Accident Reconstruction 101—Minor/Moderate/Major Accidents

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I. The Call

It is Friday at 7:30 p.m., and you are on your way home after a long week. Your cell phone rings, and recognizing the number, you know it is going to be a big case. What steps should you take?

II. Have a Plan

When responding to an accident, one needs to already know what they are going to do prior to arrival at the accident scene. Where is the accident? What is the travel direction and roadway configuration? Is this a serious accident? What are the weather conditions? Has the driver been secured? Has the accident reconstructionist been retained? Is there an adjuster already on the scene?

In a perfect world, the general processes of investigating minor, moderate, and major accidents are very similar. However, the required analysis is unique to the particular accident. It is important to communicate the scope of the investigation with the accident reconstructionist to make sure that his or her efforts will help provide understanding of your case.

The goal of an accident reconstructionist is to use the available evidence to determine the events of an accident in sufficient detail such that one can determine the pre-accident scenario. Examples include the following: position of the vehicles and pedestrians on the roadway; velocity of the vehicles and the pedestrians; actions of drivers and pedestrians prior to impact; and the mechanical integrity of components prior to an impact (not necessarily always vehicle components).

In order to complete an accident reconstruction such that the pre-accident scenario can be determined within a reasonable degree of professional certainty, a detailed investigation and review of the facts should be completed, using reliable principles and scientific methodologies.

So, what is the plan? And what is the accident reconstructionist doing out there?

III. Accident Scene Inspection

Once an accident has occurred, the evidence, which has been left on the roadway, immediately begins to deteriorate. It is ideal to get to the accident scene as soon as possible to begin the inspection and document the roadway layout and markings. Since roadways are not typically closed during an inspection, most are conducted during the day so that the reconstructionist can clearly see all the evidence and to reduce the risk of creating an additional accident.

During a scene inspection, it is important that the roadway layout is preserved, including the road names, roadway or intersection configuration, number of lanes, pedestrian walkways, traffic signals, lighting condition, road surface, posted speed limit signs, stop signs, and other non-accident related markings. In addition to documenting the roadway layout, the location and size of the witness marks should also be preserved. Examples of witness marks include gouges and grooves on the roadway; tire marks; fluid stains; debris, such as a struck pedestrian's shoe; damaged objects from the accident; and any markings made by the investigating agency.

Documenting the scene allows an investigator to recreate the entire accident scene as a three-dimensional world or a two-dimensional drawing to be used in the accident reconstruction, and potentially as a trial exhibit. There are multiple methods of documentation that can be used depending on the availability of access to the accident scene. The most popular method uses photographs to preserve the way a marking looks. This method is generally less reliable for documenting size and location.

In order to document size and location of pertinent items, the accident reconstructionist may survey the roadway. The most basic form of survey uses manual measurements. This typically requires that the accident reconstructionist spend time on the roadway to document markings. While this method is reliable and effective, there are limitations as to how much data one individual can record while avoiding traffic on a live roadway. Typical tools used to complete manual measurements include a measuring tape, chain, right-angle-prism with staff, level, and measuring wheel.

If taking manual measurements is not practical, the accident scene may also be surveyed with the help of a total station or a laser scanner. A total station is a surveying instrument that combines both angle and distance measurements within the same unit. The total station is situated off of the roadway, and its sight is positioned on a reflector, held by an individual, or directly on the marking. When the measuring sequence begins, a signal is sent to the reflector or object, and a portion of this signal is then returned to the total station. The signal is analyzed via a microprocessor to calculate the distance as well as the horizontal and vertical angles. Most total stations have a range of up to a few kilometers when using a prism, and a range of at least 100 meters in the reflectorless mode.

A 3-D laser scanner is similar to a total station, but far more versatile. Generally, there are two types of 3-D laser scanners used to document an accident scene: pulse-based and phase-shift. The pulse-based scanner, also known as a time-of-flight scanner, records the time that it takes for a laser to reach an object and travel back to the sensor. A processor in the scanner can calculate coordinates based on the laser orientation and known speed of the laser. The processor is able to record time down to a picosecond ($1x10^{-12}$ seconds). By rotating the laser and sensor, sometimes using a mirror, the scanner can scan a full 360 degrees. This operation is repeated thousands of times each second, and generates a file containing a large amount of point data of the scanned surface. This file, as displayed on a computer screen, shows the 3-D shape of the scanned surface. Phase-shift 3-D scanners operate similarly to pulse-based systems. In addition to emitting a laser pulse, this system can modulate the power of the laser beam. The reflected light is then detected and compared with the emitted light to determine the phase shift. Multiple modulation frequencies are used to increase the accuracy. All points documented by 3-D scanners are used to create a 3-D scene, but pulse-based scanners are slower than phase-shift scanners, while pulse-based scanners have greater range.

There are times when the accident occurs over a bridge or highway where no safe area exists to safely document roadway markings. Under this scenario, scene markings may be captured via aerial photographs. The setup requires an airplane or helicopter that has a special photography port located at the bottom of the fuselage permitting photographs to be taken with a vertical orientation. The photographs are able to capture and preserve both roadway and witness markings. They can be scaled to create a two-dimensional drawing to preserve the accident scene. Aerial photography also requires the use of a high-performance camera.

IV. Vehicle Inspection

Once the accident scene has been preserved, the vehicles should be inspected. The inspection protocol for a heavy truck is very different from that of a passenger vehicle. The damage to the heavy truck is documented via hand measurements or survey measurements. The mechanical inspection is thorough and includes elements from the Commercial Vehicle Safety Alliance North American Standard inspection procedure. This includes inspecting the following: inspection decals, headlamps, tail lights, turn signals, marker lights, windshield wipers, wheel rims, hubs, tires, fuel tank, exhaust system, air and electrical lines, fifth wheel, frame and body, hoses, trailer bodies, sliding tandem, cargo securement, and brakes. In order to check the heavy truck brakes, the truck engine should be running, or compressed air needs to be supplied to the heavy truck and/or trailer. With the air pressure between 90 and 100 pounds per square inch (psi), the truck brakes are fully applied, and the brake stroke is documented.

Many heavy trucks have an electronic control module (ECM) that may contain accident data. The type of information stored on an ECM is dependent on the type of engine in the heavy truck. The engines that may contain accident data include: Caterpillar, Cummins, Detroit Diesel, International, Mack, Mercedes Benz, and Volvo. The tools that can be used to image data from these engines, with the exceptions of Mack and Volvo engines, are available via aftermarket retailers and routinely used by accident reconstructionists. Electronic data from Mack and Volvo engines can only be fully imaged via one of two vendors, both of which have been designated by the Original Equipment Manufacturers (OEM). Other parties are able to image configuration data. The data may include the vehicle speed, brake signal, clutch orientation, engine speed, cruise control information for over one minute prior to the accident, fault codes, governing speed, and other configuration data. In addition to the ECM, there are additional components that may also contain accident data. These components include global positioning systems (GPS), such as QUALCOMM or PeopleNet; crash avoidance systems, such as VORAD; and similar devices.

Passenger vehicles are also subject to general mechanical inspections focusing on damage, lights, brakes, wheel rims, tires, hoses, belts, seat belts, and other mechanical components. Damage is also documented via hand or survey measurements. Many passenger vehicles contain event data recorders (EDR) that may contain accident data. The most popular EDR is the airbag control module (ACM). The ACM is known by different names but is found in most modern passenger vehicles, including models from the following vehicle brands: Acura, Honda, Nissan, Buick, Hummer, Oldsmobile, Cadillac, Infiniti, Pontiac, Chevrolet, Isuzu, Saturn, Chrysler, Jeep, Scion, Dodge, Lancia, Sterling, Fiat, Lexus, Suzuki, Ford, Lincoln, Toyota, Geo, Mazda, GMC, Mercury, and Mitsubishi. The ACM monitors and controls the operation of passenger restraining systems in the vehicle, including the air bag and seat belt pretensioners. Some late model General Motor (GM) vehicles contain a rollover sensor (ROS), as well as an ACM. The ROS measures the vehicle roll angle and also controls the passenger restraining systems. Some Ford vehicles have ACMs and powertrain control modules (PCM) that contain accident data. The PCM is the electronic control center of the vehicle. It monitors multiple sensors in the vehicle and makes adjustments to the vehicle's internal combustion engine to optimize operation.

Sometimes during vehicle inspections, there are issues that need to be documented in greater detail, due to the characteristics of the accident. Examples may include vehicle weight, headlight activity, or purported vehicle defects. Examples of alleged defects include a malfunctioning brake system or steering system resulting in the loss of vehicle control. It is critical that details relating to unique characteristics of an accident are communicated to the accident reconstructionist to ensure that nothing is missed during a general mechanical inspection. In certain instances where the defect may be related to a design issue, it is likely that multiple vehicles of the same type in a fleet would also need to be inspected.

V. Document Review

It is ideal to have the scene inspected near the time of the accident. This ensures that important information, which can be used in the accident reconstruction, is preserved until it is time to complete the analysis. During the investigation of an accident, many documents are produced that can add value to the investigation. Examples of these documents and the useful information that may be gleaned are listed below:

Police Accident and Investigation Reports: Accident location, accident date, parties and witnesses to the accident, insurance information, statements, roadway conditions, pedestrian clothing, results of toxicology testing, electronic data from vehicles, roadway markings, speed limits, and additional information.

Commercial Vehicle Inspection Report: Details of commercial vehicles involved in the accident and results of the state inspector's inspection of the vehicle.

Weather Reports: Detailed weather at the time of the accident and also warnings which may have been released to the public prior to the accident.

Traffic Signal Timing Schedule: When an accident occurs at an intersection that is controlled by traffic signals, it is recommended to contact the local municipality requesting documentation that will be useful in completing a reconstruction. Examples include traffic signal installation plans, maintenance logs for the traffic signals traffic controller programming, and traffic cabinet wiring diagrams.

Additional evidence is disclosed in the form of depositions, statements, affidavits, and additional documentation. In the case of heavy trucks, this type of information may includes the following: driver's direction and routing, driver's training record, driver's accident history, driver's log, pre-trip inspection records, scale tickets, bill of lading, vehicle maintenance records, and vehicle annual inspection records.

VI. Analysis

Once all of the evidence and file material has been collected and reviewed, the outline of the analysis will be prepared to determine what research is necessary to complete an accident reconstruction. Examples of researched material include vehicle specifications, such as dimensions and weight; vehicle stopping performance characteristics on a particular road surface; vehicle stiffness to assist in damage analysis; and other specifications, such as headlamp type. In certain projects, the data is not readily available, and testing may need to be completed to obtain reliable data in order for an analysis to be completed.

Once the evidence and file material have been reviewed, the accident reconstructionist will use scientific principles to complete the analysis. Examples of some of the most widely used scientific principles are noted below.

Algebra: An area of mathematics in which symbols are used to represent quantities so that a mathematical model may be created in equations to relate variables. An example of using Algebra is calculating the distance (D) that a vehicle traveled over a constant speed (v) during a known time interval (t), $D=v*t$.

Geometry: An area of mathematics concerned with the study of shape, size, and positions. Trigonometry, which focuses on the computational side of Geometry, is also heavily used. Geometry is used in vehicle position, velocity calculations, and in conservation of momentum calculations.

Physics: An area of science that focuses on energy and matter. The following scientific laws and principles are used extensively in vehicle accident reconstruction:

Law of Conservation of Energy: The law of conservation of energy dictates that the mechanical energy of a system is unchanged. When an object accelerates or decelerates, work is done upon the object. Work includes the application of a brake in a vehicle; acceleration from the engine; or damage as a result of an impact. When a body can do work, it is said to possess energy. Mechanical energy is classified as either potential or kinetic. Potential energy exists when an object is held up high. Kinetic energy exists when a body is moving, such as car traveling on the roadway at 45 mph. For example, if a car traveling at a high rate of speed were to strike a large immovable object, such as a concrete wall, it is expected that the car would have a substantial amount of crush damage. Utilizing conservation of energy, the speed of the car could accurately be calculated based on the amount of crush damage.

Law of Conservation of Momentum: Newton's first three laws of motion each contribute to the conservation of momentum. The law of conservation of momentum states that the momentum of a system remains unchanged. When two large objects have a collision over a very short period of time, the scientific term to describe the collision is impact. During the impact between two bodies, or vehicles, the momentum from one body is passed to the other; afterwards the bodies continue with changed velocities. For example, vehicle "A" traveling at a speed of 45 mph strikes a similar sized vehicle "B" traveling at 25 mph in the rear. The law of conservation of momentum dictates that the speed of vehicle "A" will decrease, and the speed of vehicle "B" will increase.

Kinematics: A branch of Physics that deals with the motion of objects without the consideration of forces to produce or maintain this motion. An example would be calculating the speed of a vehicle based on a skid mark.

Finally, once the scientific principles have been properly used to complete an analysis, the accident reconstructionist is ideally able to establish the pre-impact vehicle speeds, positions, and directions.

The process described above is typically used across all types of accidents: major, moderate, and minor. But, based on available information, some accidents may need to be approached in different ways.

Major Accidents: Major accidents can involve more than ten vehicles. Multiple accident reconstructionists are sometimes used to effectively inspect all of the evidence in a major accident. An example of major accident is a multi-vehicle pile-up.

Moderate Accidents: Moderate accidents can involve between one and ten vehicles. Moderate accidents can be effectively investigated by one accident reconstructionist, but an additional individual may assist depending on time demands. Reconstruction of moderate accidents normally follows the accident reconstruction process outlined in this report.

Minor Accidents: Minor accidents can involve up to five vehicles. In minor accidents, the vehicle damage is minimal and the occurrence of injury does not appear obvious based on the vehicle damage. Many times, the injury claims are not made until long after the accident. Reconstructionists are often not involved in the early investigation of a minor accident, so they may need to heavily rely on file material documenting the accident. The reliability of the analysis will be based on the depth and integrity of the file material. Injury causation analysis by a biomechanical engineer is routinely completed in minor accidents as well.

The circumstances and variables surrounding an accident can vastly differ from event to event. Therefore, a reconstructionist must be prepared to utilize the appropriate tools and scientific principles accordingly to reconstruct the accident. Just as an attorney retains an expert with the requisite knowledge, skill, experience, and education, the reconstructionist must select the appropriate industry accepted tools and methodologies.