# Large Truck Crash Reconstruction for Prosecutors

BY PROFESSOR JOHN KWASNOSKI

**National District Attorneys Association**
1400 Crystal Drive Suite 330
Arlington, VA 22202
www.ndaajustice.org

**Nelson O. Bunn, Jr.**, *Executive Director*

**National Traffic Law Center**
A Program of the National District Attorneys Association
www.ndaa.org/ntlc_home.html

**Joanne Thomka,** *Director*

**Federal Motor Carrier Safety Administration**
1200 New Jersey Avenue, SE
Washington, DC 20590
www.fmcsa.dot.gov

**Raymond P. Martinez,** *Administrator*

The National District Attorneys Association (NDAA) created this document through financial support and assistance from the United States Department of Transportation, Federal Motor Carriers Administration (FMCSA), under grant number FM-CDL-0295-17-01-00. NDAA is not part of the U.S. Government, the U.S. Department of Transportation (DOT), or the FMCSA. Therefore, NDAA does not represent the official position or policies of the FMCSA, the U.S. DOT, or the U.S. government.

# Large Truck Crash Reconstruction for Prosecutors


BY PROFESSOR JOHN KWASNOSKI

*Professor Emeritus of Forensic Physics*
*at Western New England University, Springfield, MA*


CONTRIBUTORS


**Elizabeth Earleywine**
FMCSA Legal Division

**Peter Grady**
Senior Attorney, National Traffic Law Center

**Jeanine Howard**
Staff Attorney, National Traffic Law Center

**Thomas E. Kimball**
Senior Advisor, National Traffic Law Center

**Romana Lavalas**
Senior Attorney, National Traffic Law Center

**Scott Skinner**
Oregon State Police, Retired


ACKNOWLEDGEMENTS


THE NATIONAL DISTRICT ATTORNEYS ASSOCIATION and the National Traffic Law Center gratefully acknowledge the contributions of the people and organizations whose collaborative efforts made this monograph possible. The funding for this monograph was provided by a grant from the Federal Motor Carrier Safety Administration (FMCSA). FMCSA's partnership made this project possible.

## — DEDICATION —

**Crash scenes are inherently dangerous places.** In 1996, a bill, the first of its kind, was passed in South Carolina to protect emergency responders when they were stopped on the side of the road.[1]

The necessity for the creation of "Move Over Laws" was realized when James D. Garcia, a paramedic was deemed "at fault" after being struck while helping a patient on the side of the road.[2] Today, every state has enacted a Move Over Law. Yet, despite the existence of move over laws in every State, many persons responding to crashes continue to be struck and killed. According to the "National Law Enforcement Officers Memorial Fund Website," over the past decade, 126 officers have died after being struck by a vehicle.[3]

Tow Truck Drivers are also victimized by drivers who crash into recovery scenes. The International Towing and Recovery Museum adds to the "Wall of the Fallen," in memory of towing operators who are "killed in the line of service."[4] According to the museum curator, ten to sixteen tow truck drivers die each year at crash scenes due to dangerous drivers.

This monograph is dedicated to all who put their own lives in peril responding to and working at crash scenes on our nation's roadways.

---

1 http://www.moveoverlaws.com/move-over-america.htm
2 *Id.*
3 http://www.nleomf.org/facts/officer-fatalities-data/causes.html
4 https://internationaltowingmuseum.org/wall-of-the-fallen/

# CONTENTS

# INTRODUCTION

Resources for prosecutors concerning commercial motor vehicles were few. About 61% of crashes with commercial motor vehicles occur on rural roads[5]. Prosecutors' offices in rural areas often have few attorneys and fewer resources than their larger counterparts. In addition, more and more trucks are being utilized in urban areas of the country to meet the increasing demands of our consumer economy.

The purpose of this monograph is to help prosecutors understand the factors that cause fatal large truck crashes. A commercial driver's license (CDL) represents a driver's livelihood. It also represents the notion that the CDL holder is a professional driver with a heightened awareness of the specialized regulations that apply to the operation of commercial motor vehicles. Further, possession of a CDL means that a driver has acquired skills to safely operate a commercial motor vehicle (CMV).

The Federal Motor Carrier Safety Administration (FMCSA), the federal agency responsible for providing regulatory oversight of the commercial motor vehicle industry, as well as each state's driver's license authority (SDLA) are responsible for enforcing the rules that apply to CDL holders. As prosecutors evaluate CMV collision cases, they must do so with an understanding that a conviction resulting from the culpability of a CDL holder will likely have adverse consequences to a driver's CDL. Furthermore, prosecutors who prosecute CDL holders must be aware of the federal sanctions available in section 49 of the Code of Federal Regulations, specifically, the "Major Offenses" and "Serious Traffic Violations" tables located at 49 C.F.R. § 383.51 and reproduced in this publication at Appendix I, in order to hold CMV drivers fully accountable for their actions that cause injury and/or require disqualification.

As prosecutors learn the basics of CMV crash dynamics in this manual, they should also consider the federal regulations that are designed to prevent these tragedies from occurring.

Thomas Kimball
Senior Advisor, National Traffic Law Center

[5] "Fatal crashes involving large trucks tend to occur in rural areas and on Interstate highways. Approximately 61 percent of all fatal crashes involving large trucks occurred in rural areas, 27 percent occurred on Interstate highways, and 15 percent fell into both categories by occurring on rural Interstate highways." Large Truck and Bus Crash Facts 2016, p. 45 (FMCSA, May 2018); available at https://www.fmcsa.dot.gov/sites/fmcsa.dot.gov/files/docs/safety/data-and-statistics/398686/ltbcf-2016-final-508c-may-2018.pdf

# PREFACE

The investigation and reconstruction of a crash involving a commercial motor vehicle (CMV) is in some ways similar to collisions involving automobiles. While some of the reconstruction methodologies used are the same, CMV crashes have their own distinctive factors and evidence. In addition, the dynamics of heavy trucks and some of the reconstruction methodologies are unique to CMVs. This is an overview for prosecutors who need a basic understanding of the dynamics of heavy trucks, an appreciation for their operation compared to automobiles, and an understanding of evidence they may develop that can be used to reconstruct the pre-impact movement of the vehicle.

This primer is geared toward prosecutors who already have some working knowledge of crash reconstruction principles, but who need to communicate with an expert who has specific knowledge and training in the reconstruction of heavy vehicle crashes. A prosecutor handling a CMV collision case should enlist the aid of a CMV expert(s) as soon as possible so that volatile evidence will not be lost or destroyed.

Special thanks to Scott Skinner, Oregon State Police Retired, for his proofreading and technical suggestions for the text, and for providing some of the graphics.

—John Kwasnoski

# ISSUES IN A COMMERCIAL MOTOR VEHICLE CRASH

In some ways, the investigation and reconstruction of a commercial motor vehicle crash is like an automobile crash, but there are distinctions because of the weight, braking system operation, electronic monitoring of the vehicle and driver, etc. of the commercial motor vehicle. The investigation of a commercial motor vehicle collision involves crash scene evidence that may differ from automobile collisions; such as: unique digital evidence of the performance of the vehicle and driver performance documentation that may have pivotal value in assessing criminal liability. Some of the common questions that the prosecutor may ask in assessing criminal culpability in a commercial motor vehicle crash case include:

- Why did the CMV lose control?
- Was mechanical maintenance or failure a causative factor?
- How fast was the CMV going?
- Did the driver cause the crash?
- Did the load cause the crash?
- Did another vehicle cause the crash?
- Could the driver have avoided the collision?

All CMVs are subjected to periodic safety inspections (see 49 C.F.R. § 396.17 [2017]), and motor carriers must maintain records of those inspections (see 49 C.F.R. § 390.31 [2017]). In addition, 49 C.F.R. § 396.13 (2017), requires drivers to inspect vehicles before driving (see 49 C.F.R. § 392.7, 8 [2017]). Section 49 C.F.R. § 396.11 requires that, (with the exception of intermodal equipment) "every driver shall prepare a report in writing at the completion of each day's work on each vehicle operated. . ."

### How Does a CMV Crash Differ from a Car Crash?

The major difference between car crashes and those involving commercial motor vehicles is the severity of the crash and the potential for injury that each represents because of the size of the vehicle involved. The commercial motor vehicle, because of its weight, brings significantly more kinetic energy into a crash. For example, the weight of an 80,000 lb. tractor trailer is 25 times the weight of a typical automobile; thus when each is traveling at the same speed the tractor trailer has 25 times more kinetic energy than the car. Similarly, a slow moving heavy truck may have comparable kinetic energy to a much faster moving car. Using the physics definition of kinetic energy, an 80,000 lb. tractor trailer moving at a speed of just 13 mph has the same amount of kinetic energy as a 3,200 lb. car traveling at the posted speed of 65 mph. This is illustrated in Fig. 1.

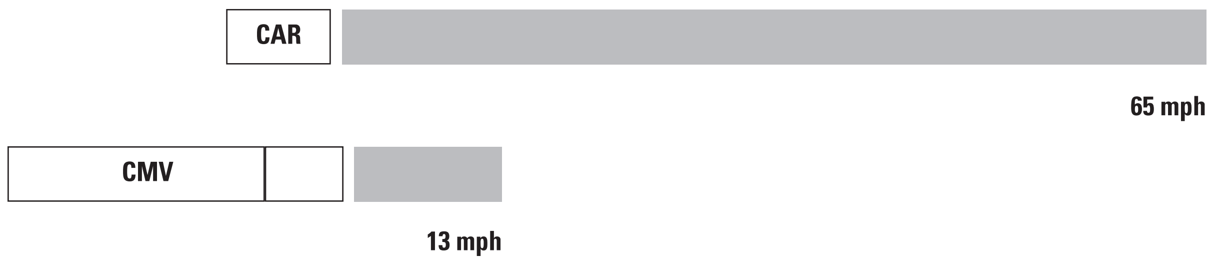


**Fig. 1—Comparison of a 3,200 lb. car and an 80,000 tractor-trailer with the same kinetic energy.**

During a crash, the CMV dissipates its kinetic energy as it loses energy to the roadway, causes damage to vehicles and/or property and creates injury to persons involved until it finally reaches a position of rest. The more energy a vehicle has to dissipate to reach its final rest position, the more severe the collision can be and the greater the potential for injury. Additionally, the heavier truck is less maneuverable than a car. Because of its greater weight, size and the fact that the CMV's tires are less frictional than car tires, the CMV creates less lateral friction, less braking, and a greater stopping distance. This limits the ability of a CMV driver to avoid a collision, and the analysis of a potential avoidance action must include factors specific to the commercial motor vehicle involved.

## Heavy Truck Nomenclature

Prosecutors should familiarize themselves with some terminology regarding heavy trucks, so they can effectively communicate with their own experts and understand the defense expert's reports and testimony. Although there are many varieties and configurations of heavy trucks, they also have many common features, as shown below in Fig. 2. There is additional information in the Glossary at the end of this monograph.

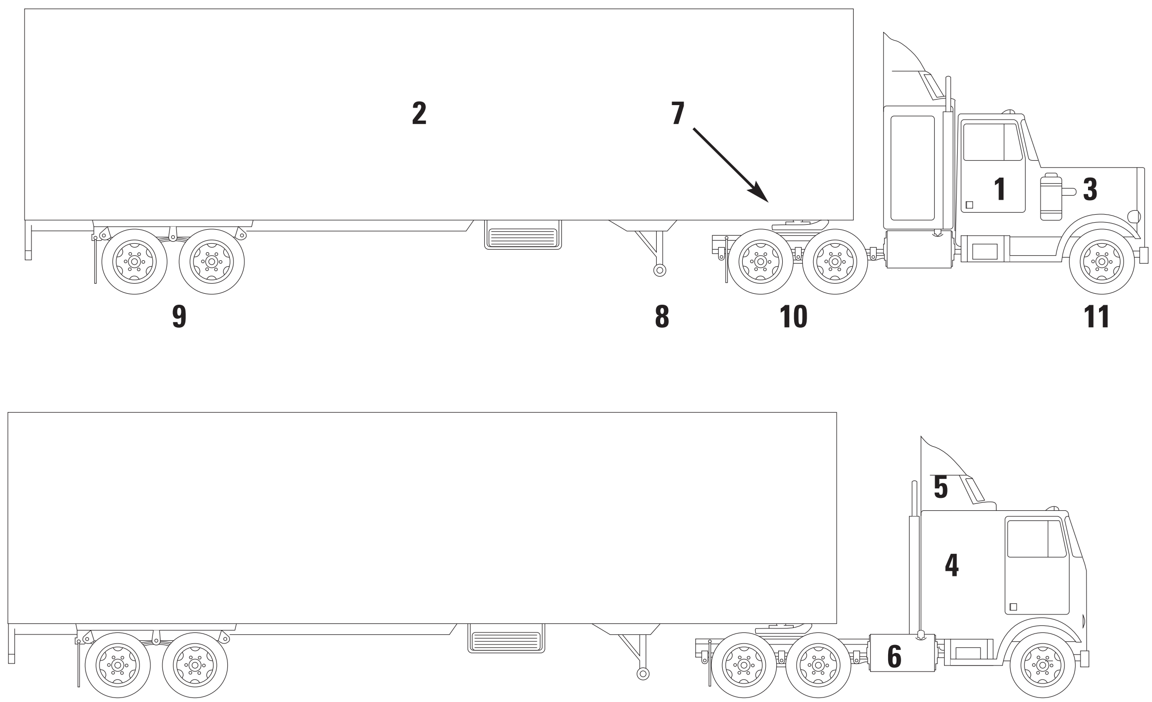


**Fig. 2—Side view and underside view of a semi-trailer truck with an enclosed cargo space.**

1. tractor unit
2. semi-trailer (detachable)
3. engine compartment
4. sleeper cabin (not present in all trucks)
5. air dam
6. fuel tanks
7. fifth wheel coupling
8. landing gear — supports detached trailer
9. tandem axles
10. drive axles
11. steering axle

## Vehicle Dynamics[6]

Commercial Leaner's Permit (CLP) holders training to obtain a class A or class B CDL must receive knowledge and skills training about the causes of skidding, jackknifing, and other emergencies, as well as training on how to recover from these conditions (see 49 C.F.R. § 380, Appendix A to Part 380, [Unit A1.3.2]; 49 C.F.R. § 380, Appendix B to Part 380, [Unit B1.3.2]). Those CDL holders who train to drive longer combination vehicles (LCVs) must also complete a unit "dealing with specific procedures appropriate for LVC emergencies. These must include evasive steering, emergency braking, off-road recovery, brake failures, tire blowouts, rearward amplification, hydroplaning, skidding, jackknifing and the rollover phenomenon. The discussion must also include a review of unsafe acts and the role they play in producing hazardous situations" (49 C.F.R. § 380 Appendix F to Part 380 [Unit 4.2]).

***Jackknifing*** refers to the folding of an articulated vehicle, such as a tractor, pulling a trailer when the tractor folds backwards like a pocket knife. If a tractor's drive axles lock and lose traction and the tractor starts to skid, the trailer's forward inertia can push the tractor until it spins the tractor around and faces it backward causing the trailer to "come around" and try to pass the tractor. This may be caused by equipment failure, improper braking, or adverse road conditions such as an icy road surface.

[6] Texas Commercial Motor Vehicle Drivers Handbook (Texas Department of Public Safety, June 2014).

Jackknifing can also be caused by failure of the trailer brakes. Frequent use of the trailer brakes alone on a long, downhill descent may cause them to overheat and fade while the tractor brakes remain fresh. In the event of an emergency stop, the tractor brakes could lock while the trailer brakes would be ineffective due to previous overheating.

***Fishtailing*** occurs when the rear tractor wheels lose traction, resulting in oversteer. This can be caused by low friction surfaces (sand, gravel, rain, snow, ice, etc.). Rear-drive vehicles with sufficient power can induce this loss of traction on any surface, which is called oversteer. During fishtailing, the rear end of the vehicle skids to one side, which must be offset by the driver counter-steering. Counter-steering is when the driver turns the front wheels in the same direction as the skid, (e.g. left if the rear swings left) and reduces engine power. Overcorrection will result in a skid in the opposite direction. Without a proper driver's reaction, the fishtailing vehicle may spin completely out of control.

***Trailer swing*** occurs when a trailer's rear wheels lock or lose lateral traction and the trailer swings to one side, while the tractor continues to move forward in alignment with the roadway (Fig. 3). This could happen on a slippery road surface, often where there is a severe crowning. Crowning is a condition where the road is higher in the middle than on its sides in order to permit water to drain off the roadway. This is not the same as "jackknifing" and is not as serious since the trailer moves back into line as the tractor continues forward. The driver must be aware, however, that the trailer could slide up against parked cars or a guard rail, or the wheels could slide into a ditch. This situation can occur especially when the trailer is empty or lightly loaded, and weather conditions cause violent gusts of crosswind.

***Hydroplaning,*** or aquaplaning, occurs when the tires of a vehicle ride up on a layer of water and lose traction. On a wet road, the grooves of a rubber tire are designed to disperse water from beneath the tire, maintaining tire frictional contact with

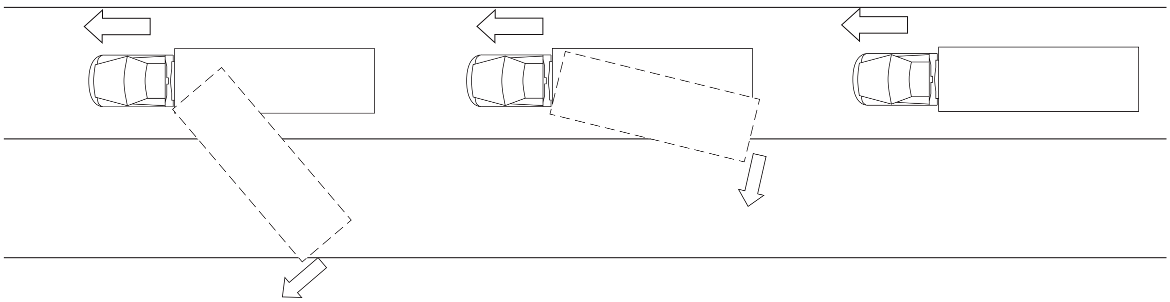

**Fig. 3—Sweeping movement of the trailer when rear trailer wheels lose traction.**

the road even in wet conditions. Hydroplaning occurs when a tire encounters more water than it can channel away, which is dependent on standing water depth on the road surface, the vehicle speed, the tread depth and tread pattern of the tires. Water in front of the wheel may create a wedge of water under the leading edge of the tire, causing it to lift from the road. The tire then skates on a sheet of water with little, if any, direct road contact and loss of control results. Hydroplaning is unlikely with a CMV tire due to the larger tire contact patch and higher tire pressures (about 100 pounds per square inch [psi]).

If multiple tires hydroplane, the vehicle may lose directional control and slide until it either collides with an obstacle, or slows enough that one or more tires contact the road again and friction is regained. Hydroplaning should be eliminated as a cause of loss of control in a crash involving wet roads by looking for potential conditions for hydroplaning to occur. Prosecutors should consider factors such as standing water on the road and the tread of the tires. In addition to the driver's speed, acceleration, braking and steering, vehicle sensitivity factors include:

- *Tire tread wear:* worn tires will hydroplane more easily for lack of tread depth, thus it is important to measure the tread depth of all tires during the vehicle post-crash inspection, if there is a possibility that hydroplaning occurred.
- *Tire inflation pressure:* severe underinflation can cause a tire to deflect inward, raising the tire center and preventing the tread from clearing water from under the tire. This makes measurement of tire inflation pressures important as part of

All CDL holders must exercise "extreme caution" in hazardous conditions, "such as those caused by snow, ice, sleet, fog, mist, rain, dust, or smoke" which may adversely affect visibility or traction. Drivers must reduce speed, and where conditions are sufficiently dangerous, discontinue operation (unless it is necessary for the safety of passengers to continue operating to a point of safety (49 C.F.R. § 392.14).

In addition, some CDL holders receive specialized knowledge and skills training to cope with extreme weather or environmental conditions. Regulations governing the knowledge and skills requirements for class A CDLs, class B CDLs, and for those seeking to operate LCVs are found at 49 C.F.R. § 380, Appendix A to Part 380 (Unit A1.2.7), 49 C.F.R.§ 380, Appendix A to Part 380 (Unit A3.11), 49 C.F.R. § 380, Appendix B to Part 380 (Unit B1.2.7) and 49 C.F.R. § 380, Appendix B to Part 380 (Unit B3.11). Applicants training for driving LCVs also receive training in extreme weather and other environmental conditions. 49 C.F.R. § 380, Appendix F to Part 380 (Unit 3.4).

the post-crash vehicle inspection.

- *Tire tread aspect ratio:* the longer and thinner the contact patch, the less likely a tire will aquaplane. Check to see that the tires on the CMV satisfy the specifications for the vehicle. Tire pressure may affect tread aspect ratio.
- *Vehicle type:* combination vehicles, like ***semi-trailers*** are more likely to experience uneven hydroplaning caused by uneven weight distribution. An unloaded trailer will hydroplane sooner than the cab pulling it. Small correctional control inputs may have no effect. If the drive wheels hydroplane, there may be a sudden audible rise in engine revolutions per minute (RPMs) as they begin to spin.

Control inputs tend to be counterproductive while hydroplaning. If the vehicle is not in a turn, easing off the accelerator may slow it enough to regain traction. Steering inputs may put the vehicle into a skid from which recovery would be difficult or impossible. If braking is unavoidable, the driver should do so smoothly and be prepared for instability. ***Electronic stability control*** (ESC) systems cannot replace defensive driving techniques and proper tire selection. These systems rely on selective wheel braking, which depends in turn, on road contact. While stability control may help recovery from a skid when a vehicle slows enough to regain traction, it cannot prevent hydroplaning. Because pooled water and changes in road conditions can require a smooth and timely reduction in speed, cruise control should not be used on wet or icy roads.

***Rollover*** occurs when a vehicle tips to the side and the center of gravity of the vehicle moves outside the tires of the vehicle, causing the vehicle to tip over. This is caused by a lateral force acting on the vehicle as a result of the centrifugal action of the vehicle weight during a turn, a road irregularity, an applied lateral force during an impact with another vehicle or object, or a lateral force caused by the weight shift of poorly secured cargo. The result of such lateral force is that the vehicle leans to one side, compressing the suspension on that side of the vehicle.

According to FMCSA's Large Truck and Bus Crash Facts 2016, published in May 2018, "[o]verturn (rollover) was the first harmful event [the first event during a crash that resulted in injury or property damage] in 5 percent of all fatal crashes involving large trucks and 2 percent of all nonfatal crashes involving large trucks." See, https://www.fmcsa.dot.gov/sites/fmcsa.dot.gov/files/docs/safety/data-and-statistics/398686/ltbcf-2016-final-508c-may-2018.pdf. Last visited on June 27, 2018.


There are mathematical models for determining the speed at which rollover would occur during a turning motion. These should be used with caution as they may not involve dynamic loading caused by cargo shift or suspension and tire effects. The higher the center of gravity of the vehicle, the greater the propensity to roll. Therefore, a post-crash investigation must consider a number of factors such as: the load configuration before the crash, the method of securing the load in the trailer, and the nature of the load with regard to its weight, density, and loading configuration. Determining the center of gravity of the loaded trailer can be an important part of the reconstruction and might be overlooked in the initial investigation. In fact, during the post-crash reconstruction, it may be very diffcult to determine the load configuration at the time of the crash.

***Offtracking*** occurs when the wheels of the trailer of a semi-trailer combination (a tractor unit attached to a semi-trailer is often referred to as a combination vehicle) do not follow the same path as those of the tractor (Fig. 4). A common example of this would be the paths of the tractor tires and the trailer tires when a combination vehicle is rounding a city corner at low speed. The tractor swings out into the intersection to begin its turn, but the trailer wheel track inside the tractor and the rear trailer wheels actually may ride up over the curb. This can result in a collision with an unexpecting pedestrian or a passenger vehicle in the driver's blind spot. If this situation occurs, the driver of the truck may not have realized that a collision has occurred. This might result in the truck leaving scene, in which case, a prosecutor must consider whether such a charge is appropriate.

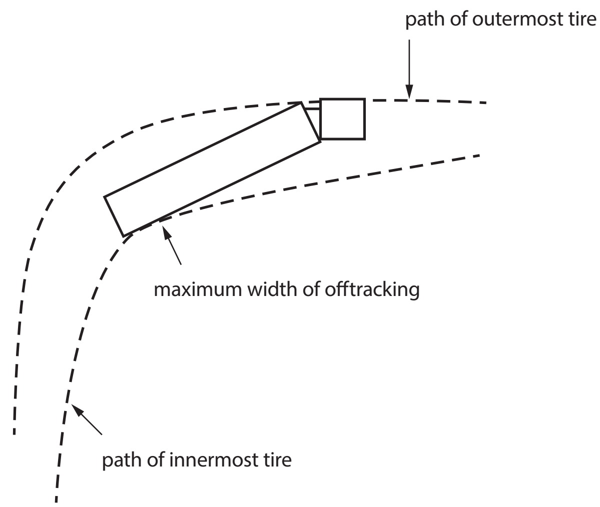


**Fig. 4—Tractor-trailer offtracking in a low speed turn.**

## Crash Factors

### *Braking*[7]

Semi-trucks use air pressure, rather than hydraulic fluid, to actuate the trailer brakes[8]. The braking system is therefore called ***pneumatic***. The use of air hoses allows for ease of coupling and uncoupling of trailers from the tractor unit. A common failure is ***brake fade***, usually caused when the drums or discs and the linings of the brakes overheat from excessive use. This typically occurs after descending a long grade on which the driver uses the trailer brakes rather than the ***engine braking*** to retard the heavy truck's motion.

When the pneumatic brakes are applied there is a short ***brake lag*** or delay before the brake activates since pressure must build up to create the braking force. This is shown in Fig. 5 and results in a short delay in the start of braking action even though the brake pedal has been depressed. This brake delay does not occur in automobile braking systems that use a fluid to activate the brake mechanism.

The parking brake of the tractor unit and the emergency brake of the trailer are spring brakes that require air pressure to be released. They are applied when air pressure is released from the system and disengaged when air pressure is supplied to the brake system. This is a fail-safe design feature which ensures that if air pressure to either unit is lost, the vehicle will slow to a halt, instead of continuing without brakes and becoming dangerously uncontrollable.

Another braking feature of semi-trucks is engine braking.

[7] Inoperative/defective brakes resulted in 57,771 violations during roadside inspections in 2016. *2017 Pocket Guide to Large Truck and Bus Statistics*, Figure 2-11, p. 24 (FMCSA, June 2017).

[8] *Required brake systems are discussed at 49 C.F.R. § 393.40.*

Semi-truck brakes could be either a compression brake (sometimes called a "Jake Brake"), an exhaust brake or a combination of both. However, the use of a compression brake alone produces a loud and distinctive noise, and to control noise pollution, some local municipalities have prohibited or restricted the use of engine brake systems inside their jurisdictions, particularly in residential areas. The advantage to using engine braking instead of conventional brakes is that a truck can descend a long grade without overheating its brakes, resulting in brake fade. Some vehicles can also be equipped with hydraulic or electric retarders, which slow the vehicle with near-silent operation. Transmission retarders are common on many transit buses.

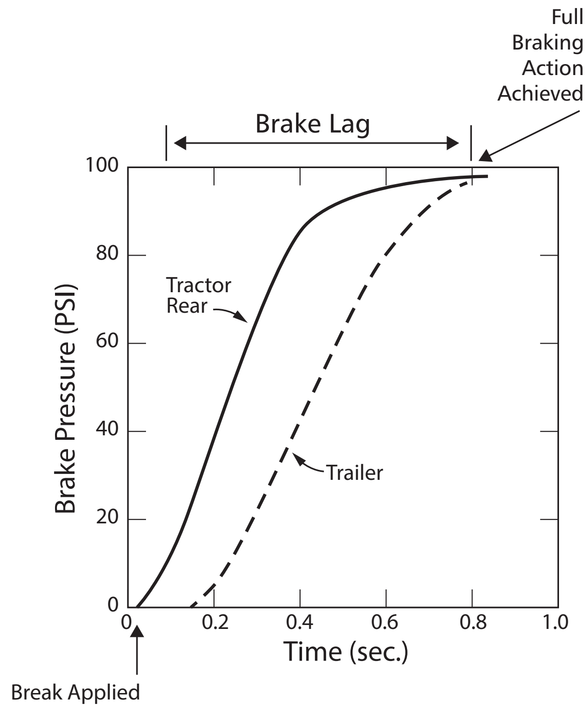


**Fig. 5—Brake pressure v. time showing delay in reaching 100% braking action.**

### *Antilock Braking Systems*[9]

In principle, brake systems used on commercial vehicles are quite simple. When the brakes on a vehicle are applied, forces are generated at the vehicle's wheels that slow the vehicle. As the driver applies force and movement to the brake pedal, air pressure from pressurized reservoirs is delivered through a series of valves and lines to the brake chamber located at the wheel brake.

The purpose of an ***anti-lock braking system*** (ABS) is to help maintain directional stability and control during braking, and possibly reduce stopping distances on some road surfaces. ABS is potentially effective in any situation where the driver brakes hard enough to activate the system, and where conventional brakes may lock the wheels and contribute to directional instability. It is believed that ABS could reduce commercial vehicle crashes involving jackknifing, loss-of-control, run-off-road, lane departure, or skidding—to the extent that these phenomena may be caused by brake-related directional instability. However, ABS will have no effect on situations where a truck is standing still, moving too slowly for ABS activation, or proceeding straight ahead when another vehicle unexpectedly hits it in the side or rear.

Sensors continuously monitor wheel speed and send that information to the ***Engine Control Module*** (ECM)[also known as the "Engine Control Unit" or "ECU"], which processes the

[9] *Anti-lock brakes are discussed at 49 C.F.R. § 393.55.*

information based upon the algorithm that has been embedded into the ECM. Most ABS systems have a separate Engine Control Unit that is usually mounted in the cab near the center of the dash. The ABS ECU and the Engine Mounted ECM are in constant communication with one another via the ***Controller Area Network*** (CAN), a method of communication between a network of electronic devices to share information or data with each other. Based on the data processed by the ECM, it will send output signals to the modulator valve to provide appropriate brake pressure control. Specifically, as the ECM receives and interprets the wheel speed signals from the sensors, it uses this information to determine if a wheel is approaching lock and when and how to activate the ABS valves. Through this valve actuation, the ECM can regulate air pressure to the brake chambers preventing lock-up and achieving maximum tire-road friction. ABS will not independently apply the brakes, but rather allows the braking pressure to increase to the level that is currently being demanded by the driver. ABS takes its pressure supply and signal from the standard pneumatic brake system. It cannot supply a higher pressure to the brakes than the driver is requesting. ABS is passive when the vehicle is not being braked and in the vast majority of braking operations when wheel lock is not pending.

The trailer ABS also has an ECM that receives wheel speed information from sensors located in the wheel ends of the axles. These are called frame mounted ECUs. There may be two or more sensors on the trailer, depending on the number of axles and the ABS configuration. Sensors continuously monitor wheel speed and send this information to the ECM. When a wheel starts to lock, the ECM, using the wheel speed information and programmed algorithm, sends output signals to control the operation of the ABS modulator valves. In theory, this enables the system to maintain wheel slip in the optimum range for maximum braking while maintaining vehicle stability by avoiding wheel slide. By assuring that the wheels are rolling and therefore capable of generating stabilizing side forces, ABS minimizes any tendency for trailer swing due to hard braking conditions. All new tractors manufactured after March 1, 1997 are required to have ABS, and all new trailers manufactured after March 1, 1998 are required to have ABS[10]

### *Wheels and Tires*[11]

Although dual wheels are the most common, the use of two single, wider tires, known as super-singles, on each axle is becoming popular among bulk cargo carriers and other weight-sensitive operators. With increased efforts to reduce greenhouse gas emissions, the use of the super-single tire is gaining popularity. One of the major disadvantages of the super-singles is if a tire should become deflated or be destroyed, there is not another tire attached to the same hub to maintain the dynamic stability of the vehicle, as would be the case with dual wheels. With dual wheels (called "dualies"), the remaining tire may be overloaded, but it will typically allow the vehicle to be safely stopped or driven to a repair facility. Of course, the condition of the tires should be examined at a crash scene, noting low tread depth (tread baldness) or pre-crash tire failure in the form of ***retread separation*** or another defect. Prosecutors should note that defective tires may not excuse the driver or company from crash culpability.

**TIP FOR PROSECUTORS:**
*Determine when the tires were last inspected and their condition at that time.*

The Code of Federal Regulations in section 49 C.F.R. § 393.75, mandates that "[n]o motor vehicle shall be operated on any tire that (1) [h]as body ply or belt material exposed through the tread or sidewall, (2) [h]as any tread or sidewall separation, (3) [i]s flat or has an audible leak, or (4) [h]as a cut to the extent that the ply or belt material is exposed."

### *Driver Visibility and Blind Spots*

The perspective of the CMV driver may be critical to assessing criminal culpability after a CMV crash. The driver's view of the vehicle environment is limited by the structure of the cab, the blind spot in front of the tractor, blind spots created by the side mirrors and the trailer, etc. It may be helpful to create a visual mapping of the driver's visibility as the driver's actions, or lack thereof, are examined. This might include an investigator sitting in the cab while an assistant walks around the cab to help map the visibility blind spots of the driver.

There are numerous references to driver blind spots or "no zones," and a quick internet search can be very helpful when this issue is being investigated. A drawing illustrating the potential blind spots surrounding a tractor trailer combination is shown in Fig. 6.

Driver blind spots, in conjunction with offtracking, should be investigated in a crash involving a tractor-trailer and pedes-

[10] 49 C.F.R. § 393.55 (a) (2017).

[11] There were 139,948 violations for Tread Depth Less Than 2/32 of Inch in violation of 49 C.F.R. § 393.75(c) in 2016 identified during roadside inspections. *2017 Pocket Guide to Large Truck and Bus Statistics*, Figure 2-11, p. 24 (FMCSA, June 2017).

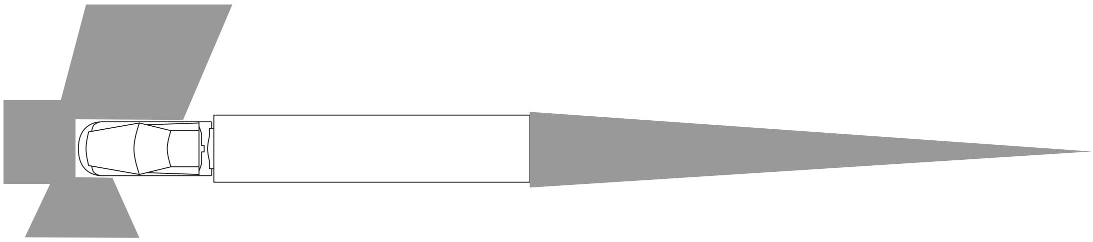

**Fig. 6—Driver blind spots surrounding a combination vehicle.**

trian in which the pedestrian walks into the roadway unsuspecting of the offtracking by the rear of the trailer. The driver may not see the pedestrian, which may result in the CMV operator leaving the scene without realizing a collision has occurred.

Many fatal two-vehicle crashes involving a large truck and another vehicle occur in these "no zones" surrounding a CMV. The chart reproduced below illustrates the problem of head-on and rear collisions involving large trucks and an additional vehicle. Both the large trucks and other vehicles were struck in the front 31 percent of the time, but the trucks were impacted in the rear three times as often as the other vehicles (21% and 7% respectively).

### Percentage of Two-Vehicle Fatal Crashes Involving Large Trucks, by Initial Impact Point of the Large Trucks and Other Vehicles, 2016[12]

This issue is such a problem that the FMCSA has created an

| Impact Point on Large Truck | Impact Point on Other Vehicle[12] Front | Left Side | Right Side | Rear. | Total |
|---|---|---|---|---|---|
| Front | 31% | 13% | 10% | 7% | 60% |
| Left Side | 9% | 1% | 1% | 0% | 12% |
| Right side | 6% | 1% | 0% | 0% | 0% |
| Rear | 21% | 0% | 0% | 0% | 22% |
| Total | 66% | 15% | 11% | 7% | 100% |

**Note:** Totals may not equal the sum of components due to independent rounding.
Source: 2016 FARS ARF

[12] Traffic Safety Facts, Large Trucks: 2016 Data, Report No. DOT HS 812 497, p. 3 (National Center for Statistics and Analysis, National Highway Traffic Safety Administration (Revised May, 2018).

ad campaign warning motorists about CMV "no zones." A graphic[13] from FMCSA's ad campaign is reproduced below.


The Code of Federal Regulations in section 49 C.F.R § 393.75, mandates that "[n]o motor vehicle shall be operated on any tire that (1) [h]as body ply or belt material exposed through the tread or sidewall, (2) [h]as any tread or sidewall separation, (3) [i]s flat or has an audible leak, or (4) [h]as a cut to the extent that the ply or belt material is exposed.

Driver fatigue and sleep deprivation issues motivate the extensive "Hours of Service" regulations and the requirement that drivers maintain daily duty status logs. See 49 C.F.R. Part 395, Subpart A for Hours of Service regulations, and specifically, 49 C.F.R. § 395.8 for drivers' daily logs. Electronic logging devices (ELDs) regulations are at 49 C.F.R. Part 395, Subpart B.

### *Fatigue, Sleep Deprivation*

When the prosecutor is assessing the negligence or recklessness of the CMV driver an important consideration will be whether driver fatigue was a factor. The CMV crash investigator should pay attention to driving logs, cell phone records, vehicle GPS histories, ***electronic logging devices*** (ELDs), fleet dispatcher records, etc. to build the most accurate timeline for the driver leading up to and after the crash. This information may also warrant the enlistment of a fatigue or sleep expert who can interpret whether the driver's behavior prior to the crash was affected by lack of rest. Recent statistical data[14] has shown that driver fatigue may be a major factor in CMV crashes and may be able to be corroborated by the ECM data or the reconstruction of the pre-impact driver behavior and motion of the vehicle.

Crash investigators should secure documentation of all safety inspections for the specific CMV involved, whether conducted by the motor carrier or by any driver of the CMV, including the one conducted on the day of the crash by the driver involved in the crash. See 49 C.F.R. §§ 396.11, 396. 13, and 396.17.

## Post-crash Investigation

The post-crash investigation at scene will be very similar to the investigation of a car crash with the usual attention to roadway evidence, witness statements, development of a scaled drawing, imaging of the vehicle's ***event data recorder*** (EDR) and the gathering of other evidence that will be needed by a reconstructionist. Information about investigative activities can be found in the publication, *Commercial Drivers' Licenses: A Pros-*

[13] https://www.fmcsa.dot.gov/ourroads/large-blind-spots (last visited on July 10, 2018).

[14] FMCSA *Report to Congress on the Large Truck Crash Causation Study*, Executive Summary, p. 3 (March 2006) *available at* https://www.fmcsa.dot.gov/safety/research-and-analysis/report-congress-large-truck-crash-causation-study (last visited on June 27, 2018).

*ecutor's Guide to the Basics of Commercial Motor Vehicle Licensing and Violations*[15], published by the National District Attorneys Association (NDAA).

In addition to the at-scene evidence, the investigation of a commercial vehicle collision might also include:

- cargo configuration and pre-crash securement[16]
- cameras showing driver and/or driver's view[17]
- global positioning system (GPS) data
- log books, receipts, bills of lading
- cell phone data, Cellebrite imaging tool
- infotainment center in dash
- on-board speed, steering, and braking monitoring (engine control module, ECM)
- vehicle response data.

The investigation might involve more personnel than a typical car crash because of the state and federal regulation of commercial motor vehicles. Certainly, the prosecutor should make every effort to assure that a specially-trained CMV investigator and/or reconstructionist is involved early in the investigation when evidence may be volatile and lost if not collected in a timely manner. Experts who might be necessary as the case develops include:

- a commercial motor vehicle reconstructionist,
- a heavy truck mechanical expert and/or vehicle inspector,
- a human factors expert,
- a metallurgist,
- a heavy vehicle handling and performance expert,
- a cargo loading/securement expert,
- a driver training expert, or
- a driver fatigue/sleep expert.

> At any given point in time, the most important safety "expert" in a CMV is the DRIVER. FMCSA regulations require that CMV drivers pass a physical examination that certifies the driver is physically qualified to operate a motor vehicle. (See 49 C.F.R §§ 391.41 (a) (1) (i), 391. 45 [2018]). Where a medical defense is raised, prosecutors should be aware that certified medical examiners who examine CMV drivers are required to provide a copy of a medical certificate (see Appendix II) to the driver, as well as to the driver's employer (if requested). (See 49 C.F.R. §§ 391.43 (a)-(g) [2018]).

Prosecutors should be aware that the frequency of fire associated with CMV crashes can also complicate and limit the post-crash CMV investigation including the ability to gather digital evidence from a vehicle's event data recorder (EDR) and other onboard data collection devices.

[15] *Commercial Drivers' Licenses: A Prosecutor's Guide to the Basics of Commercial Motor Vehicle Licensing and Violations*, Second Edition, pp. 17–26; *available at* http://ndaa.org/pdf/CDLMono_REV2017_FinalWeb.pdf.

[16] *Cargo is to be properly secured when loaded to protect against shifting and falling cargo (see 49 C.F.R. § 393.100 to 49 C.F.R. § 393.114) and is to be inspected by the driver before a trip, within the first 50 miles of a trip, and re-inspected if the driver makes a duty status change, if the CMV has been driven for 3 hours, or if the CMV has been driven for 150 miles, "whichever occurs first." 49 C.F.R. § 392.9.*

[17] Event based video systems often come standard in tractor trailer fleets, an example of one such system may be found at vestigeview.com.

### *Electronic Mapping of Evidence*

Many law enforcement agencies use a device similar to what a surveyor uses to ***map*** the locations of evidence at a crash scene. That data is then used to produce a scale to-drawing of the scene from which measurements can be made. At the scene, one officer holds a prism pole with reflector on the evidence being mapped while another officer operates the ***theodolite*** that sends an infrared pulse from the instrument to the mirror. The pulse reflects back to the sending unit, and the transit time is converted into a distance, as shown in Fig. 7. There is also a robotic version of this instrument that allows the person with the reflector pole to simply stand over an evidentiary point and the theodolite follows the pole around the scene robotically. An advancement to this system is a "***scanner***," which does not require an evidence pole to scan the scene thousands of times each second to produce a very detailed and accurate 3-D image of the scene and the evidence.

A 3-D scanner essentially combines a total station (surveying instrument) to a digital camera. Unlike the total station, a 3-D scanner does not require the use of an evidence pole. The laser can reflect off most surfaces (and the evidence itself) to document everything within its line of sight. The laser makes a measurement, moves and then records the next measurement. It repeats this, measuring tens of thousands of points every second. The device also can record digital photos of the scene.

**Fig. 7—Electronic mapping instrument (left) and evidence mapping pole/mirror (right).**

The data from the mapping instrument can then be inputted into a Computer Assisted Drawing (CAD) software which can produce a scaled drawing of the crash scene data. The data can also be inputted into other software to produce the foundation for a video animation of the crash. Both types of evidence have been generally accepted in many State and Federal courts and may involve a pre-trial defense motion to exclude.

### *Drone Photography*

The use of unmanned aerial devices (drones) is gaining widespread use in crash scene documentation and may be especially helpful for heavy vehicle crashes which often encompass very large scenes. The drone with an attached camera (as shown in Fig. 8) can be flown over the scene to photograph the scene. The drone operator views a small video screen to see what the camera is seeing, and then the aerial photographs can be used with ***photogrammetry*** software to produce a scaled drawing of the scene. This can save a tremendous amount of time and get the road or highway open to mitigate the effects of the crash on traffic. It also allows the production of an overall view of the crash scene, including the nature of the roadway prior to the location of the crash. The drone is also helpful for documenting the damage resulting from the crash and the final rest positions of all the vehicles involved.

**Fig. 8—Drone/camera for scene photography, aerial photograph.**

## CMV Collision Reconstruction Topics

### *Speed Estimates from Tire Mark Evidence*

The tire mark evidence developed by a commercial motor vehicle might include skid marks or ***ABS scuff marks*** created by the braking action of the vehicle in an emergency stopping maneuver. Information on this type of evidence is found in standard reconstruction texts.[18] As the vehicle's kinetic energy is dissipated by the friction action of the tire-road interface, the vehicle slows and may eventually come to rest. The result is the familiar "minimum speed from skid marks" equation where "f" is the road drag factor (adjusted for grade), "d" is the distance the vehicle skidded, "η" is the % of available brak-

[18] John Kwasnoski, Crash Reconstruction Basics for Prosecutors (American Prosecutor's Research Institute, 2003) available at http://www.ndaa.org/pdf/crash_reconstruction_basics.pdf.

ing that was used, and "√" is the symbol for the square root within the equation.

**Eq. 1** $$S = \sqrt{30 f d \eta}$$

The tire mark evidence of braking for a heavy vehicle may have a unique appearance caused by the wheels of the trailer "bouncing" during the skidding, as shown in Fig. 10. The bouncing motion causes differing amounts of pressure to push the tires down onto the roadway, resulting in what is called a "skip skid." The skip skid is a continuous skid, measured from beginning to end, even though it appears to start and stop as the locked tire bounces. This bounce is usually the result of a road irregularity, but the tire is in contact will the roadway at all times.

This minimum speed estimate (detailed below) is a basic tool for the reconstructionist. Its application to heavy truck evidence requires careful attention. The "f" is for the road friction index (***drag factor***). Truck tires develop less friction than automobile tires because of the harder, less frictional, rubber compound used to manufacture the truck tires. Use of a drag factor developed for car tire would produce a speed estimate that is too high.

The method for measuring the drag factor might be either a ***drag sled*** or a digital accelerometer, as described in the literature.[19] But in making such a measurement the investigator of the CMV crash must be sure to determine the drag factor for a commercial truck tire, which has less friction than a typical automobile tire (Note: this might include using an exemplar tire, rather than the actual tires on the crashed vehicle, and there may not be any significant difference among tire brands). Typical drag factor charts published in reconstruction texts are for automobile tires and should not be used without correcting a chart value, so it applies to truck tires. Also, any effect of ABS performance and road grade should be included when determining the drag factor to be used in the calculation.

The percentage of braking, "η," historically called the "***brake efficiency***" since it was often used to account for inoperative brakes or unused braking capacity, but it represents the ratio of

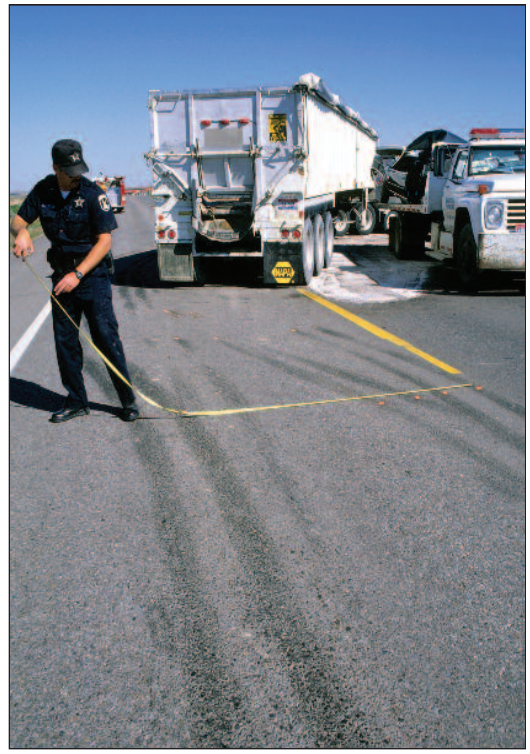

**Fig. 9—Appearance of heavy vehicle braking marks.**

**Fig. 10—Appearance of locked wheel skip skid marks made by an empty trailer.**

[19] *Kwasnoski's Little Red Book*, Legal Sciences (2017).

the vehicle's weight that is causing braking compared to the total vehicle weight. A drawing showing weight distribution on a semi-trailer during emergency braking is shown in Fig. 11 to illustrate this concept. In the drawing, if we determine from a post-crash inspection that the right front tractor tire and one of the rear trailer tires are on wheels that are not braking (inoperative), the braking percentage of the vehicle under that condition would be:

$$\eta = \frac{100 - 7 - 16}{100} = .77$$

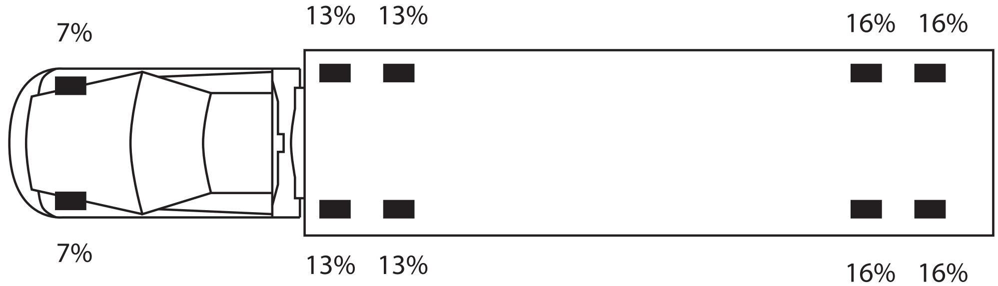


**Fig. 11—Example of weight distribution for a tractor - semi-trailer combination.**

It should be noted that to account for brakes that are out of adjustment[20], an individual wheel may exhibit partial braking. This partial breaking is inputted into the reconstruction equation as a percentage of a wheel's full contribution, with this percentage being determined by careful measurements of the brake mechanism itself. For example, if a particular brake mechanism is found to be only 70% operative, and that wheel would ordinarily contribute 13% of the vehicle's braking, then that wheel would have contributed only (.70) x (.13) = .091 (9.1 %) of the full braking potential (13%) for that wheel. The mathematical documentation for all the wheels of the heavy truck is tedious and involves a braking percentage for each wheel, with the result being an overall brake efficiency or brake percentage, $\eta$, for the vehicle that would be used in Eq. 1.

***Example:*** The truck discussed above put down 187 ft of skid marks, and the road surface had a measured drag factor for the truck tires equal to 0.59. Using that information and the measured brake efficiency of 77% resulting (see percentage of brak-

[20] Drivers must inspect and report on brakes "at the end of each day's work. . ." see 49 C.F.R. § 396.11.

ing equation above) from the post-crash brake inspection, a minimum speed for the truck at the beginning of skid marks is found to be:

$$S = \sqrt{30 f d \eta} = \sqrt{[30 (0.59) (187) (0.77)]} = 50.4 \text{ mph}$$

It is important to note that many of the commercial vehicles traveling on our interstates may have a defective ABS system and many of our CMVs may have "out-of-service"[21] brake defects. One cannot estimate the minimum speed of a CMV without inspecting the braking system because there is the risk of identifying the wrong factor that contributed to the crash (speed vs. poor maintenance, for example).

Speed was a factor in 17% of truck crashes with at least one large truck occupant fatality in 2016. (Commercial Motor Vehicle Facts, FMCSA-ADO-14-001 [November 2017]), available at: https://www.fmcsa.dot.gov/safety/data-and-statistics/2016-commercial-motor-vehicle-traffic-safety-facts-sheet.

### *Time — Distance — Speed (TDS) Analyses*

As with the reconstruction of automobile crashes, reconstruction of commercial motor vehicle crashes also include evaluating the relationships between time of travel, distance traveled, and the speed of the CMV just prior to, during and after a collision occurs. For motions at constant speed, these relationships can be described with the three equations:

Motor carriers may not establish schedules which would require a driver to drive over the speed limit and may not "permit nor require" such operation. See 49 C.F.R. § 392.6.

**Eq. 2** $d = 1.47\, S\, t$ where $d$ = distance traveled in an amount of time, $t$

**Eq. 3** $S = d / 1.47\, t$ $S$ = vehicle speed in miles/hr

**Eq. 4** $t = d / 1.47\, S$ $t$ = time of travel

1.47 is the required conversion of mph to ft/sec

In a collision reconstruction, an expert may focus on a method for determining vehicle speed and may make an incorrect assumption in the calculations, making that calculated speed inconsistent with a TDS analysis of the motion. The TDS analysis may be very useful in the following instances:

- Interpreting (or corroborating) the data from the ***event data recorder*** (EDR) image.
  - Example: The image from the EDR indicates the CMV speed at times before the crash occurred. The change in speed can be related to the braking action and drag factor of the roadway by the reconstructionist thus validating the pre-impact speed data in the EDR image.

[21] Under the Code of Federal Regulations, a motor vehicle shall be deemed "out-of-service" if by reason of its mechanical condition or loading it would likely cause an accident or a breakdown. See, 49 C.F.R. § 396.9 (c) – Inspection of motor vehicles and intermodal equipment in operation.

- Reconciling the EDR data with the reconstruction.
- Verifying (or discrediting) the statement of a witness or operator.
- Analyzing video of the pre-crash motion of the vehicle to assess vehicle speed.
    - ***Example:*** By noting landmarks in the video of the pre-impact motion of the vehicle, a reconstructionist can visit the scene and make distance measurements between those landmarks. Then, by using the elapsed time on the video, the speed of the vehicle can be determined using Equation 2. Caution needs to be used here. This method can be accurate over great distances, but the elapsed time counter should not be relied upon for short distances, especially with a vehicle mounted camera. It is better to break the video down into its individual frames and then count the time between the earth fixed measurement points.

      The key here is to run a sensitivity check on your time frame and distance measurements. Prosecutors should only use investigators that are properly trained in calculating speed from video.

- Interpreting GPS data to assess average pre-crash vehicle speed.

It should be noted that interpreting GPS data to assess the average pre-crash speed of a vehicle would be similar to determining the CMV speed from video of the vehicle. The GPS data might include larger distances — therefore only an <u>average speed</u> over the whole interval might be able to be determined. GPS is common on many CMV mounted telematics units like **AOBRDs** (Automatic On-Board Recording Device) and ELDs. ELDs are required on CMVs as of December 18, 2017 unless the CMV is currently equipped with an AOBRD. All CMVs will have to have an ELD by 2019.[22]

- Evaluating the time available for the driver to initiate an evasive action.
    - ***Example:*** The first appearance of a dangerous situation occurs when the CMV is 340 ft from the danger, with the

[22] 49 C.F.R. 395.8(a)(1)(i), (ii).

truck moving at a speed of 70 mph. Using Equation 4, it is determined that the driver had $t = d / 1.47 S = 340 / 1.47(70) = 3.3$ seconds to initiate an evasive action and avoid the danger.

- Assessing the operator's perception-response time from physical evidence of visibility, brake application, etc.
- Understanding operator input or action from the EDR data.
- Rebutting an incorrect vehicle speed estimate.

There are also numerous ***Time, Distance, Speed*** relationships for vehicles that are moving at non-constant speeds. Examples include a vehicle accelerating from a stopped or non-stop position and making a turn across oncoming traffic, the TDS relationships during a braking action, the relative motion (time lapse recreation) of a vehicle and pedestrian during an evasive action, and many others. The TDS relationships may be overlooked by the reconstructionist during the investigation because the reconstructionist may not primarily focus on estimating vehicle speed. The TDS calculations may provide additional information about the pre-crash motion of the vehicle involved that could be useful, including:

- How much time did an operator have to initiate a potential evasive action?
- How much time did the headlights of the vehicle afford to the operator to initiate an evasive action?
- How much time did an operator take to react to a danger?
- What would have been the vehicle speed at impact if there had been pre-crash braking?
- What would have been the spatial relationship of two vehicles under a hypothetical situation?
- What was the stopping distance for the commercial motor vehicle?

### *Stopping Distance, Crash Avoidance*

The assessment of stopping distance is obviously an important "What if…" question with regard to determining culpability. The stopping distance for an automobile consists of two phases: perception-reaction distance and braking (to stop) distance. The stopping distance for a CMV consists of three phases: perception-reaction distance (also called perception-response distance), brake activation or "brake lag" distance (called brake latency), and braking (to stop) distance. This is because the CMV uses air to activate the brakes instead of the hydraulic fluid that is used in automobiles.

The perception-reaction distance, d, is calculated with Equation 1, in which the elapsed time, t, is the ***perception-reaction*** time (PRT) of the operator[23]. The assumed PRT may be highly disputed in the reconstruction by human factors experts on both sides. The brake lag, which results from the buildup of air pressure when the CMV brakes are applied, is well studied and documented and will be discussed in the section on braking. The brake lag time may range from 0.1–0.5 seconds and may be measurable for a particular vehicle as the delay time between pressure being applied to the brake pedal and the resulting movement of the brake pad or caliper. During the brake lag, the vehicle continues to move forward with its speed undiminished since there is no braking action occurring. Figure 12 shows the stopping behavior of an automobile in comparison to a CMV operating at the same speed when emergency braking is applied.

***Example:*** Given a vehicle speed of 55 mph, an operator's PRT of 1.5 seconds, and road drag factor of 0.80, the stopping distance for an automobile would be calculated to be:

$$X_S = 1.47\ S\ t_{PRT} + S^2 / 30\ f$$

$$X_S = 1.47\ (55)\ (1.50) + 55^2 / 30(0.80) = 121 + 126 = 247 \text{ feet}$$

Comparably, given a vehicle speed of 55 mph, an operator's PRT of 1.5 seconds for a CMV with a brake lag time of 0.5 seconds and an effective drag factor of 0.64, the stopping distance would be calculated to be:

$$X_S = 1.47\ S\ t_{PRT} + 1.47\ S\ t_{LAG} + S^2 / 30\ f$$

$$X_S = 1.47\ (55)\ (1.50) + 1.47(55)(0.50) + 55^2 / 30(0.64) = 121 + 40 + 157 = 318 \text{ feet}$$

Also note that the braking distance for the brakes to bring

Prosecutors should be aware of the relationship of perception time to distraction. Perception time is greatly reduced if a driver is paying attention to a cell phone instead of the road.

6% of large truck fatal crash data involved large truck driver distraction as a factor, of which 16% was related to cell phone use. (Commercial Motor Vehicle Facts, FMCSA-ADO-14-001 [November 2017]), available at: https://www.fmcsa.dot.gov/safety/data-and-statistics/2016-commercial-motor-vehicle-traffic-safety-facts-sheet.

Perception time is also reduced by alcohol and drug impairment.

The U.S. Department of Transportation (DOT) drug and alcohol testing regulations for commercial driver licensed (CDL) employees are contained in 49 C.F.R. Part 382, and 49 C.F.R. Part 40. A summary of the federal drug and alcohol testing regulations concerning CDL holders can be found at: https://www.fmcsa.dot.gov/regulations/drug-alcohol-testing/drug-and-alcohol-testing-brochure-drivers. Last visited July 23, 2018. FMCSA's regulations regarding the use of alcohol and drugs by CMV drivers may be found at 49 C.F.R. §§ 392.4, 5.

In addition to investigating the possible use of alcohol or other drugs by the driver (see 49 C.F.R. § 392.4 and § 392.5 as well as 49 C.F.R. Part 382), investigators should determine whether prohibited hand-held electronic devices (see 49 C.F.R. § 392.80 and § 392.82) may have affected the driver's perception and reaction times. Investigators should also examine a driver's available medical history. 49 C.F.R. Part 391, Subparts E and F.

[23] www.visualexpert.com — This is the web site of Dr. Marc Green, human factors expert, that includes resource materials about perception-reaction time and other human factors topics related to vehicle crashes.

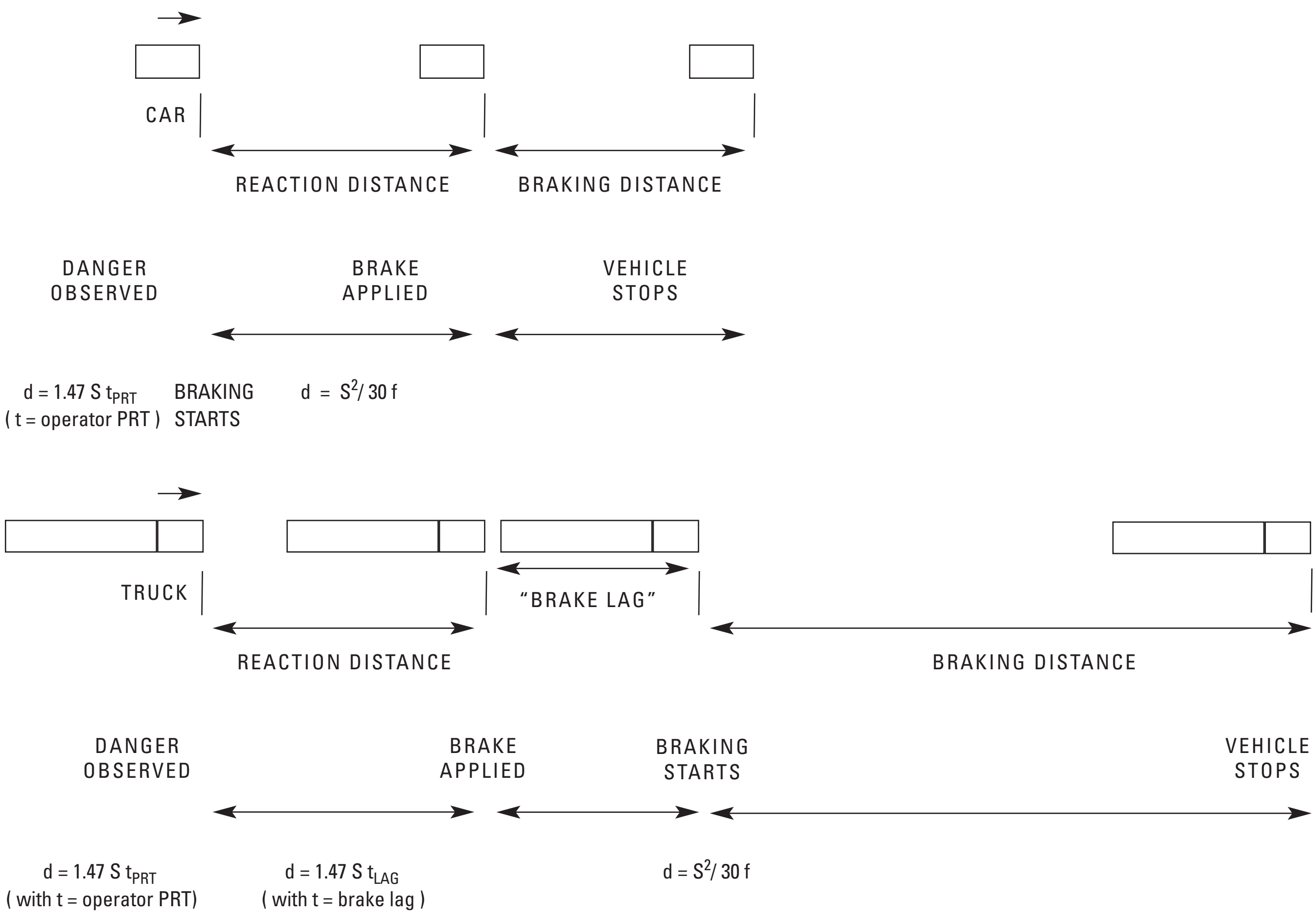


**Fig. 12—Stopping actions for an automobile and a CMV.**

the vehicles to rest is longer for the CMV than for an automobile because the drag factor for the CMV's tires is less than that of the automobile's tires, which is a result of a harder, less frictional chemical compound used in the CMV's tires to facilitate their durability under heavier loads.

It should be noted that contrary to common thought, the ***weight*** of the commercial motor vehicle does not appear anywhere in this stopping distance calculation. The greater stopping distance for the heavier CMV is a result of brake lag and less frictional tires, not vehicle and cargo weight. The concern for a CMV operating overweight is that the overweight condition can reduce the effectiveness of the braking system itself, which might cause longer stopping distances.

*Speed from Tachometer/Gearing Data*

If the *tachometer* of the CMV or the ECM/EDR has recorded engine revolutions per minute, this may afford the reconstructionist an independent method to estimate the pre-crash speed of the vehicle. The revolutions of the engine, coupled with information about the gearing of the vehicle, can produce data about the rotation rate of the tires and thus, the physical circumference of the tires can then be used to determine the forward rate of motion of the vehicle. This methodology has been used for years in motorcycle and automobile reconstruction and its validity has been confirmed. A graphic showing the data flow in the calculation is shown below in Fig. 13.

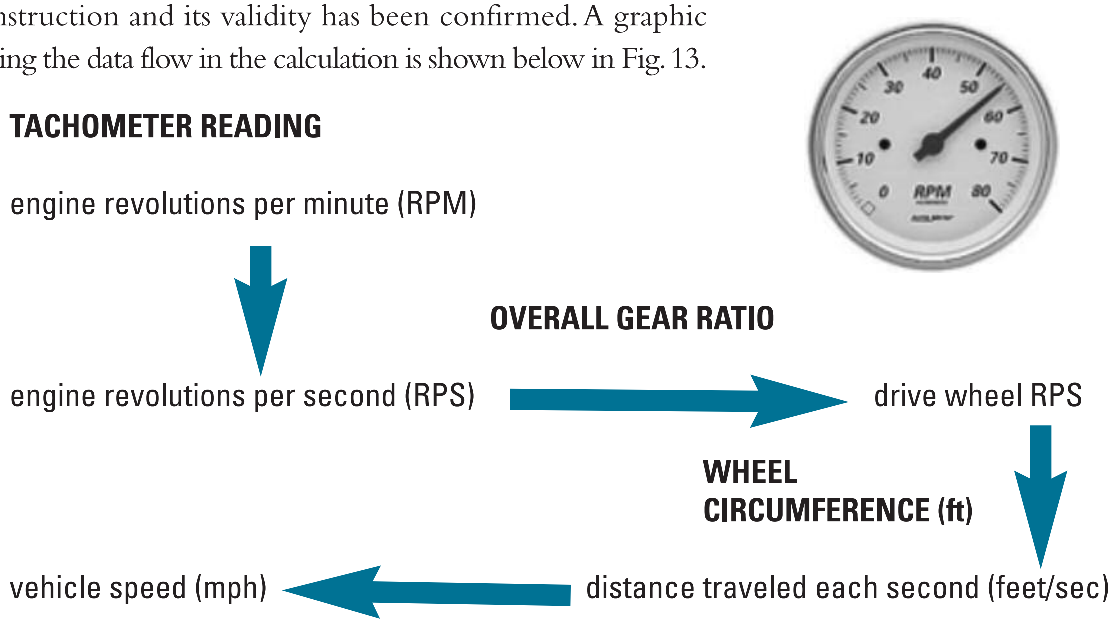


**Fig. 13—Data flow - speed estimate from tachometer reading.**

*Engine Control Module (ECM)*

The engine control modules utilized in most commercial vehicles have the capability to record and store potentially valuable pre-crash information in a function called an ***Event Data Recorder*** (EDR). While the downloading of a truck's ECM may provide information related to the vehicle's speed, braking and other parameters prior to a collision, it is important to understand that the ECM was NOT designed primarily as a data recording device to aid crash reconstructionists. Rather, its primary purpose is for the management of engine functions. As such, the extraction and interpretation of data from an ECM requires substantial knowledge and experience in order to avoid some of the common errors, such as erroneous speed reports and inaccurate time segments associated with some of these recording devices. To complicate matters further, there are often numerous reports available from an ECM download. Some of these reports can contain extremely valuable information related to the vehicle's status just prior to an event while other reports are less useful from a collision reconstruction viewpoint.

The electronic engine control module is the most common source of electronic crash data in heavy trucks and buses. Data can include vehicle speed, engine RPMs, throttle, steer angle, brake and clutch use, and other information for up to 90 seconds before a crash and for a short period after the crash. This data can shed light on key questions like whether a truck was being driven at an appropriate speed and in an appropriate manner before a crash or whether the driver responded in a reasonable way to an emerging hazard.

Engine Control Module data can be analyzed to establish a timeline with corresponding positional information. Using a known position in the ECM data, such as the area of impact or final rest position, the event data can be analyzed to provide a position for every sample of the vehicle's speed — often providing great insight up to 90 seconds prior to collision. This can be a valuable tool in evaluating both physical evidence and reliability of testimony.

It is best to ***image*** the ECM data soon after a crash because driving a truck, or even powering it up, can alter or even erase the crash data (a snapshot is taken of the data in the ECM, but the data is not removed from the ECM so the term "imaging" is used). Retrieving the data in a way that will withstand the tests of litigation requires expertise. It is also important to document the accuracy of the ECM clock and note certain truck features so that crash data can be correctly interpreted. If the truck is relatively undamaged, module downloads can be conducted by connecting a laptop to a port in the vehicle cab. If the vehicle electronics are badly damaged, then the ECM must be transplanted into an identical truck or a physical connection must be made directly to the module. Both methods introduce risk of erasing or overwriting data and should be per-formed by an expert.

Once crash data has been imaged, it can be tempting to rely on it at face value. However, due to some significant limitations, it should be interpreted along with the physical evidence traditionally relied on by reconstructionists, like tire marks and other evidence previously discussed. Speed values, for example, can be incorrect if certain calibration values programmed into the ECM do not match the actual truck features, or the truck's drive wheels were sliding on the road. Both inaccuracies have the same root cause: the ECM calculates the speed of the truck based on information from a sensor that measures how fast the truck's driveshaft is spinning. This calculation relies on programmed calibration factors and is only accurate if the drive wheels are not slipping on the road (due to heavy acceleration, braking, yaw, or airborne motion).

### *Longitudinal Acceleration Rates for Heavy Trucks*

The rate at which a heavy vehicle can accelerate depends on the engine, the vehicle weight, and the skill of the operator. However, it also depends on vehicle speed since that will affect what gear is being used in the transmission. Vehicles have greater acceleration capability at lower speeds than at higher speeds. There is published data for the maximum acceleration rate when a vehicle starts from a stopped position, but the prosecutor should remember that without EDR or video evidence, there are a range of acceleration rates that may have occurred in a particular instance. While a reconstructionist may make an assumption about the rate of acceleration as a starting point in a calculation, a range of values should be considered in the analysis. This would be particularly critical when a time-lapse of the vehicle is being developed. Any testing to determine acceleration capacity of the vehicle should be done with an exemplar vehicle.

### *Speed Estimates from Damage*

The damage caused by a CMV to cars that may be involved in a collision often includes the front of the truck overriding the car, or in the case of a rear-end collision, the car may underride the truck. This condition makes it very difficult to estimate an equivalent speed from the damage to either the car or the truck, so in general the analysis of damage created by a car-CMV impact must be analyzed cautiously. That is because of the lack of empirical evidence regarding the crush of the vehicles, vehicle stiffness, etc. associated with the underride or override conditions. While there are empirical formulas for trailer underride, these should only be used by investigators specifically trained in this methodology. In addition, very little empirical testing has been done to support analyzing the damage to the CMV itself (in the case of underride or override crashes), so crush analysis is of limited use in determining the impact speed of the CMV.

### *Speed from Rollover Analysis*

If a CMV overturns, it may create tire mark evidence that can be utilized to analyze the rollover. The radius of the impending rollover mark, along with vehicle specific measurements like tire deflections and spring compression, need to be considered. A static rollover model, which treats the CMV as a rigid object will tend to overestimate the rollover speed. For heavy vehicles, a dynamic rollover speed calculation should always be considered since it more accurately accounts for vehicle articulation and the effects of the suspension and tires. This requires knowledge of the pre-crash load distribution in the trailer to determine the vertical center of mass location of the vehicle.

## Closing Thoughts

Prosecutors must be aware of and consider the nuances of commercial motor vehicle reconstruction. They need to gather evidence at the crash scene particular to CMV crashes; be aware that volatile evidence may be lost by moving the CMV; and understand that the involvement of trucking specialists in the case's development differentiate these crashes from passenger vehicle crashes. The prosecutor should also expect that because of the potential for civil litigation, the defendant operator will be strenuously defended, often involving multiple experts.

# GLOSSARY

**Accelerometer:** an instrument that is attached to a vehicle to assess the road-tire drag factor when emergency braking is applied.

**Antilock Brake System (ABS):** a braking method in which wheel sensors prevent the wheels from locking and produce a greater drag factor and vehicle steering during the braking action.

**Antilock Brake System (ABS) Scuff Marks:** the evidence of braking made by ABS activated braking, and similar in nature to skid mark evidence created by locked-wheel braking.

**Automatic On-board Recording Device (AOBRD):** an electric, electronic, electromechanical, or mechanical device capable of recording driver's duty status information accurately and automatically as required by 49 C.F.R. §395.15. The device must be integrally synchronized with specific operations of the commercial motor vehicle in which it is installed. At a minimum, the device must record engine use, road speed, miles driven, the date, and time of day.

**Brake Efficiency (Brake Percentage):** the percentage of full braking that was developed by a particular wheel or by the overall vehicle that takes into account the weight distribution of the vehicle.

**Brake Fade:** the loss of brake effectiveness caused by prolonged heating of the brakes accompanying use of braking in a long descent or a malfunction of the brakes.

**Braking Distance:** the distance required to bring a vehicle to a stop after full braking has been applied.

**Brake Lag:** the delay between the application of brake pressure and the onset of braking action, caused by the air pressure buildup necessary to activate the brake mechanism.

**Collision Data Retrieval (CDR) System:** the instrument used to image the crash data that has been captured in the ECM or other event data recording device in the vehicle.

**Controller Area Network (CAN):** a method of communication between various electronic devices like engine management systems, active suspension, ABS, gear control, lighting control, air conditioning, airbags, etc., embedded in a vehicle.

**Drag Factor:** the friction index or number that describes how "sticky" a road surface is for a particular tire that is braking on that surface.

**Drag Sled:** a device that facilitates the measurement of road friction (drag factor) by pulling the sled with a calibrated spring scale.

**Drone:** an unmanned aerial device equipped with a camera and which can fly over a crash scene to take photographs.

**Dualies:** two wheels on one end of an axle that increase the amount of weight that can be supported on that axle location.

**Electronic Logging Device (ELD):** a device or technology that automatically records a driver's driving time and facilitates the accurate recording of the driver's hours of service.

**Electronic Stability Control (ESC):** a system which distributes power to the tires of a vehicle based on the amount of individual tire slippage, and designed to prevent loss of vehicle control.

**Engine Braking:** the slowing of a vehicle by the action of engine compression acting to retard the vehicle's motion.

**Engine Control Module (ECM):** an electronic module designed to protect the vehicle's engine from damage, and which also contains an EDR capability.

**Event Data Recorder (EDR):** a function within the ECM that facilitates the recording of vehicle data prior to a crash and for some time after the crash.

**Full-trailer:** a full-trailer is like the semi-trailer with the difference that the full trailer has axles at the front end and rear end and therefore it can be parked on its own without the need of prime mover or landing legs to support it. The front axle (or axles) has steering capability, and a drawbar is provided to couple with the prime mover.

**Gear Ratio Speed Analysis:** a method of determining vehicle speed from the tachometer RPMs, the vehicle gearing, and tire information.

**Gross Vehicle Weight (GVW):** the total weight of fully equipped truck (or trailer) and payload.

**Gross Combination Weight (GCW):** the total weight of fully equipped tractor, trailer or trailers, and payload.

**Human Factors Expert:** an expert who opines on driver behavior, including perception-reaction time, visibility, driver response to emergency, etc.

**Hydraulic:** a braking system that uses a liquid as the fluid to transmit the necessary force to activate the brake mechanism.

**Hydroplaning:** the riding up on a layer of water that exists between a tire and the road surface, caused by the tire's inability for the tread to channel water from under the tire.

**Imaging the EDR:** the process of making a record of the data contained in the Event Data Recorder using a specialized Crash Data retrieval System software.

**Jackknifing:** the action of a tractor-semi-trailer combination folding at the fifth wheel because of imbalanced braking or mechanical failure.

**Offtracking:** the distance between the outside of the front tractor wheel and the outside of the rearmost trailer wheel as a vehicle makes a turn.

**Mapping:** the documentation of evidence locations using a digital system utilizing laser, or other, distance and angle measuring technology, such as the Total Station.

**Perception-Reaction Time (PRT):** the time required for the driver's brain to perceive, recognize, decide, and then initiate an action in response to an emergency; may also be called perception-response time.

**Photogrammetry:** the science of making measurements from photographs.

**Pneumatic:** a braking system that uses compressed air as the fluid to transmit the necessary force to activate the brake mechanism.

**Reaction Distance:** the distance traveled by a vehicle while the driver's mind is going through the perception-reaction process of reacting to an emergency.

**Retread Separation:** the compromise of the integrity of a tire when the retread material, wrapped in a layer around the tire, separates from the tire because of the centrifugal effects of tire rotation.

**Rollover:** the action that occurs when a vehicle tips to the side and the center of mass of the vehicle gets outside the tires.

**Scanner:** an evidence documenting instrument that uses a scanning laser beam to collect a huge number of digital evidence points to allow the user to construct a 3-D image of a crash scene or vehicle damage.

**Semi-trailer:** A semi-trailer is pulled by a truck tractor or a prime mover. The semi-trailer has a kingpin near the front end to couple with the prime mover and has axles at the rear. The semi-trailer also has brakes, suspension, and lights. A pair of landing legs are fixed near the front end to support the semi-trailer after it is decoupled from the prime mover.

**Skid Marks:** tire marks made by locked tires (either locked by braking or by damage), that get darker as the skid proceeds.

**Stopping Distance:** the total distance it takes for a heavy vehicle to come to a stop, including the perception-response distance, the brake lag distance, and the braking distance.

**Tachometer:** an instrument used to measure the rotation speed of a shaft or a disk, as in a motor. The instrument typically calibrates measurement in revolutions per minute (RPMs).

**Tandem Axles:** two axles that are combined by means of a balancer such that the axles work in tandem.

**Tare Weight:** the empty weight of a trailer without payload and without the prime mover.

**Theodolite:** a surveying instrument with a rotating laser beam for measuring horizontal and vertical angles.

**Time – Distance – Speed Analysis (TDS):** an analysis that utilizes the mathematical relationship(s) among the variable of a motion – elapsed time, distance traveled, and vehicle speed.

**Total Station:** an instrument consisting of a mapping unit and a retroreflective evidence mirror that uses a pulse of infrared light to measure and document evidence locations at a crash scene, and which can be used to map road geometries, curvatures, etc. to produce a to-scale drawing of a crash scene.

**Trailer Swing:** the motion of the semi-trailer that sweeps the trailer laterally when trailer traction is lost.

# APPENDIX I

**Disqualification tables from 49 C.F.R. 385.51(b), (c), (d) and (e) (2017)**

**Acronyms used in the tables:**

- **"CMV" is "commercial motor vehicle"**
- **"CDL" is "commercial driver's license"**
- **"CLP" is "commercial learner's permite"**

**Table 1**

(b) *Disqualification for major offenses.* Table 1 to §383.51 contains a list of the offenses and periods for which a person who is required to have a CLP or CDL is disqualified, depending upon the type of vehicle the driver is operating at the time of the violation.

**Table 2**

(c) *Disqualification for serious traffic violations.* Table 2 to §383.51 contains a list of the offenses and the periods for which a person who is required to have a CLP or CDL is disqualified, depending upon the type of vehicle the driver is operating at the time of the violation

**Table 3**

(d) *Disqualification for railroad-highway grade crossing offenses.* Table 3 to §383.51 contains a list of the offenses and the periods for which a person who is required to have a CLP or CDL is disqualified, when the driver is operating a CMV at the time of the violation.

**Table 4**

(e) *Disqualification for violating out-of-service orders.* Table 4 to §383.51 contains a list of the offenses and periods for which a person who is required to have a CLP or CDL is disqualified when the driver is operating a CMV at the time of the violation.

## TABLE 1 to §383.51 — DISQUALIFICATION FOR MAJOR OFFENSES

| If a driver operates a motor vehicle and is convicted of: | For a first conviction or refusal to be tested while operating a CMV, a person required to have a CLP or CDL and a CLP or CDL holder must be disqualified from operating a CMV for | For a first conviction or refusal to be tested while operating a non-CMV, a CLP or CDL holder must be disqualified from operating a CMV for | For a first conviction or refusal to be tested while operating a CMV transporting hazardous materials as defined in §383.5, a person required to have a CLP or CDL and a CLP or CDL holder must be disqualified from operating a CMV for | For a second conviction or refusal to be tested in a separate incident of any combination of offenses in this Table while operating a CMV, a person required to have a CLP or CDL and a CLP or CDL holder must be disqualified from operating a CMV for | For a second conviction or refusal to be tested in a separate incident of any combination of offenses in this Table while operating a non-CMV, a CLP or CDL holder must be disqualified from operating a CMV for |
|---|---|---|---|---|---|
| (1) Being under the influence of alcohol as prescribed by State law. | 1 year. | 1 year. | 3 years. | Life. | Life. |
| (2) Being under the influence of a controlled substance. | 1 year. | 1 year. | 3 years. | Life. | Life. |
| (3) Having an alcohol concentration of 0.04 or greater while operating a CMV. | 1 year. | Not applicable. | 3 years. | Life. | Not applicable. |
| (4) Refusing to take an alcohol test as required by a State or jurisdiction under its implied consent laws or regulations as defined in §383.72 of this part. | 1 year. | 1 year. | 3 years. | Life. | Life. |
| (5) Leaving the scene of an accident. | 1 year. | 1 year. | 3 years. | Life. | Life. |
| (6) Using the vehicle to commit a felony, other than a felony described in paragraph (b)(9) of this table. | 1 year. | 1 year. | 3 years. | Life. | Life. |
| (7) Driving a CMV when, as a result of prior violations committed operating a CMV, the driver's CLP or CDL is revoked, suspended, or canceled, or the driver is disqualified from operating a CMV. | 1 year. | Not applicable. | 3 years. | Life. | Not applicable. |
| (8) Causing a fatality through the negligent operation of a CMV, including but not limited to the crimes of motor vehicle manslaughter, homicide by motor vehicle and negligent homicide. | 1 year. | Not applicable. | 3 years. | Life. | Not applicable. |
| (9) Using the vehicle in the commission of a felony involving manufacturing, distributing, or dispensing a controlled substance. | Life—not eligible for 10-year reinstatement. | Life—not eligible for 10-year reinstatement. | Life—not eligible for 10-year reinstatement. | Life—not eligible for 10-year reinstatement. | Life—not eligible for 10-year reinstatement. |

**TABLE 2 to §383.51—DISQUALIFICATION FOR SERIOUS TRAFFIC VIOLATIONSS**

| If the driver operates a motor vehicle and is convicted of: | For a second conviction of any combination of offenses in this Table in a separate incident within a 3-year period while operating a CMV, a person required to have a CLP or CDL and a CLP or CDL holder must be disqualified from operating a CMV for | For a second conviction of any combination of offenses in this Table in a separate incident within a 3-year period while operating a non-CMV, a CLP or CDL holder must be disqualified from operating a CMV, if the conviction results in the revocation, cancellation, or suspension of the CLP or CDL holder's license or non-CMV driving privileges, for | For a third or subsequent conviction of any combination of offenses in this Table in a separate incident within a 3-year period while operating a CMV, a person required to have a CLP or CDL and a CLP or CDL holder must be disqualified from operating a CMV for | For a third or subsequent conviction of any combination of offenses in this Table in a separate incident within a 3-year period while operating a non-CMV, a CLP or CDL holder must be disqualified from operating a CMV, if the conviction results in the revocation, cancellation, or suspension of the CLP or CDL holder's license or non-CMV driving privileges, for |
|---|---|---|---|---|
| (1) Speeding excessively, involving any speed of 24.1 kmph (15 mph) or more above the posted speed limit | 60 days | 60 days | 120 days | 120 days. |
| (2) driving recklessly, as defined by State or local law or regulation, including but, not limited to, offenses of driving a motor vehicle in willful or wanton disregard for the safety of persons or property | 60 days | 60 days | 120 days | 120 days. |
| (3) making improper or erratic traffic lane changes | 60 days | 60 days | 120 days | 120 days. |
| (4) following the vehicle ahead too closely | 60 days | 60 days | 120 days | 120 days. |
| (5) Violating State or local law relating to motor vehicle traffic control (other than a parking violation) arising in connection with a fatal accident | 60 days | 60 days | 120 days | 120 days. |
| (6) driving a CMV without obtaining a CLP or CDL | 60 days | Not applicable | 120 days | Not applicable. |
| (7) driving a CMV without a CLP or CDL in the driver's possession[1] | 60 days | Not applicable | 120 days | Not applicable. |
| (8) driving a CMV without the proper class of CLP or CDL and/or endorsements for the specific vehicle group being operated or for the passengers or type of cargo being transported | 60 days | Not applicable | 120 days | Not applicable. |
| (9) violating a state or local law or ordinance on motor vehicle traffic control prohibiting texting while driving a CM | 60 days | Not applicable | 120 days | Not applicable. |
| (10) Violating a State or local law or ordinance on motor vehicle traffic control restricting or prohibiting the use of a hand-held mobile telephone while driving a CMV.[2] | 60 days | Not applicable | 120 days | Not applicable. |

[1] Any individual who provides proof to the enforcement authority that issued the citation, by the date the individual must appear in court or pay any fine for such a violation, that the individual held a valid CLP or CDL on the date the citation was issued shall not be guilty of this offense.

[2] *Driving, for the purpose of this disqualification,* means operating a commercial motor vehicle on a highway, including while temporarily stationary because of traffic, a traffic control device, or other momentary delays. Driving does not include operating a commercial motor vehicle when the driver has moved the vehicle to the side of, or off, a highway and has halted in a location where the vehicle can safely remain stationary.

#### TABLE 3 to §383.51—CDL DISQUALIFICATION FOR RAILROAD-HIGHWAY GRADE CROSSING OFFENSES

| If the driver is convicted of operating a CMV in violation of a Federal, state or local law because: | For a first conviction a person required to have a CLP or CDL and a CLP or CDL holder must be disqualified from operating a CMV for | For a second conviction of any combination of offenses in this Table in a separate incident within a 3-year period, a person required to have a CLP or CDL and a CLP or CDL holder must be disqualified from operating a CMV for | For a third or subsequent conviction of any combination of offenses in this Table in a separate incident within a 3-year period, a person required to have a CLP or CDL and a CLP or CDL holder must be disqualified from operating a CMV for |
|---|---|---|---|
| (1) The driver is not required to always stop, but fails to slow down and check that tracks are clear of an approaching train | No less than 60 days | No less than 120 days | No less than 1 year |
| (2) The driver is not required to always stop, but fails to stop before reaching the crossing, if the tracks are not clear | No less than 60 days | No less than 120 days | No less than 1 year |
| (3) The driver is always required to stop, but fails to stop before driving onto the crossing | No less than 60 days | No less than 120 days | No less than 1 year |
| (4) The driver fails to have sufficient space to drive completely through the crossing without stopping | No less than 60 days | No less than 120 days | No less than 1 year |
| (5)The driver fails to obey a traffic control device or the directions of an enforcement official at the crossing | No less than 60 days | No less than 120 days | No less than 1 year |
| (6) The driver fails to negotiate a crossing because of insufficient undercarriage clearance | No less than 60 days | No less than 120 days | No less than 1 year |

#### TABLE 4 to §383.51—DISQUALIFICATION FOR VIOLATING OUT-OF-SERVICE ORDERS

| If a driver operates a CMV and is convicted of… | For a first conviction while operating a CMV, a person required to have a CLP or CDL and a CLP or CDL holder must be disqualified from operating a CMV for | For a second conviction in a separate incident within a 10-year period while operating a CMV, a person required to have a CLP or CDL and a CLP or CDL holder must be disqualified from operating a CMV for | For a third or subsequent conviction in a separate incident within a 10-year period while operating a CMV, a person required to have a CLP or CDL and a CLP or CDL holder must be disqualified from operating a CMV for |
|---|---|---|---|
| (1) Violating a driver or vehicle out-of-service order while transporting non-hazardous materials | No less than 180 days or more than 1 year | No less than 2 years or more than 5 years | No less than 3 years or more than 5 years |
| (2) Violating a driver or vehicle out-of-service order while transporting hazardous materials as defined in §383.5, or while operating a vehicle designed to transport 16 or more passengers, including the driver | No less than 180 days or more than 2 years | No less than 3 years or more than 5 years | No less than 3 years or more than 5 years |

# APPENDIX II

Form MCSA-5876 OMB No. 2126-0006 Expiration Date: 11/30/2021

**Public Burden Statement**
A Federal agency may not conduct or sponsor, and a person is not required to respond to, nor shall a person be subject to a penalty for failure to comply with a collection of information subject to the requirements of the Paperwork Reduction Act unless that collection of information displays a current valid OMB Control Number. The OMB Control Number for this information collection is 2126-0006. Public reporting for this collection of information is estimated to be approximately 1 minute per response, including the time for reviewing instructions, gathering the data needed, and completing and reviewing the collection of information. All responses to this collection of information are mandatory. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to: Information Collection Clearance Officer, Federal Motor Carrier Safety Administration, MC-RRA, 1200 New Jersey Avenue, SE, Washington, D.C. 20590.

U.S. Department of Transportation
Federal Motor Carrier
Safety Administration

**Medical Examiner's Certificate**
(for Commercial Driver Medical Certification)

I certify that I have examined **Last Name:** ____________ **First Name:** ____________ in accordance with *(please check only one)*:

◯ the Federal Motor Carrier Safety Regulations (49 CFR 391.41-391.49) and, with knowledge of the driving duties, I find this person is qualified, and, if applicable, only when *(check all that apply)* ***OR***

◯ the Federal Motor Carrier Safety Regulations (49 CFR 391.41-391.49) with any applicable State variances (which will only be valid for intrastate operations), and, with knowledge of the driving duties, I find this person is qualified, and, if applicable, only when *(check all that apply)*:

☐ Wearing corrective lenses
☐ Wearing hearing aid
☐ Accompanied by a ____________ waiver/exemption
☐ Accompanied by a Skill Performance Evaluation (SPE) Certificate
☐ Driving within an exempt intracity zone (49 CFR 391.62) *(Federal)*
☐ Qualified by operation of 49 CFR 391.64 *(Federal)*
☐ Grandfathered from State requirements *(State)*

The information I have provided regarding this physical examination is true and complete. A complete Medical Examination Report Form, MCSA-5875, with any attachments embodies my findings completely and correctly, and is on file in my office.

**Medical Examiner's Certificate Expiration Date**

**Medical Examiner's Signature** | **Medical Examiner's Telephone Number** | **Date Certificate Signed**

**Medical Examiner's Name** ***(please print or type)***

◯ MD ◯ Physician Assistant ◯ Advanced Practice Nurse
◯ DO ◯ Chiropractor ◯ Other Practitioner *(specify)* ____________

**Medical Examiner's State License, Certificate, or Registration Number** | **Issuing State** | **National Registry Number**

**Driver's Signature** | **Driver's License Number** | **Issuing State/Province**

**Driver's Address**
Street Address: ____________ City: ____________ State/Province: ________ Zip Code: ________

**CLP/CDL Applicant/Holder** ◯ Yes ◯ No

**This document contains sensitive information and is for official use only. Improper handling of this information could negatively affect individuals. Handle and secure this information appropriately to prevent inadvertent disclosure by keeping the documents under the control of authorized persons. Properly dispose of this document when no longer required to be maintained by regulatory requirements.**

## ABOUT THE AUTHOR

**John B. Kwasnoski** is Professor Emeritus of Forensic Physics at Western New England University, Springfield, MA, after thirty-one years on the faculty. He is a certified police trainer in more than twenty states, and has instructed prosecutors, police, and civil attorneys on more than 350 occasions across the U.S. He is the crash reconstructionist on the "Lethal Weapon – DWI Homicide" team formed by the National Traffic Law Center to teach prosecutors how to utilize expert witness testimony and cross examine adverse expert witnesses.

Prof. Kwasnoski has reconstructed more than 1,200 crashes, including multiple and single vehicle, pedestrian, motorcycle, and train crashes, and has given sworn testimony on more than 200 occasions; he has been training the NYPD collision reconstruction unit since 2001; and continues to serve as a consultant to prosecutors nationwide on motor vehicle homicide cases. He has worked for more than twenty major insurers as a consultant/expert witness and has conducted training for claims adjusters and special investigators for several insurance companies.

Professor Kwasnoski is the author and co-author of several books, has published more than 60 journal and newsletter articles on collision reconstruction, and maintains an active speaking schedule nationwide.

Legalsciences.com, John Kwasnoski's website, provides information, educational resources and training opportunities for professionals involved in the criminal justice system who handle impaired driver and motor vehicle crash cases.

Select publications Professor Kwasnoski authored include: *Kwasnoski's Little Red Book, From Crash to Courtroom: Collision Reconstruction for Lawyers and Law Enforcement and Crash Reconstruction Basics for Prosecutors* written for the American Prosecutors Research Institute (now, the National District Attorneys Association). For more information, visit Legalsciences.com.

To request additional copies of this monograph
visit www.NDAA.org.

National District Attorneys Association
1400 Crystal Drive, Suite 330
Arlington, VA 22202