.

LAW ENFORCEMENT AGENCY

The Kentucky State Police (KSP) employs approximately 1,000 troopers who are responsible for law enforcement throughout the state with no city or county limits of jurisdiction. The KSP is divided into several divisions:

- Administrative
- Commercial Vehicle Enforcement
- Operations
- Technical Services

The Operations Division enforces criminal and traffic laws, investigates all reported complaints and criminal law violations, as well as any other functions necessary to protect the citizens of Kentucky. This division is comprised of three operational troops: West Troop, East Troop, and the Special Enforcement Troop; the East and West troops are further broken down into 16 Posts.

The state of Kentucky covers 40,409 square miles, has almost 28,000 miles of roadways, and according to the 2015 U.S. Census Bureau, has a population of 4,425,092 [1KeyData 2016; Kentucky Transportation Cabinet 2016; United States Census Bureau 2016].

TRAINING AND EXPERIENCE

The trooper received a bachelor of arts degree before graduating from the Kentucky State Police Academy in January 2015. He had worked in his assigned post for approximately 5 months.

At the time of the crash, the Kentucky Revised Statute (KRS) 16.040 [Kentucky Legislature 2017] listed the following qualifications for all persons appointed as officers, at the time of their appointment:

- Be a citizen of the United States and a resident of the Commonwealth.

- Be of good moral character and in good health.
- Be not less than twenty-one (21) years of age.
- Possess a valid driver's license against which no more than six driver demerit points have been assessed.
- Possess:
  (a) a minimum of 60 college hours of credit or an associate's degree from an accredited college or university; or
  (b) a high school diploma with at least 2 years of active military duty or in law enforcement; or
  (c) 2 years' experience as a full-time, sworn law enforcement officer.

Those who meet the qualifications are eligible to apply to the KSP academy. The application process to be accepted into the academy includes a written exam, a physical agility test, an interview, a background investigation, and a polygraph test. The physical agility test is made up of five events [KSP, no date (a)], including:

- Bench press (based on body weight percentage)
- 2 minute sit-up test
- 300 meter run
- 2 minute push-up test
- 1.5 mile run

All new recruits and active troopers must attend the KSP Academy for basic training. The cadets spend 23 weeks and more than 1,000 hours in a military-style program, training on firearms, defensive tactics, criminal investigations, emergency driving, counter ambush, as well as other aspects of law enforcement [KSP, no date (b)]. Although a standalone class in traffic incident management (TIM) is not included in the academy curriculum, the TIM concepts are included in the week-long driving course and the 40-hour collision training.

After graduation, troopers remain on probation for 1 year. Probationary troopers must complete 8 weeks of field training at their assigned post, under the supervision of a field training officer (FTO). During the remainder of the probation period, the troopers are shadowed by their FTO; the troopers operate alone but their shadow will randomly review police reports completed by the trooper and follow up with him or her if necessary.

KSP has a Law Enforcement Accelerated Program (LEAP) for peace officers of other Kentucky law enforcement agencies who would like to become a KSP trooper. The length of the accelerated class is 11 weeks. To be eligible for the LEAP class, the officers must be currently working or have not been separated or retired for more than 12 months from the other Kentucky law enforcement agency [KSP 2002].

The KSP academy also provides advanced training for KSP troopers. All sworn, Kentucky law enforcement officers (LEOs) are required to attend at least 40 hours of training annually.

ROAD AND WEATHER CONDITIONS

The roadway was an asphalt-surfaced federal highway with one lane in each direction, eastbound and westbound. A double, solid, center line divided the lanes; a 12-foot–wide shoulder and guardrails were located on the outside of both lanes. The posted speed limit was 55 mph.

The crash occurred in a curve with a radius of 665.24 feet, measured from the middle of the westbound lane. Single, yellow and black, left chevron arrow warning signs were posted to indicate approaching a curve;

however, no advisory speed limit signs were posted prior to the curve. The roadway was illuminated with streetlights.

From archived weather reports, the local temperature was approximately 77 degrees F at the time of the crash; the dew point was approximately 73 degrees F. The humidity for the area on the date of the crash was 86%. However, the maximum humidity recorded for that area was 98%; thus, the humidity when the crash occurred may have been more than 86%, due to the large water source nearby (see Diagram 1). The skies were cloudy and visibility was recorded as 7 miles; winds were from the northwest with an approximate speed of 5 miles per hour [Weather Underground 2015].

Diagram 1. Crash site in relation to waterway.
(Courtesy of Google Maps)

VEHICLES INVOLVED

The patrol unit involved in the crash was a 2010 Ford Crown Victoria. The vehicle was equipped with front and side impact airbags as well as shoulder/lap safety harnesses. Modifications such as emergency light bar, sirens, and mobile data terminals (MTDs) were installed aftermarket. A blue light emitting diode (LED) emergency light bar was affixed to the top of the patrol unit. All maintenance was up to date. At the time of the crash the trooper was wearing his shoulder harness and the emergency light bar was activated.

A 2015 Freightliner Cascadia tractor pulling a 2003 Dorsey box trailer was also involved in the crash. The vehicle had a raised roof sleeper. The tractor was equipped with a shoulder/lap safety harness and a fire extinguisher. At the time of the crash, no leaks or damage was detected with the air brakes. All tire tread measurements on all five axles of the tractor and trailer were within the acceptable limits as per Code of Federal Regulations Title 49 subpart 393.75 Tires. The driver was wearing his shoulder/lap safety harness when the crash occurred.

INVESTIGATION

At approximately 1725, Dispatch received complaints of a reckless driver from two separate witnesses. The trooper received the request for service by radio, activated his emergency lights, and traveled toward the location of the reckless driver. One of the complainants stayed on the phone line with Dispatch, providing updates of the reckless driver’s location and erratic behavior; in turn, Dispatch continued to update the trooper, who continued traveling westbound trying to catch up to the reckless driver.

Using a cell phone, the trooper called Dispatch at approximately 1738 and requested additional information on the reckless driver. It is unknown whether the trooper was holding the phone or using a hands-free method. The dispatch operator asked the trooper to hold while he retrieved the information from the dispatch officer speaking with the witness. The dispatch operator returned and reported the location. While on the phone with Dispatch, the trooper passed a motorist on a straight stretch of the roadway; by using the audio from Dispatch and the power control module from the patrol unit, it was determined that the trooper was traveling 90–100 miles per hour (mph) as he overtook this vehicle. At this time, the trooper determined the reckless driver was too far ahead of him to catch and was going to disregard the call. The trooper, still on the phone with Dispatch, re-entered the westbound lane, slowed down to an estimated speed of 83 mph, and began to enter a left-handed curve.

As the trooper entered the curve, a tractor trailer driver traveling eastbound at 45 mph observed the trooper lose control of the patrol unit. Yaw marks from the front and rear passenger side tires indicated that this occurred approximately 1.25 feet from the fog line of the westbound lane. The tractor trailer driver stated that at this time the patrol unit had made a 180-degree rotation and was still rotating and skidding toward the tractor trailer. The tractor trailer driver applied his brakes, leaving 70 feet of skid marks, and steered toward the shoulder in an attempt to avoid the patrol unit.

The patrol unit continued rotating for 205 feet, revolving 270 degrees counterclockwise before ending in the eastbound lane with the driver’s side door in front of the oncoming tractor trailer (see Diagram 2). Upon impact with the tractor trailer, the body of the patrol unit was torn from its frame and the driver’s side was pushed into the passenger side (see Photo). At the deepest point, the intrusion of the driver’s side measured approximately 58 inches. After impact, the tractor trailer continued traveling east 16.3 feet, and the patrol unit came to rest 19.7 feet east of impact in the eastbound lane, facing north.

When the trooper had entered the turn, he was still on his cell phone. The dispatch operator heard the trooper shout; he called out to the trooper but got no response. After a short period of silence, he heard people talking in the background over the trooper's cell phone. The dispatch operator called out to the trooper and to those in the background; however, no one heard his voice and he could not determine what was occurring at that time.

Dispatch started receiving 911 calls at approximately 1752, advising of a crash that involved a state trooper. The motorist the trooper had passed witnessed the crash and stopped to offer assistance. The motorist stated he saw the driver of the tractor trailer moving so he ran straight to the patrol unit but could get no response from the trooper. Multiple emergency response units responded to the scene, including several law enforcement agencies, EMS, rescue, and fire departments. The driver of the tractor trailer received minor injuries and was able to exit his vehicle without assistance. The trooper was trapped inside the patrol unit; emergency responders used vehicle rescue equipment to remove the door and extricate the trooper, who was pronounced dead at the scene.

Photo. Patrol unit at scene, post-crash.
(*Photo courtesy of Kentucky State Police.*)

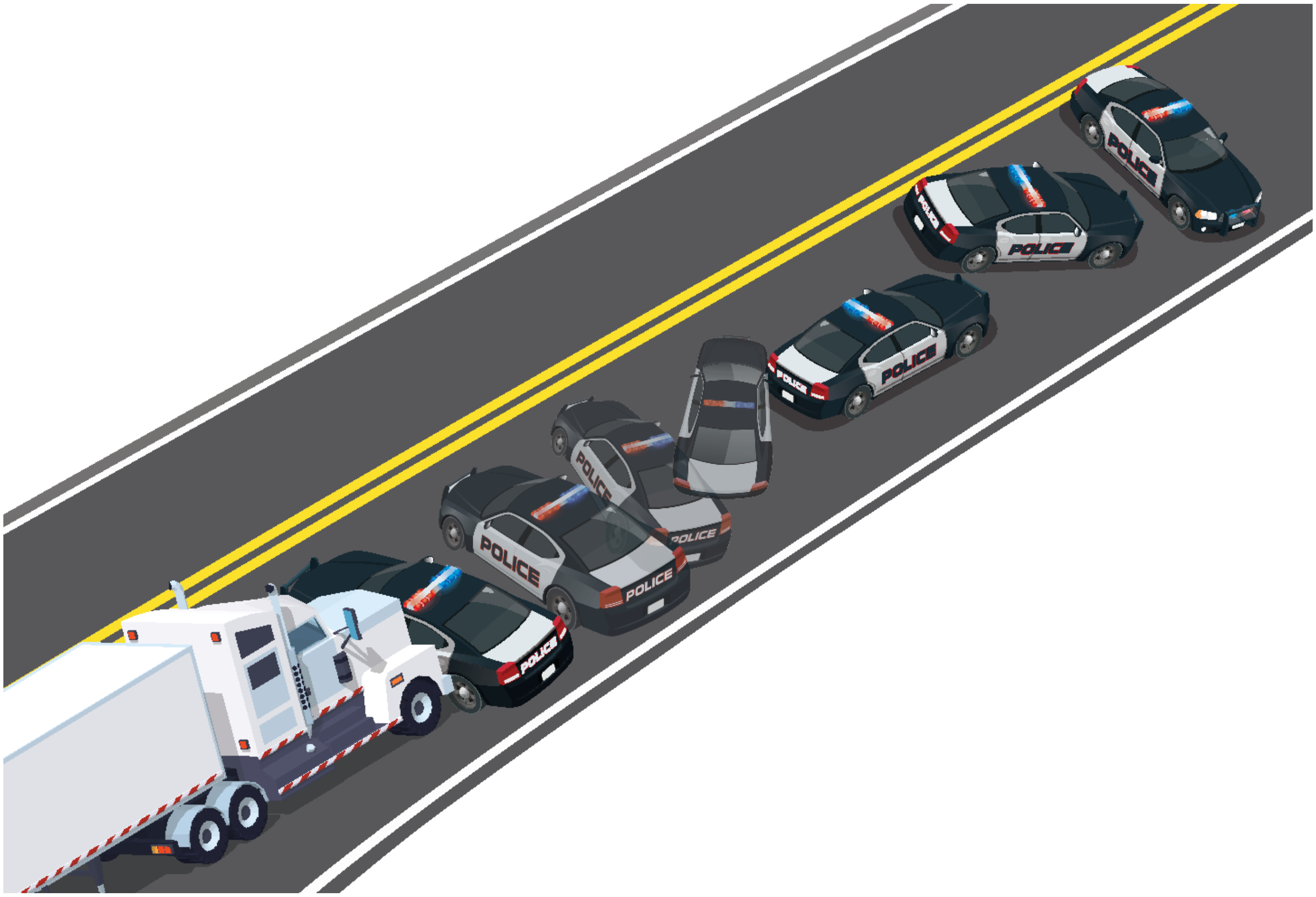

Diagram 2. Counterclockwise rotation of patrol unit as trooper lost control and was struck by oncoming tractor trailer.

At approximately 1815, the KSP Collision Analysis Team was notified to investigate and reconstruct the incident. The investigators computed the radius of the curve in the westbound lane. Then using the yaw marks made by the patrol unit, computed the radius for the passenger-side tire path and adjusted for the tire track width. Next, the investigators used a computerized instrument for measuring tire-to-road friction to obtain the coefficient of friction (*cof*), which was determined to be 0.8. The roadway had no superelevation or degree of grade. Superelevation is the tilting or banking of the roadway along a horizontal curve to help reduce centrifugal forces that develop as a vehicle goes around a curve [MichiganTech, no date]. The radius, *cof*, and superelevation are necessary to compute the critical speed, which is defined as “the speed at which a vehicle will lose lateral control on a given roadway curve” [Glennon 2006]. The following formula is used to calculate the critical speed (S):

$$S = 3.86\sqrt{Radius\ (cof \pm superelevation)}$$

The table below shows the variables used in the computation.

Table. Variables used to determine critical speed.

Variable	Roadway	Trooper
Track Width (feet)	–	6.5
Radius (feet)	665.24	578.91
Coefficient of Friction (g)	0.8	0.8
Superelevation	0	0

Note. Dash indicates not applicable.

Therefore, the critical speed for the curve in the westbound lane was 89 mph (rounded to nearest tenth).

Using the same formula, the radius computed from the yaw marks, and the track width, the calculated speed the patrol unit was traveling when the tires began to slip was 82.8 mph.

$$R = \text{Radius} - \left\{\frac{trackwidth}{2}\right\}$$

Thus, the trooper’s patrol unit was traveling at a speed lower than the speed determined for the tires to exceed friction limits and begin to slip sideways.

The investigators proposed two theories for why the trooper would have lost control. First, the trooper may have oversteered coming into the curve. Oversteering a vehicle when driving through a curve decreases the radius the vehicle is traveling, which lowers the speed at which the driver loses control.

The second theory deals with road conditions. One witness described the roadway as slippery, as if it had rained. This could be attributed to the local temperature, dew point, and humidity. The crash occurred approximately three-tenths of a mile from a major waterway and hydroelectric power station, providing a source for moisture in the air and on the roadway. The *cof* was measured hours after the crash and could have been lower at the time of the crash; the lower the number, the slicker the surface. Using a *cof* of 0.7, the critical speed of the westbound curve is reduced to 83.26 and the trooper’s critical speed is reduced to 77.47.

CONTRIBUTING FACTORS

Occupational injuries and fatalities are often the result of one or more contributing factors or events that result in the injury or fatality. NIOSH investigators identified the following contributing factors in this incident:

- Vehicle speed
- Use of a cell phone while driving
- Roadway conditions and/or weather

CAUSE OF DEATH

The Kentucky State Medical Examiner's Office recorded the cause of death as multiple injuries sustained in a motor vehicle collision.

RECOMMENDATIONS/DISCUSSION

The following recommendations focus on methods that could be used to eliminate or mitigate the factors identified as contributing to this incident. They are not aimed at any agency but are intended for consideration by law enforcement agencies, state and local governments, and departments of transportation nationwide, as well as safety researchers and the general public.

Recommendation #1: Law enforcement agencies should establish and enforce standard operating procedures for the use of onboard vehicle equipment and other electronic devices, such as cell phones, when operating vehicles.

The primary responsibility of a LEO operating a patrol unit is the safe operation of that vehicle. However, LEOs constantly process information from multiple sources including radios, cell phones, and mobile data terminals (MDT) or computers, as well as watching for vehicle violations and acts of crime while operating a patrol unit. In 2010, approximately 75% of patrol units were equipped with MDTs [Berg 2012]. Although the onboard equipment and electronic devices provide information necessary and valuable to the duties of a LEO, their use may also cause distractions and potentially unsafe conditions.

Although it appears that humans can multitask in reality, studies have shown the brain is rapidly switching between tasks and not performing them simultaneously [Lin et al. 2016]. For each task the brain must select and process the information then encode it to create a memory. This applies to audio, visual, manual, and cognitive tasks. However, the brain has limited capacity, and when there is too much information, the brain decides what to ignore [NSC 2012]. Experiments have shown that multitasking makes it more difficult to organize your thoughts, and the quality of each task is negatively impacted; in approximately 40% of crashes, some aspect of driver perception and information processing was a contributing factor [Olson et al. 2010].

Even when the driver is looking ahead, if the information channel of the brain is occupied with something else such as a conversation, the driver's ability to detect or respond is reduced. For this reason, there is no difference between hand-held and hands-free devices; the problem is not the hands on the wheel but the mind on the road [Strayer et al. 2013] [Atchley et al. 2017]. By examining eye movements, researchers found that when drivers are occupied with a secondary cognitive task, they will look away from the road less often, resulting in tunnel vision [Strayer et al. 2013, A].

Motorists collect information mostly through observing roadway alignment, markings, and reading signs. However, motorists can only focus on one visual source at a time; therefore they take quick glances, shifting their attention [AASHTO 2001]. Increased speed also reduces the amount of information a driver can see and limits the time available to receive and process information [AASHTO 2001].

The use of MDTs while the patrol unit is in motion creates a potential risk because a LEO's focus is on operating the MDT and not driving. In one study, researchers from British Columbia rode along with LEOs for an entire shift and collected data on the number of tasks an officer performed while driving.

The study found:

- 77% of the officers used their MDT while driving.
- 55% of the officers used their MDT while driving and performed one additional task.
- 11% of the officers used their MDT while driving and performed two additional tasks.
- 7% of the officers used their MDT while driving and performed three additional tasks [Anderson et al. 2005].

The following are examples of policies currently in place at some law enforcement agencies pertaining to the use of MDTs while operating a patrol unit:

- Officers shall not type on the MDT when the vehicle is in motion unless a circumstance exists requiring immediate action.
- Other than one-button responses to indicate an employee is en route to, has arrived at, or is clearing a scene, typing messages on the MDT while the vehicle is being operated is prohibited.
- Members should avoid extensive use of an MDT or laptop while driving a department vehicle, as this may cause unreasonable distraction and unsafe conditions.
- Officers should pull over if they need to type anything more than a simple one- or two-button response.
- Field personnel shall use the MDT for receiving and acknowledging routine dispatch assignments, updating unit status, and querying databases when practical to do so, with due regard to officer safety [Friedman 2013a].

Technology is available to assist in limiting a LEO’s use of an MDT while operating a patrol unit. One option is software that shuts down many of the computer's functions when the car accelerates past a certain speed that is determined by the law enforcement agency. When an officer drives above the predetermined speed, a box on the screen turns red and the keyboard is disabled. However, even when the keyboard is locked, the screen continues to show updates from dispatchers, as well as other important information, and officers can still see the GPS screen to help direct them to an emergency. A second option is technology that permits LEOs to use voice commands or prompts instead of typing on the keyboard [Friedman 2013b].

Establishing or updating existing SOPs to balance the risks and benefits of using onboard electronics is a necessity; however, to be successful, the SOP must be enforced.

Recommendation #2: Law enforcement agencies should establish and enforce standard operating procedures for the maximum miles per hour over the posted speed limit a law enforcement officer may use when responding to a call.

The 2011 Kentucky Revised Statute 189.940, exemptions from traffic regulations states, “The speed limitations set forth in the Kentucky Revised Statutes do not apply:

> (a) To emergency vehicles when responding to emergency calls.
> (b) To police vehicles when in pursuit of an actual or suspected violator of the law.
> (c) To ambulances when transporting a patient to medical care facilities.
> (d) To the driver thereof when giving the warning (continuous use of emergency lights and siren) required by subsection (5)(a) and (b) of this section.

The statute also states that this exemption does not relieve the emergency vehicle operator from the duty to drive with due regard for the safety of all persons and property upon the highway [Kentucky Legislature 2011].

Using the yaw marks at the crash scene, it was determined the trooper was travelling at approximately 83 mph when he lost control of his patrol unit. The posted speed limit on the roadway was 55 mph.

LEOs face many hazards and dangerous situations in the line of duty (LOD); however, motor vehicle-related events are consistently a leading cause of LOD deaths. The main ways to control a hazard are:

- Eliminating or removing the hazard
- Engineering controls to reduce the source of exposure
- Administrative controls such as training and policies
- Personal protective equipment [NIOSH 2016]

Although elimination is the most effective hazard control, it is not possible to remove driving from the duties of a LEO. However, it is possible to implement and enforce SOPs, as well as provide training on safe driving, and make sure LEOs understand the risks they face on roadways. Creating an SOP that caps the maximum miles per hour over the posted speed limit identifies how fast a LEO may travel when responding to a call.

Research has shown “increased travel speeds—even at low levels—are directly related to both the likelihood of a crash occurring and to the severity of crash outcomes” [Road and Traffic Authority of New South Wales 2011b]. The likelihood of a driver being involved in a fatal crash increases when the vehicle is traveling over the posted speed limit [Road Accident Research Unit Adelaide University 2001]. Increased speed reduces the amount of information a driver can visually see and limits the time available to receive and process this information. Small increases in travel speed can result in large increases in braking distances and speed at point of impact, significantly increasing the risk of a serious or fatal injury [AASHTO 2001].

> The faster you drive, the harder you hit another vehicle, pedestrian, or other object in a crash. Even exceeding the speed limit by a small margin can have a considerable impact. Consider this example: A driver notices a pedestrian crossing the road. If the car is travelling at 50 km/h (31 mph) and the driver brakes when the pedestrian is 29 meters (95 feet) away, there will be enough space in which to stop without hitting the pedestrian. Increase the vehicle speed by just 10 km/h (6 mph) and the situation changes dramatically. At 60 km/h (37 mph), with the pedestrian 29 meters (95 feet) away and the driver braking at the same point, the car will be travelling at 44 km/h (27 mph) when it hits the pedestrian [Road and Traffic Authority of New South Wales 2011a].

Diagram 3 is adapted from Road and Traffic Authority of New South Wales showing the stopping distance and speed at impact with the pedestrian 29 meters (95 feet) away.

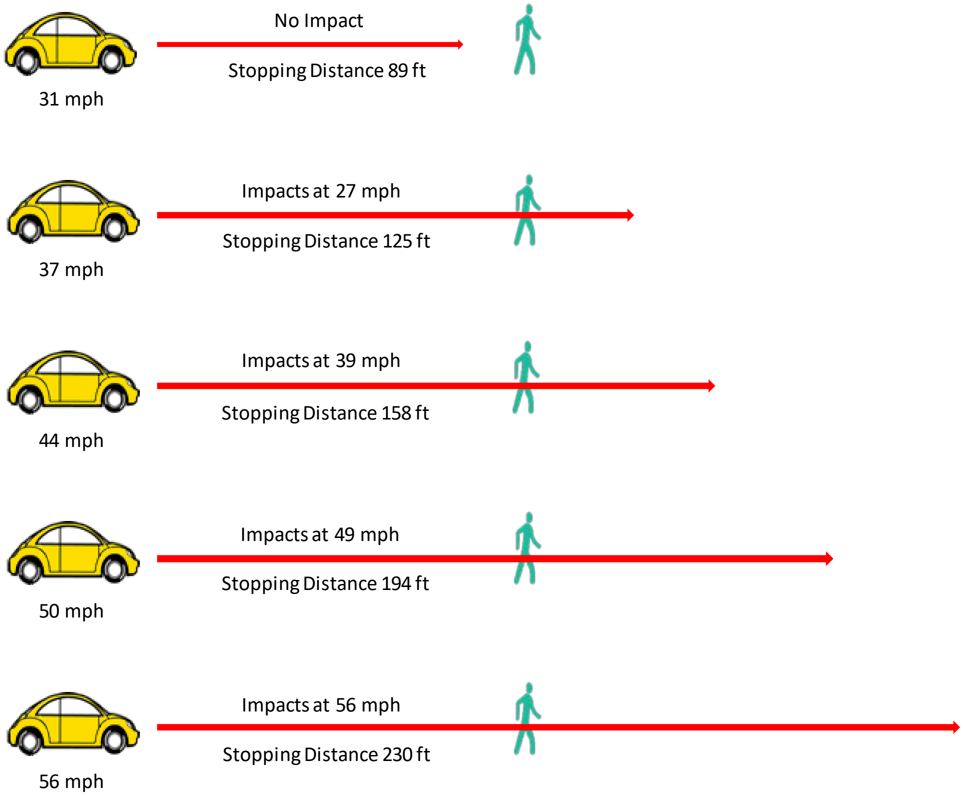

Diagram 3. Speed, stopping distance, and impact speed
(Adapted from Road and Traffic Authority of New South Wales [2011b].)

One way to monitor the speed of a LEO's patrol unit during a response may be through the use of vehicle monitoring devices. Monitoring systems can be installed in the patrol units and programmed to send an alert when the speed exceeds the set points. The monitoring system can record the data for each occurrence and reports can be downloaded for each patrol unit at regular intervals. The data can be used to support corrective action, depending upon the circumstances related to each occurrence. The data retrieved from the patrol units can also be used to identify areas where training may need modification or reinforcment.

Recommendation #3: Law enforcement agencies and training academies should emphasize the driving skills of matching vehicle speed with roadway and environmental conditions.

Discussion: The number of law enforcement officers (LEOs) who died in traffic-related incidents during 2016 was 53, which is a 10% increase from 2015 [National Law Enforcement Officers Memorial Fund 2016]. The thought process and decision-making skills of driving should be emphasized in the LEO driver training; a different decision by an officer may have had a different outcome, and the risk of injuries and fatalities increases with speed [Donnell et al. 2009]. Many of the crashes involved high speeds and adverse road conditions;

therefore, matching the speed of the patrol unit with the roadway conditions, including surface alignment, and environmental conditions should be part of the academy curriculum.

At any given time, a driver is receiving and processing information that influences decisions being made. Motorists select driving speed on conditions such as knowledge of vehicle limitations, roadway conditions, driver ability, and purpose of travel. One specified driving speed for any one location will not remain constant under all possible conditions [Donnell et al. 2009]. Increased speed reduces the amount of information a driver can see and limits the time available to receive and process information; thus, a motorist relies on training or previous experience when the information necessary for a proper reaction is missing [AASHTO 2001].

Three elements of all crashes are the driver, the vehicle, and the roadway. According to the *Motor Vehicle Accident Reconstruction and Cause Analysis* [Limpert 2016], the environment affects all three. The driver can be affected by fog, sun glare, weather, buildings, and other conditions. The vehicle can be affected by such things as the effectiveness of fog-reducing headlights; rain, snow, or mud on the windshield; or by water or ice affecting the brakes and/or tire traction. The roadway is mostly affected by the environment through weather-related problems with tire roadway friction.

Surface friction or skid resistance—the force that develops between the roadway and tires of a vehicle—is needed to drive, brake, and negotiate curves. The higher the surface friction, the more resistance a vehicle has to slipping and sliding; however, as a vehicle's speed increases, the amount of friction needed to stop or prevent sliding increases. High speeds, alone or in combination with other factors, increase the probability that more friction will be needed than is available. Adverse environmental conditions increase this probability and one of its more common results, skidding [Donnell et al. 2009].

According to the Federal Highway Administration [FHWA 2017], each year approximately 22% of all vehicle crashes are due to adverse weather, and 73% of weather-related crashes are due to wet pavement. Water on a roadway acts as a lubricant and can significantly reduce surface friction. "Even as little as 0.002 inches of water on the pavement can reduce the coefficient of friction by 20 to 30 percent" [FHWA 2014].

All air has some water vapor, and the amount of water the air can hold varies with temperature. The dew point is the temperature at which the air is saturated with water vapor. The warmer the air, the more water vapor it can hold; however, once the air cools down to the dew point, it can no longer hold the water vapor, and the excess is condensed into water droplets or ice crystals. A moist atmosphere, such as near rivers, has more water vapor and raises the dew point temperature; thus the air temperature does not have to cool as much to produce water droplets. The water droplets then form on the roadway as dew or frost [University of Washington, no date].

In this incident, the area where the crash occurred was 200 feet from a bridge that crosses the fifth largest river within the continental United States, which backs up into a lake that covers 160,300 acres [KentuckyLake.com 2017]. On the day of the incident, the humidity for the area was 86%. However, archived records list the air temperature at 77 degrees and the dew point at 73 degrees, meaning the air was nearly saturated and the weather station where the archived reports were obtained is approximately 20 miles inland, away from the water source and crash site; therefore, the conditions at the crash site may have been different than the weather station. Witnesses at the scene stated the road felt slippery as if it had rained, but no rain had fallen on that day in the vicinity of the crash. During interviews, law enforcement officials stated in the past, several other crashes had occurred in the same curve due to the slippery roads.

The normal operation of a vehicle is a process in which the vehicle, driver, and roadway form a closed loop. When one of the elements changes, adjustments need to be made. Training that emphasizes the importance of speed, friction, and recognizing adverse road conditions will heighten the awareness of crash causation. Outside agencies such as Alert International, Drive to Survive, and Below 100 are available to provide training on vehicle operations.

Alert International provides multiple resources for LEOs, including a *Law Enforcement Training Reference Guide*. How to establish a training process, driving policies, and instructional guidelines and aids can all be found in the training reference guide. The mission of Alert International is "to provide assistance to states in establishing effective and defensible standards for employment and training of law enforcement officers in the field of emergency vehicle operations" [Alert International 2017].

Drive to Survive is a training program that focuses on vehicle dynamics in relation to how and why crashes occur, as well as topics for the safe operation of a police vehicle during routine and emergency conditions. The training is conducted using the same techniques used by crash investigators and includes roadway friction, critical curve speeds, hydroplaning, and other important topics [Drive to Survive, no date].

Below 100 is an organization with a vision to reduce the LEO line-of-duty deaths (LODD) to less than 100 per year. Their program has identified five initiatives, including speed of patrol unit, to improve officer safety. The program believes advanced driver training and awareness of the trends in preventable LODDs will influence LEOs and reduce the number of fatalities. The Below 100 Program offers training classes, tools, and other resources for law enforcement agencies and provides risk assessment templates to identify the needs of individual agencies [Below 100, no date].

Excessive speed, surface alignment, and roadway conditions were all contributing factors of this crash. As speed increases, the amount of friction needed to control a vehicle increases. The moisture on the roadway further decreased the amount of friction created between the tires and roadway, thus increased the gap between friction available and friction needed for safe operation.

Recommendation #4: Law enforcement agencies and training academies should consider including in the training curriculum techniques for managing adrenaline surge.

Discussion: Adrenaline is a hormone, released within a couple minutes of being exposed to stress, fear, or situations of potential danger and triggers the body's fight-or-flight response [The Free Dictionary, no date]. The sound of the siren, a high-speed pursuit or code three run, as well as the want of apprehension, are all triggers for adrenaline overload, or also referred to as adrenaline dump. When an excess amount of adrenaline is released, tunnel vision or target fixation can occur [Humes 2003]. Fine motor skills, such as hand-eye coordination, and complex motor skills, such as making decisions involving secondary tasks where speed and timing are critical, are reduced. Adrenaline overload can also make it difficult to access short-term memory, the reasoning part of the brain [Humes 2003].

A LEO cannot stop or prevent this adrenaline overload; however, techniques on how to respond to the triggers can lessen adverse effects. The Tactical Arousal Control Technique (TACT) should become an involuntary, subconscious reaction to the triggers or stimulus. The most common form of TACT is tactical or combat breathing [Asken 2007]. The technique is to breathe in cycles counting one to four; breathe in through your nose, stop and hold your breath, exhale through your mouth, stop and hold your breath, and repeat the cycle. Combat breathing can lower blood pressure and stress level as well as reduce the side effects of the adrenaline overload [Humes 2003].

Although the technique is simple and has proven to be effective, combat breathing is difficult for LEOs to remember to do when needed. The goal is to have the LEO "learn it until they forget about it" thus, combat breathing becomes a stimulus response action [Humes 2003]. A suggested method of training is for 5 to 10 minutes every day, have the LEOs practice combat breathing while listening to a siren. To add to this training, have the LEOs watch a dash cam recording of pursuits at the same time. Humes [2003] states that if this is done every day at the academy, the LEO will automatically start combat breathing at the sound of a siren. Humes also suggests practicing combat breathing during stress-induced, reality-based training scenarios.

The crash involving the trooper occurred while he was trying to locate a reckless driver. Prior to the crash, the trooper was traveling at approximately 100 mph, talking to Dispatch on a cell phone, and listening to communications on the radio. As he approached the curve in the road, his patrol unit slowed and entered the curve at approximately 83 mph. At this time, his patrol unit began to yaw, moving into the path of an oncoming tractor trailer. The trooper was exposed to several adrenaline-inducing triggers, including speed and the anxiety of locating the reckless driver. The adrenaline overload could have lessened the trooper's fine and complex motor skills. The fine motor skills include hand-eye coordination, which is constantly being used while driving. Based on the information that drivers see, they move their hand on the steering wheel to keep the car free from accidents [CogniFit, no date]. Seeing danger, making a decision of what action to take to avoid a crash, and then acting on that decision are considered a complex motor skill [Web Traffic School 2005].

Recommendation #5: Departments of transportation should consider the use of supplemental traffic control devices in addition to the minimum specified by the* Manual of Uniform Traffic Control Devices (MUCTD) *to warn motorists of upcoming curves.

Discussion: Traffic control devices are used to promote safety and efficiency on roadways by providing guidance and warnings to motorists to reduce the number of crashes [FHWA 2009]. Motorists rely on the signs to indicate changes in roadway alignment. In section 2C.06, the *Manual of Uniformed Traffic Control Devices (MUTCD)* states, "Uniform application of these traffic control devices with respect to the amount of change in the roadway alignment conveys a consistent message establishing driver expectancy and promoting effective roadways."

Warning signs are intended to improve curve safety by alerting the driver of a change that may not be apparent or expected. Safe negotiation of curves requires warning motorists in advance to provide enough time for detection, recognition, decision, and reaction, also known as Perception-Response Time. Warning signs convey a message to the motorist; however, the number of road signs a motorist is exposed to may reduce the effectiveness of the signs [FHWA 2009].

Rumble strips are a series of rough-textured or slightly raised or depressed road surfaces that vibrate the steering wheel and make a noise inside the vehicle. Rumble strips can be on the shoulder or center lane to alert motorists they are leaving their lane of travel or placed across the lane of travel to alert drivers to unexpected roadway conditions, including changes in horizontal alignment [FHWA 2009]. Rumble strips provide warning to those unfamiliar with the area but also to those motorists who become complacent in their driving habits. Repetitive driving of the same roadways with no incident can allow a motorist to rely on past experiences or skills and not be alert to surrounding conditions [Wilson 2010].

Flashing lights or warning beacons are visible day or night and understood by motorists to signal caution or provide warning [Olson et al. 2010]. Section 4L.03 of MUTCD states that one condition of using a warning beacon is to supplement a warning or regulatory sign or marker [FHWA 2009]. Adding a MUTCD W1-2 curve warning sign with a flashing light could alert motorists to the approaching change in the horizontal alignment of the roadway.

Delineators provide motorists guidance to changes in horizontal alignment of a roadway. Post-mounted delineators (PMDs) can be free-standing on individual posts or mounted on a guardrail at a distance determined by the radius of the curve as defined by the MUTCD. When mounted close together, the delineators form what appears as a continuous ribbon. However, the MUTCD recommends when necessary, adjusting the spacing so that several are visible at the same time to the motorist upon approaching and throughout a horizontal curve. Raised pavement markers (RPM) may also be used with longitudinal line markers to alert motorists of changes in roadway alignment and as guides for vehicle positioning [FHWA 2009]. A study using horizontal curves and various combinations of delineators and reflective devices was conducted to determine what combination provided the most visible detection of a curve. The subjects were to respond when the curve was visible. Adding RPMs to the center line and PMDs on the outside edge of the roadway provided the largest increase in the distance a curve was visible [National Transportation Library 1997].

The motorist's perception of the roadway affects decision making, and the perception of a curve can influence the motorist's speed. However, the motorist's perception can be altered or influenced by use of traffic control devices such as rumble strips, flashing lights, delineators, or warning signs [Olson et al. 2010].

At the time of this incident, the horizontal curve in the roadway where the crash occurred was marked by three chevron alignment signs and a roadway surface warning sign stating bridge ices before road. The addition of any one or combination of rumble strips, flashing warning lights, PMDs, or RPMs could enhance the driver's awareness to the change in roadway alignment and may alert the motorist of a situation needing special attention.

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INVESTIGATOR INFORMATION

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