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NATIONAL TRAFFIC LAW CENTER

The background of the entire page is a photograph of a traffic accident scene. On the left, a white truck with a blue stripe is partially visible. In the center, a blue sedan has a severely damaged front end, with its hood crumpled and metal parts exposed. To the right, the front corner of a yellow vehicle is visible. In the background, a red fire truck is parked, and various emergency equipment, including hoses and cables, are scattered around the scene. The lighting suggests it is daytime.

Crash Reconstruction Basics

FOR PROSECUTORS

February 2026

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The National Traffic Law Center is a program of the National District Attorneys Association. This document was prepared under Cooperative Agreement Number 693JJ91950010 from the U.S. Department of Transportation, National Highway Traffic Safety Administration. Points of view or opinions in this document are those of the authors and do not necessarily represent the official position or policies of the U.S. Department of Transportation, National Highway Traffic Safety Administration, the National District Attorneys Association, or the National Traffic Law Center. This publication is intended to provide a general overview of alcohol toxicology in impaired driving cases. While some sections of this publication address issues that are inherently legal, this publication is not intended to provide legal advice. Therefore, it is important to seek legal advice from a licensed attorney on specific issues or questions the reader may have. Please ensure compliance with all local and state laws when considering information contained in this publication.



National Traffic Law Center

The National District Attorneys Association's National Traffic Law Center (NTLC) is a resource designed to benefit prosecutors, law enforcement, judges, and criminal justice professionals. The mission of NTLC is to improve the quality of justice in traffic safety adjudications by increasing the awareness of highway safety issues through the compilation, creation, and dissemination of legal and technical information and by providing training and reference services.

When prosecutors deal with challenges to the use of breath test instruments, blood tests, horizontal gaze nystagmus, crash reconstruction, and other evidence, the NTLC can assist with technical and case law research. Likewise, when faced with inquiries from traffic safety professionals about getting impaired drivers off the road, the NTLC can provide research concerning the effectiveness of administrative license revocation, ignition interlock systems, sobriety checkpoints, and much more.

The NTLC has a clearinghouse of resources including case law, research studies, training materials, trial documents, and information regarding crash reconstruction, toxicology, drug recognition, and many other topics. The information catalogued by the Center covers a wide range of topics with emphasis on impaired driving and vehicular homicide issues.

The professional staff at the NTLC includes experienced trial attorneys and research staff. Assistance is specifically provided in all areas of trial preparation, including methods to counter specific defenses. The NTLC facilitates the direct exchange of information among prosecutors, judges, and other criminal justice professionals in the field.

NTLC is a program of the National District Attorneys Association. NDAA's mission is to be the voice of America's prosecutors and to support their efforts to protect the rights and safety of the people.

For additional information, contact NDAA or NTLC, 1400 Crystal Drive, Suite 330, Arlington, Virginia 22202, (phone) 703-549-9222, (fax) 703-836-3195, or visit www.ndaa.org.



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Preface and Acknowledgments

First published in 2003, NTLC's *Crash Reconstruction Basics for Prosecutors* monograph has served as a primer for prosecutors on the basic science, investigative techniques, and questions to ask in cases involving traffic collisions. Authored by the nationally recognized expert on crash reconstruction, Professor John Kwasnoski, he dispelled much of the mystery, myth and mathematical phobias surrounding this material in the monograph. Never before was material like this assembled for prosecutors. For years, this monograph has been used by prosecutors to strengthen investigations, learn the truth, and honor their calling to serve justice.

In the twenty-plus years since its publication, however, significant technology developments necessitated this update to include information relating to, for example, vehicle forensics and infotainment systems as well as the legal challenges they present to prosecutors and law enforcement. This update will help prosecutors develop their knowledge to better handle vehicular crash cases.

The National Traffic Law Center, along with a committee of national subject matter experts, updated the *Crash Reconstruction Basics for Prosecutors* monograph in 2025. This guide was the result of a collaborative process that drew on the knowledge, expertise, and patience of the following dedicated traffic safety professionals:

Jack Arnold, Traffic Safety Resource Prosecutor, Tennessee District Attorneys General Conference, Nashville, TN

John Bauer, Assistant Prosecuting Attorney III, St. Charles County Prosecuting Attorney's Office, St. Charles, MO

Kinga Canike, Director, Traffic Safety Training Program, Prosecuting Attorneys Association of Michigan, and Traffic Safety Resource Prosecutor, Lansing, MI

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Tara Jenswold, Assistant Attorney General, Wisconsin Department of Justice, and Traffic Safety Resource Prosecutor, Madison, WI

Phil Smart, Sergeant, Montana Highway Patrol, Traffic Homicide Investigator, Missoula, MT

James Williams, Lt. Metro Nashville (TN) Police Department, Support Services—Traffic Section, Nashville, TN

Preface and Acknowledgments

Additionally, this updated publication features a range of illustrative images originally published in the training materials of the Northwestern University Center for Public Safety School of Professional Studies. These illustrations help clarify complex and technical concepts and their inclusion significantly enhances the clarity, accessibility, and educational value of the content. We gratefully acknowledge the generous permission granted by Adam Hyde, Director of Highway and Transportation Safety Programs to republish these visual materials. We extend our sincere thanks to the original creators and rights holders for their generosity and support.

Dedication

This monograph is dedicated to John Kwasnoski—not only a consummate professional and inspiring instructor, but also a trusted colleague and friend whose passion for truth touches everyone who knows him. John’s work has never been just about crash reconstruction; it has been about people, about justice, about honesty; ensuring truth speaks louder than doubt.

John’s influence reaches far beyond the technical mastery of crash analysis. Through his teaching, he has shaped generations of professionals, instilling in them a deeper understanding and appreciation of the profession and science of crash reconstruction. His classrooms are more than places of learning; they are forums for critical thinking, rigorous inquiry, and unwavering commitment to accuracy. Prosecutors, investigators, and fellow experts alike have benefited from his unique ability to translate complex principles into practical tools for the pursuit of justice.

May this work reflect the integrity, clarity, and dedication John has championed throughout his career.

For more information about John and the work he does, click [HERE](#) (Legal Sciences—The Science of Collisions).



Introduction

Crash reconstruction plays a critical role in helping prosecutors understand and present the dynamics of serious traffic incidents, especially those involving fatalities or criminal charges. As vehicles become more technologically advanced resulting in more available data for the crash reconstructionist, the ability to reconstruct a crash with precision has grown significantly. Prosecutors must be equipped not only to interpret the findings of reconstruction experts but also to integrate those findings into a compelling legal narrative. This requires a foundational understanding of the science behind crash analysis, the types of evidence available, and the legal implications of each phase of a collision.

According to the National Highway Traffic Safety Administration (NHTSA), an estimated 39,345 people died in traffic crashes in 2024, marking a 3.8% decrease from the 40,901 fatalities reported in 2023.¹ This decline represents the lowest fatality rate since 2019, at 1.20 deaths per 100 million vehicle miles traveled, despite Americans driving more miles overall.² While this trend is encouraging, the total number of traffic fatalities remains significantly higher than a decade ago, underscoring the continued importance of thorough crash investigations and effective prosecution. Prosecutors who understand the mechanics and evidentiary value of crash reconstruction are better positioned to pursue justice and contribute to broader traffic safety efforts.

¹ National Center for Statistics and Analysis. (2025, April). Early estimate of motor vehicle traffic fatalities in 2024 (Traffic Safety Facts Crash•Stats Brief Statistical Summary. Report No. DOT HS 813 710). National Highway Traffic Safety Administration.

² *Id.*

Understanding Fundamentals of a Crash

The National Highway Traffic Safety Administration (NHTSA) defines a motor vehicle traffic crash as an incident involving one or more motor vehicles in-transport originating on or had a harmful event (injury or damage) on a public trafficway, such as a road or highway. Crashes occurring on private property not regularly used by the public for transport, including some parts of parking lots and driveways, are excluded.³ Law enforcement officers routinely investigate traffic crashes as part of their daily responsibilities, and their findings are often subject to review by criminal prosecutors. Effective collaboration between law enforcement and prosecutors is critical to ensuring informed and just prosecutorial decisions. To support this process, prosecutors must possess a foundational understanding of crash dynamics to accurately interpret the evidence and contextual factors surrounding a collision.

Roles in Crash Investigation

A crash investigation is different than a crash reconstruction, but both are commonly confused.

Traffic Crash Investigator

The crash investigator is a trained and experienced professional with specialized skills in identifying, documenting, and analyzing evidence resulting from a collision. Their responsibilities span both on-scene and post-scene investigative tasks, including:

- Photographic Documentation—Capturing detailed images of the collision scene, involved vehicles, and relevant evidence.
- Scene Measurement and Mapping—Using manual or electronic tools to accurately document the physical layout and evidence at the scene.
- Vehicle Examination—Assessing vehicles for damage, mechanical defects, and other critical data points.
- Technical Analysis—Conducting specialized investigations involving Event Data Recorders (EDRs), tire and lamp examinations, and other technical components.
- Interviews—Gathering information through interviews with witnesses, involved parties, and relevant individuals such as medical professionals.
- Evidence Preservation and Recovery—Securing and collecting various forms of evidence, which may include biological samples, medical documentation, or digital records.

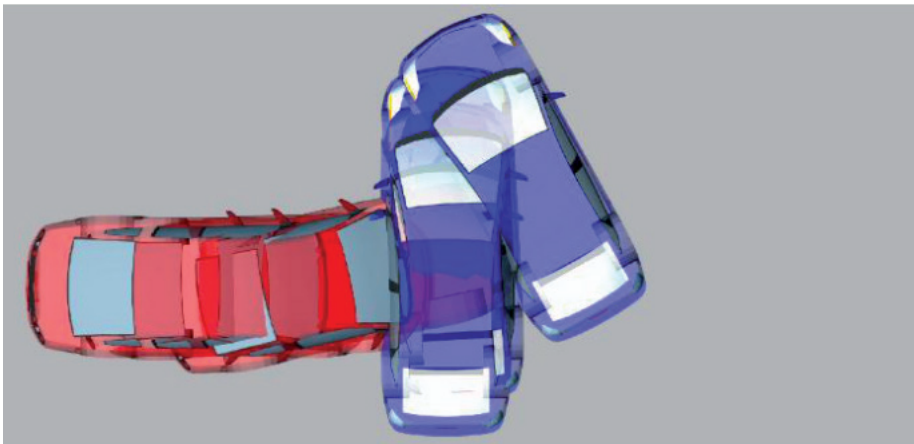
³ National Center for Statistics and Analysis. (2024, September). *Summary of motor vehicle traffic crashes: 2022 data* (Traffic Safety Facts. Report No. DOT HS 813 643). National Highway Traffic Safety Administration.

Traffic Crash Reconstructionist

A crash reconstructionist is a highly trained professional who builds upon foundational investigative skills with advanced expertise in collision analysis. This role goes beyond basic crash investigation by applying specialized methodologies to determine how a collision occurred and to provide expert interpretations and conclusions. The reconstructionist evaluates all aspects of the incident, including pre- and post-impact vehicle positioning, speed estimations, and contributing factors. In essence, the reconstructionist synthesizes available evidence and data to reconstruct the sequence of events leading to and following the crash.

Traffic Collision Phases

Although a traffic collision unfolds in a fraction of a second—typically between 90 and 150 milliseconds (0.09 to 0.15 seconds)—it consists of several distinct phases governed by the laws of physics. Despite the rapid progression, understanding each phase is essential. For prosecutors, even a basic familiarity with these stages enables them to guide witnesses and the trier of fact through the sequence of events with clarity and precision. The illustration below displays the key phases of a collision; a summary of the phases follows.

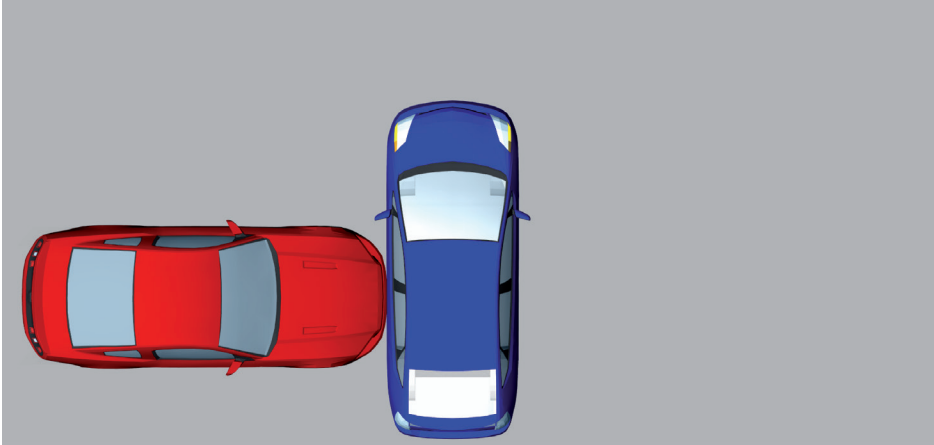


Pre-Impact Phase

This phase includes all events leading up to the initial contact between two vehicles. It may involve factors such as pre-impact skidding, loss of control, driver distraction, or driver impairment. A critical component of this phase is the driver's perception and response time to the developing emergency, which significantly influences the dynamics of the impending collision.

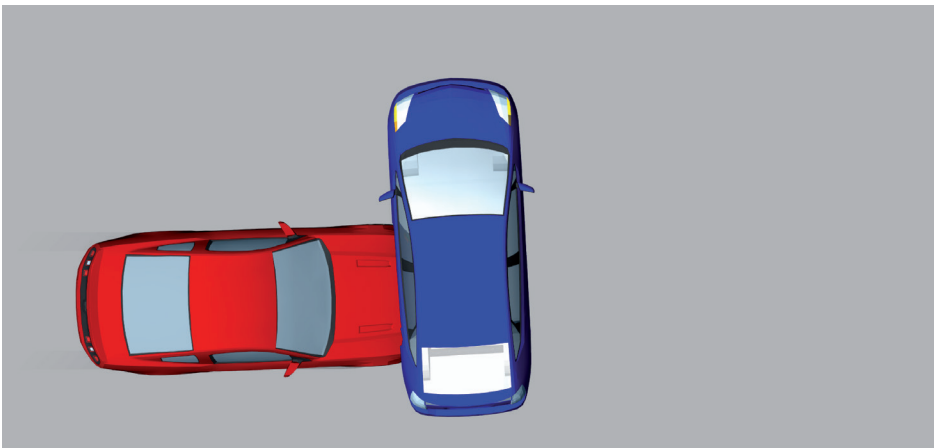
First Contact Phase

This phase marks the onset of a collision, defined by the initial moment when physical contact occurs between two objects and interaction forces begin to develop. In the context of impact analysis, this precise point corresponds to the vehicles' impact speeds.



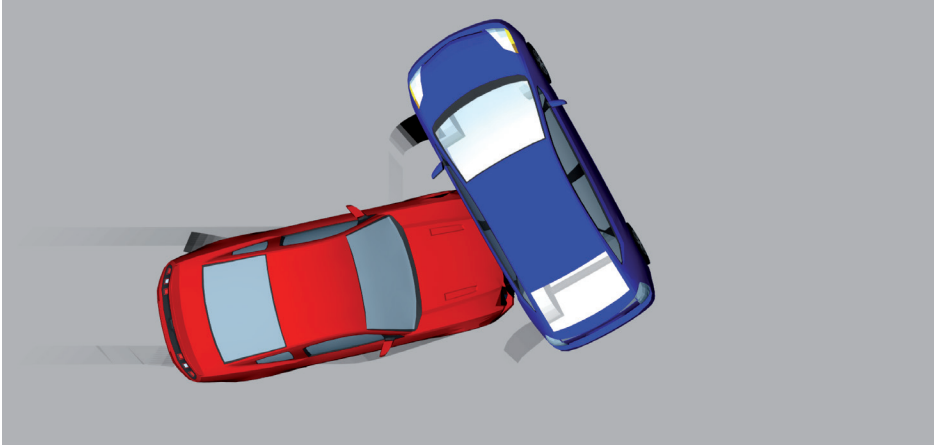
Maximum Engagement

This is the point during the collision when the forces between the two bodies reach their peak, typically resulting in the greatest extent of vehicle damage. This phase generally occurs rapidly after first contact—within 90–150 milliseconds (0.09 to 0.15 seconds).



Separation

This marks the moment when the forces between the colliding bodies dissipate, and the vehicles begin their post-impact trajectories. At this state, the vehicles may disengage and move independently, or they may remain interlocked and continue moving together away from the point of the collision.

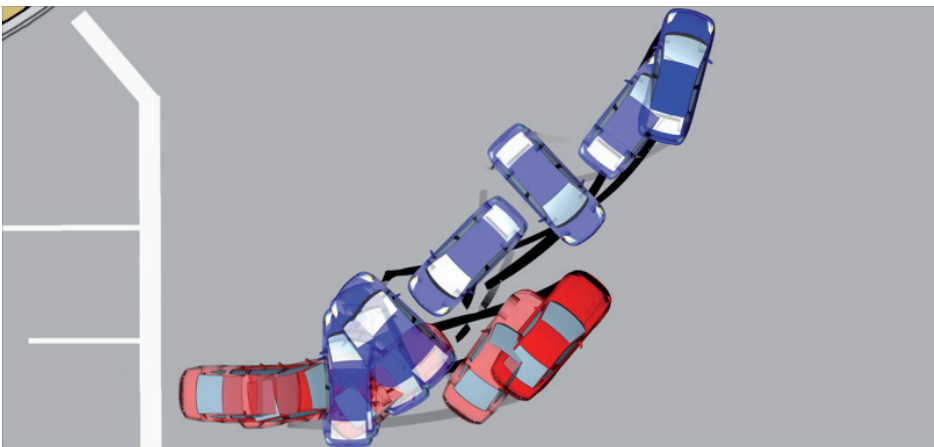


After Impact Movement

This phase encompasses all motion occurring after the primary collision forces have subsided. During this stage, vehicles or bodies may skid, rotate, roll over, or continue to move in a straight path until they reach a final resting position.

Final Rest

This refers to the point at which the vehicles or bodies come to a complete stop following the collision. It is important to note that this position is typically reached in an uncontrolled manner—without driver input—or, in some cases, under the driver's control as they attempt to manage the vehicle's movement post-impact.



Crash Reconstruction Analysis

A reconstruction analysis is conducted to determine the mechanics of a traffic collision, focusing on how the incident occurred rather than why. The reconstructionist—typically a professionally trained law enforcement officer—possesses advanced skills, training, and experience in evaluating collision events comprehensively.

Overview of Reconstruction Analysis

A thorough reconstruction includes a detailed review of:

- Roadway Evidence—Such as tire marks, scrapes, and gouges.
- Vehicle Damage and Deformation—Including crush analysis to assess impact severity and direction.
- Electronic Data—From sources like Event Data Recorders (EDRs), surveillance or dashcam footage.
- Witness and Participant Statements—Including those from vehicle occupants, bystanders, and relevant professionals.

These elements are analyzed using established methodologies such as momentum analysis, energy analysis, and velocity calculations to determine critical factors like vehicle speeds, pre-impact trajectories, and lane deviations. At its core, a reliable reconstruction is built upon a meticulous and well-documented crash investigation.

There are numerous analytical reconstruction methods, and the following sections of this monograph will provide an overview to the prosecutor for each procedure.

Step-By-Step Reconstruction Process

One of the most effective ways for a reconstructionist to mitigate bias and ensure analytical accuracy is by following a structured, systemic methodology. In the field of crash reconstruction, this systematic approach begins at the outset of the analysis and typically involves the following eleven steps:

- Scale Diagramming—Create to-scale drawings of each vehicle involved and the collision scene evidence, using precise measurements obtained from the scene.
- Damage Assessment—Analyze vehicle damage, focusing on deformation patterns commonly referred to as vehicle crush.
- Damage Classification—Distinguish between contact damage (direct impact) and induced damage (resulting deformation).
- Principal Direction of Force (PDOF)—Identify the direction of force applied during impact, typically represented by an arrow within the contact damage area, based on the movement of vehicle components.

- Rotation Analysis—Evaluate how each vehicle rotated during and after the collision.
- Maximum Engagement Placement —Position the vehicles at the point of maximum engagement during the collision.
- First Contact Placement—Reconstruct the initial point of contact between the vehicles.
- Separation Placement—Determine and illustrate how the vehicles separated following impact.
- Scene Correlation—Compare the reconstructed positions of the vehicles with physical evidence from the scene diagram, identifying indicators of first contact, maximum engagement, and separation.
- Evidence Alignment—Cross-reference collision and rotational evidence with the diagram, adjusting vehicle placements as needed for accuracy.
- Comprehensive Evidence Review—Ensure all physical evidence—such as tire marks, gouges, debris, and other roadway indicators—is accounted for and integrated into the analysis.

This structured procedure forms the foundation of a reliable reconstruction and is typically initiated at the very beginning of the analytical process.

Momentum-Based Analysis

A momentum analysis is one of the most widely used tools in crash reconstruction for estimating vehicle impact speeds. Momentum, defined as the product of an object's mass and velocity, represents the quantity of motion an object possesses. In physics, momentum is a conserved quantity—meaning the total momentum before a collision must equal the total momentum after—making it a powerful principle for analyzing vehicle dynamics during a crash.

This method is particularly effective in two types of collisions:

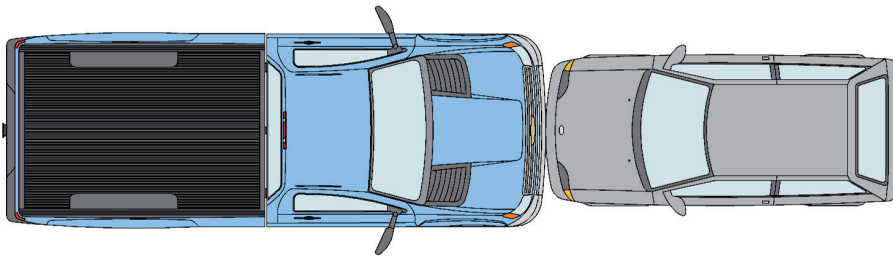
- Collinear Collisions—Where vehicles travel in the same or opposite directions and collide head-on or rear-end.
- Oblique Collisions—Where vehicles strike at an angle, such as in a T-bone or side-impact crash.

By applying momentum analysis, reconstructionists can determine key factors such as pre-impact speeds and directional changes, offering critical insights into how the collision unfolded.

Collinear Collision

Consider a scenario of a larger, eastbound blue truck striking a smaller, westbound silver car engaged in a head-on collision (see image below). If both vehicles are traveling at 30 mph at the moment of impact, the truck—due to its significantly greater mass—possesses more momentum. As a result, following the collision, both vehicles will move in the eastbound direction, driven by the truck's dominant momentum.

This scenario illustrates a collinear collision, where the centers of mass of both vehicles approach the area of impact along nearly the same straight line. The conservation of momentum principle explains the post-impact motion and highlights how mass and velocity interact to influence collision outcomes.

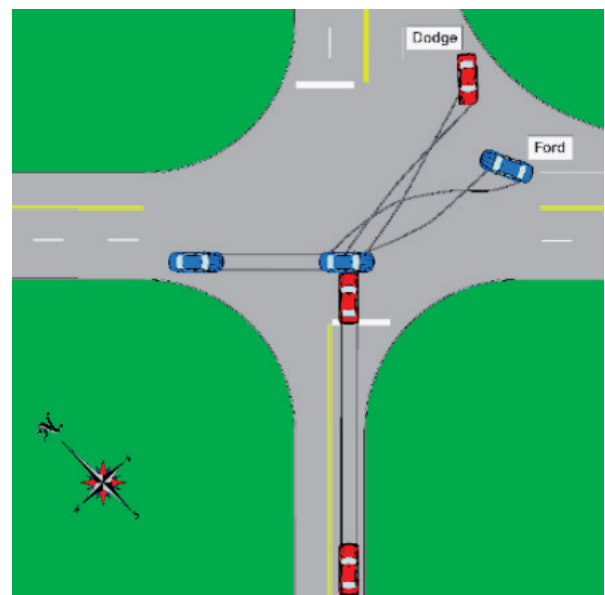


Oblique Collision

An oblique collision occurs when the velocity vectors of the vehicles' centers of mass approach the area of impact at an angle, rather than directly head-on or rear-end, relative to one another. A common example is a side-impact or T-bone crash. Although the angle of approach differs from a collinear collision, the same fundamental principle applies: the conservation of linear momentum. That is, the total momentum before the crash equals the total momentum after the crash.

In oblique collisions, the vehicle with greater momentum—due to higher speed, greater mass, or both—typically exerts more influence on the post-impact movement of both vehicles. For instance, if one car is traveling faster at the time of impact, its momentum will more strongly dictate the resulting trajectories. In the example below, the red car, moving slightly faster than the blue car, causes the combined post-impact motion to shift more in its original (northern) direction. This illustrates why, in oblique collisions, the final paths of the vehicles often align more closely with the momentum vector of the dominant vehicle.

Momentum analysis is a relatively straightforward method in collision reconstruction, provided the reconstructionist has sufficient information about the momentum involved. Momentum, defined as the product of an object's mass and its velocity, represents the quantity of motion. Understanding how momentum is distributed and conserved before and after a collision allows investigators to estimate vehicle speeds, directions, and interactions with a high degree of accuracy.



Managing Unknown Variables

In many collision investigations, the pre-impact speeds of the vehicles are unknown and become the primary objective of a momentum analysis. Like any analytical process, momentum analysis involves both known and unknown variables. Key variables include:

- Vehicle Weights—Including occupants and cargo.
- Pre-Impact Angles—The angles at which the vehicles approached the first contact with one another.
- Post-Impact Angles—The angles at which the vehicles departed the collision.
- Post-Impact Speeds—The speeds of the vehicles at the moment they separated after impact.

Vehicle weights are typically straightforward to determine, either by physically weighing the vehicles or referencing manufacturer specifications. Scene diagramming is used to establish approach and departure angles, as well as to assess the extent of vehicle damage. Post-impact speeds are estimated by analyzing the movement and rotation of the vehicles from the area of impact to their final rest positions. This involves evaluating tire marks, vehicle drag factors, and the distances traveled after the collision.

Once the reconstructionist identifies and quantifies the necessary variables, the subsequent calculations follow a systematic process using established mathematical formulas to determine the vehicles' impact speeds.

Drag Factors and Surface Interaction

One of the more time-intensive aspects of collision analysis involves establishing the roadway coefficient of friction, denoted by the Greek letter Mu (μ). This coefficient represents the resistance to motion between two surfaces in contact—such as a vehicle's tires on asphalt or a car's roof sliding across grass. In essence, it quantifies the "slipperiness" of the surfaces and is a critical factor in calculating vehicle deceleration during a crash. Crash reconstructionists source friction values from published research or determine the values through on-site testing using electronic measurement tools.⁴

Closely related to the coefficient of friction, the drag factor is a technical term used in crash reconstruction to describe the net decelerating force acting in the direction of motion, divided by the weight of the object. While the Drag Factor may equal the coefficient of friction under ideal conditions, it often varies due to real-world influences—such as grade changes (uphill or downhill movement), surface irregularities, or mechanical issues like brake failure.

Once established, the drag factor becomes a key variable in calculating a vehicle's acceleration or deceleration rate. This rate is determined by multiplying the drag factor by the acceleration due to gravity (approximately 32.2 ft/s²). Understanding and accurately determining the drag factor is essential for reconstructing vehicle dynamics and estimating speeds during a collision event.

⁴ Crash reconstructionists have moved away from the use of traditional drag sleds, once a common tool among investigators, since the 2006 publication of a Society of Automotive Engineers study finding the drag sleds unable to accurately replicate the behavior of a skidding tire under real-world conditions and lacked repeatability during the test. See Bartlett, Wade & Baxter, Albert & Livesay, Ed & Schmidt, Bruno & Stanard, Terry & Wright, William. (2006). Comparison of Drag-Sled and Skidding-Vehicle Drag Factors on Dry Roadways. 10.4271/2006-01-1398.

Change in Velocity (Δv)

Once the collision analysis is complete and impact speeds have been established, the next step involves calculating the change in velocity, commonly referred to as delta- v (Δv). This value represents the vector difference between a vehicle’s velocity at initial contact and its velocity at separation—essentially capturing the effect of the collision during the collision impulse phase.

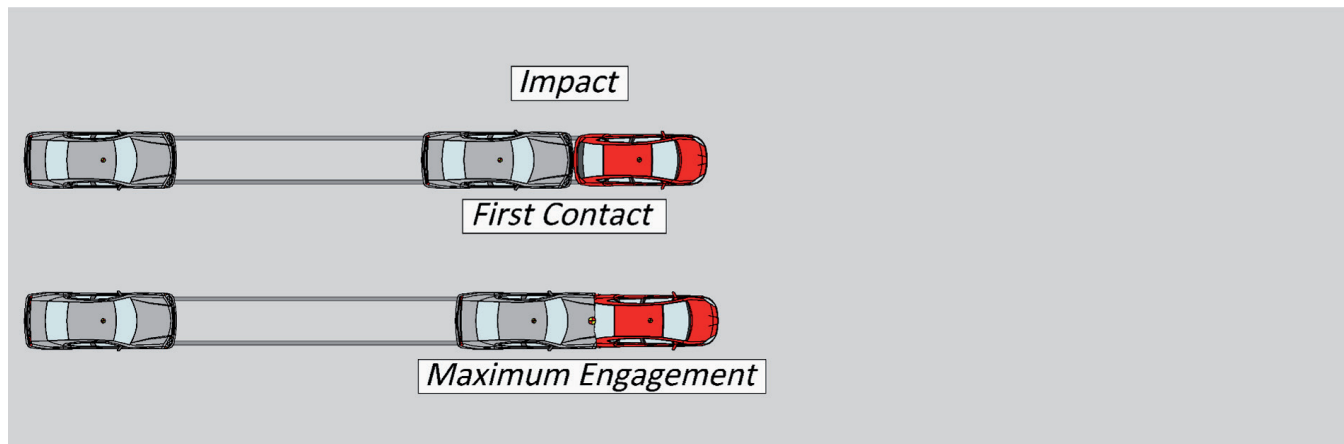
Delta- v is a critical metric in crash reconstruction, as it provides insight into the severity of the impact and the forces experienced by the occupants. It also serves as a valuable point of comparison with electronic data sources, such as Event Data Recorder (EDR) outputs, and can support injury analysis by correlating crash dynamics with potential trauma outcomes.

Collision Visualization and Sequence

The following demonstrates the collision impulse derived from a momentum analysis.

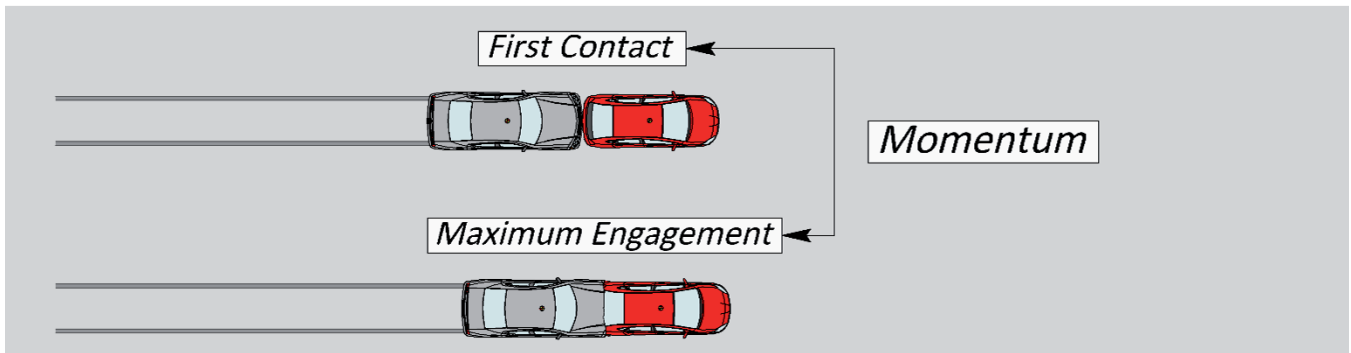
The images below are provided to help illustrate the collision scenario and clarify the sequence of events. In this example, the red vehicle is stationary on the roadway when it is rear-ended by the silver vehicle.

As previously discussed, the first phase of a collision sequence is pre-impact movement. Here, the silver vehicle enters a skid prior to impact, ultimately striking the rear of the red vehicle. The moment of first contact represents the impact speed. To fully understand the dynamics, an additional calculation would be required to estimate the silver vehicle’s pre-skid speed, accounting for the deceleration that occurred during the skid phase.

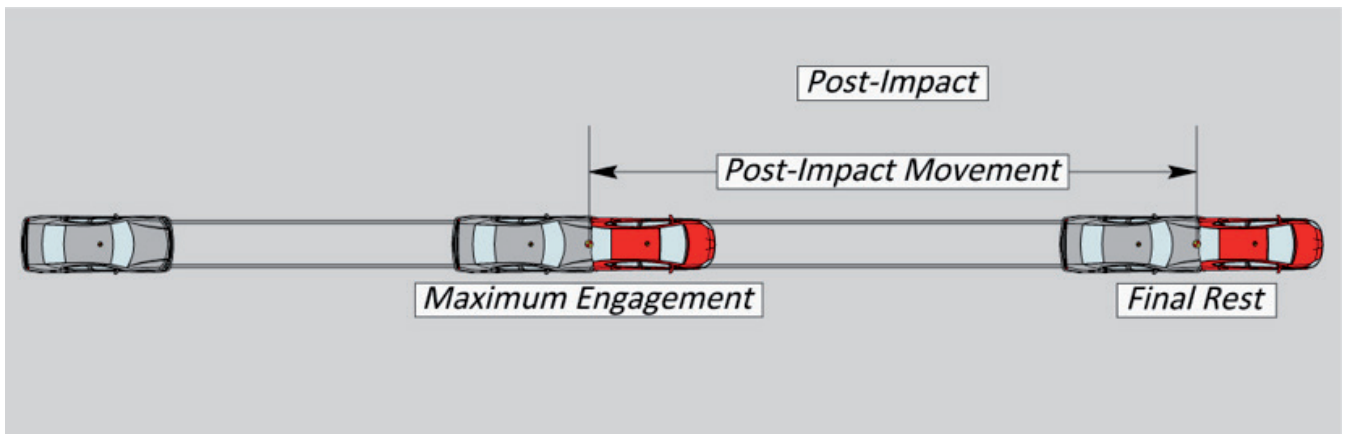


From First Contact to Maximum Engagement

The interval between first contact and the point of maximum engagement—when collision forces peak—occurs within a matter of milliseconds. During this brief but critical phase, momentum is rapidly transferred between the vehicles. In this example, the red car experiences acceleration while the silver car undergoes deceleration, reflecting the directional exchange of force and momentum during impact.

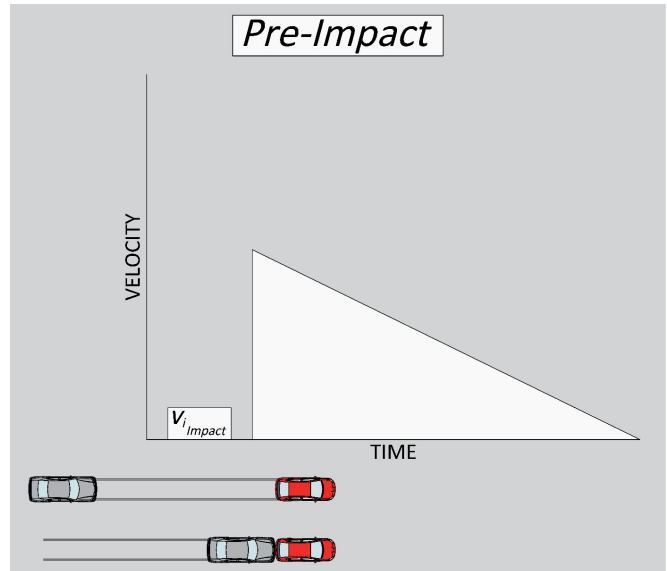
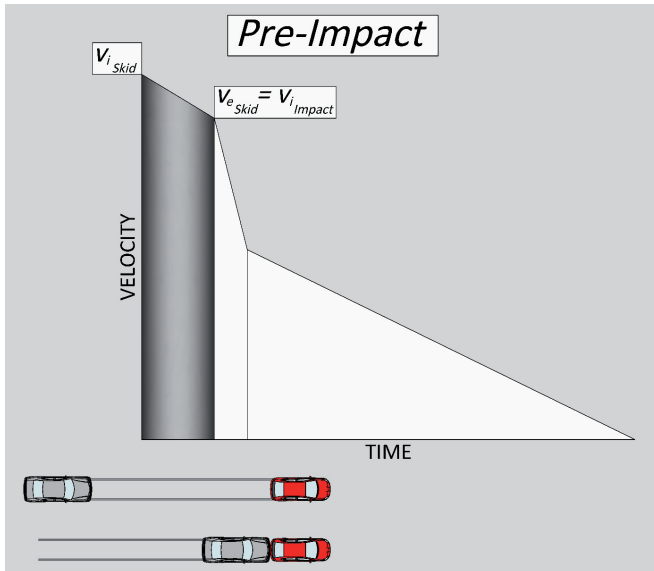


Following separation, both vehicles continue their post-impact trajectories until reaching their respective final rest positions.



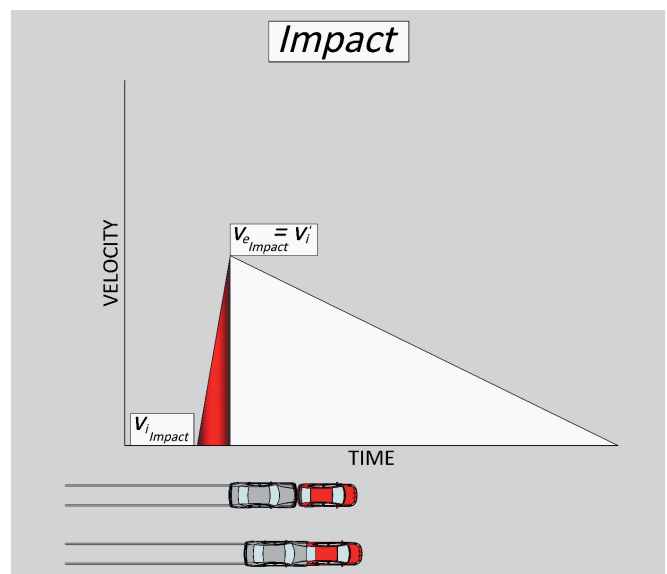
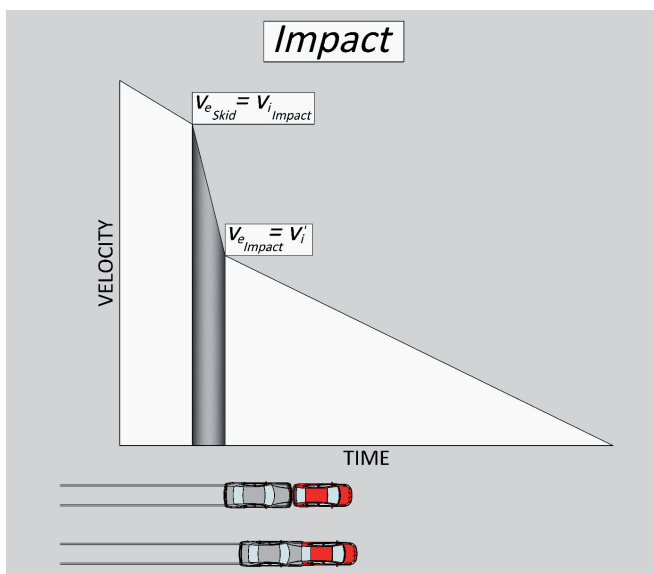
Graphical Representation of the Pre-Impact Phase

When examining the crash graphically, begin with the pre-impact phase. In this graph, the vertical axis (y-axis) represents vehicle speed, while the horizontal axis (x-axis) represents time. The silver car starts at a pre-skid speed and experiences a slight reduction in velocity as it begins to skid prior to impact. This deceleration is captured as a downward slope on the speed-time curve, reflecting the loss of speed during the pre-impact sequence.



Impact Phase (First Contact)

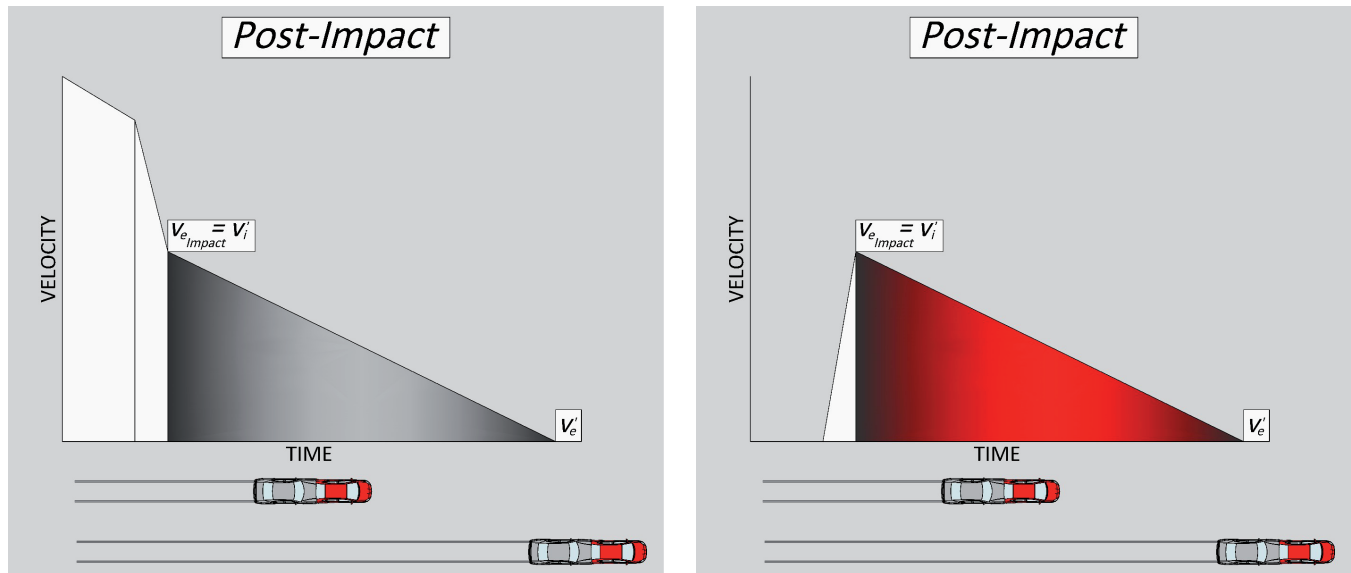
The impact phase begins at the moment of first contact between the vehicles. At this point, the silver car is traveling at its impact speed, while the red car is stationary, with a velocity of zero miles per hour. This velocity differential initiates the momentum transfer that defines the dynamics of the collision.



Delta- v and Separation Phase

In the delta- v portion of the graph, the silver car decelerates sharply due to momentum transfer, represented by a steep downward slope. Simultaneously, the red car accelerates from a standstill, shown as a steep upward slope. This exchange of momentum occurs over a very short time interval—measured in milliseconds—highlighting the rapid nature of the impact phase.

Following the collision, the separation phase begins. During this stage, both vehicles move away from the area of impact and continue their motion—either independently or together—until reaching their respective final rest positions.



Energy-Based Analysis

The second widely used methodology for determining vehicle impact speeds in a collision is the Conservation of Energy analysis. This technique serves as a valuable tool for crash reconstructionists, especially in cases where a momentum analysis is not feasible or when additional validation of findings is needed. In collision reconstruction, two primary forms of energy are considered: Kinetic Energy, which relates to the motion of the vehicles, and Potential Energy, which is associated with position or deformation—particularly the structural changes that occur during impact. By analyzing these energy transformations, reconstructionists can gain critical insights into the dynamics of the crash.

Energy is a conserved quantity, meaning it cannot be created or destroyed—only transformed from one form to another. In a collision, the energy present before impact is redistributed into various forms such as heat, sound, vehicle deformation, and post-impact motion. Despite these transformations, the total energy remains constant. If a reconstructionist can accurately account for all relevant energy components, this analysis can be used to reliably estimate vehicle speeds at the time of the crash.

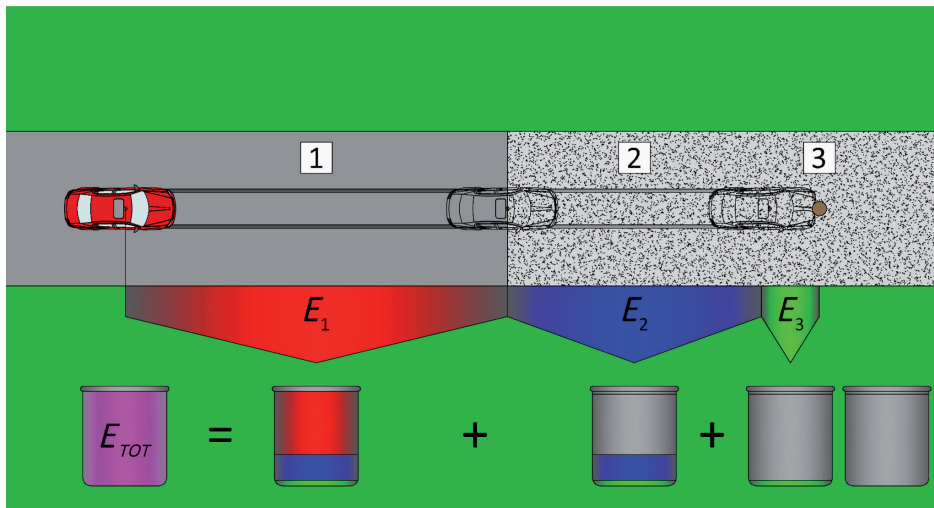
Using fundamental principles, a reconstructionist can estimate a vehicle's pre-incident speed by analyzing the energy transformations that occurred during its motion. This process requires key information such as the vehicle's weight, the drag factors of the surfaces it traveled over, and the distances involved. If the vehicle collides with an object, the energy dissipated through damage must also be considered.

Crash Reconstruction Analysis

For example, if a red car skids across asphalt, then gravel, and ultimately strikes a pole, three distinct energy components are analyzed:

- E_1 : Energy transformed due to slowing on asphalt
- E_2 : Energy transformed due to slowing on gravel
- E_3 : Energy dissipated through vehicle deformation upon impact with the pole

By summing these components, the total kinetic energy at the beginning of the event can be determined, which in turn allows for an estimate of the vehicle's speed at the start of the skid.



The second commonly used energy analysis method in crash reconstruction involves Potential Energy, specifically through crush analysis. This approach focuses on the energy absorbed by a vehicle as it deforms during impact. By examining the permanent damage and comparing it to known stiffness coefficients from crash-tested exemplar vehicles, a reconstructionist can estimate the energy dissipated during the collision. This energy estimate is often expressed as the Barrier Equivalent Velocity (BEV)—the speed at which the vehicle would need to strike a rigid barrier to produce equivalent damage.

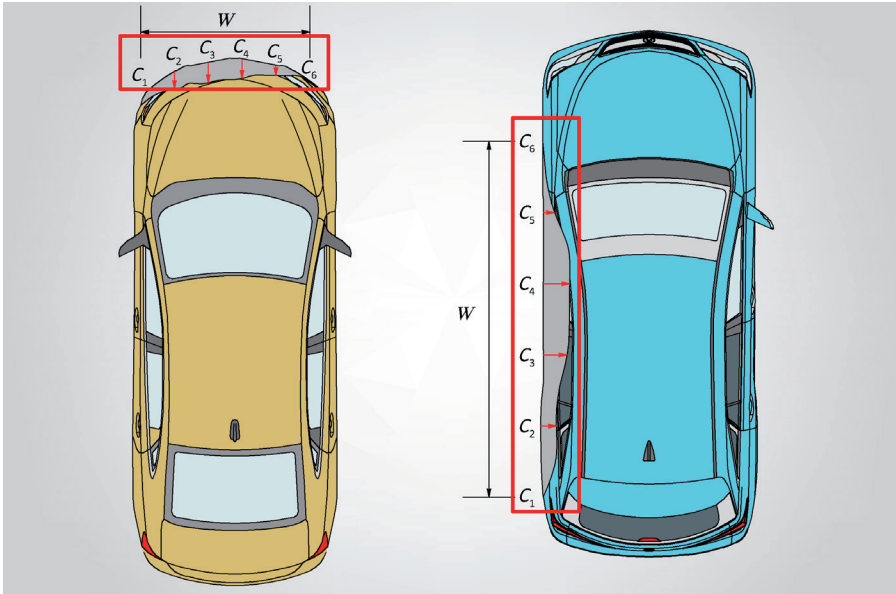
To estimate the energy dissipated through vehicle damage, a reconstructionist must know the stiffness coefficients of the vehicles involved. These coefficients vary depending on the location of impact—such as the front, rear, or sides—due to structural differences like engine components, crumple zones, and frame rails.

Investigators commonly reference crash test data published by the National Highway Traffic Safety Administration (NHTSA) to determine appropriate stiffness values. In these tests, a vehicle is driven into a rigid barrier at a known speed—typically around 35 mph—and the resulting permanent deformation is measured. As impact speed increases, so does the extent of deformation, following a predictable relationship described by Hooke's Law. From this relationship, stiffness coefficients are derived, representing how much force is required to produce a given amount of crush. These values can then be applied to real-world collisions to estimate the energy dissipated doing damage during the collision, which is essential for calculating the Barrier Equivalent Velocity (BEV) and, ultimately, the vehicle's speed at the time of the crash.

Crash Reconstruction Analysis

Once stiffness values are established, the reconstructionist collects precise damage measurements from the vehicle, known as “C-Measurements.” These measurements represent the depth of permanent crush at various points across the damaged area. By applying the stiffness coefficients to these values, the average force exerted during the collision can be calculated, along with the total energy dissipated.

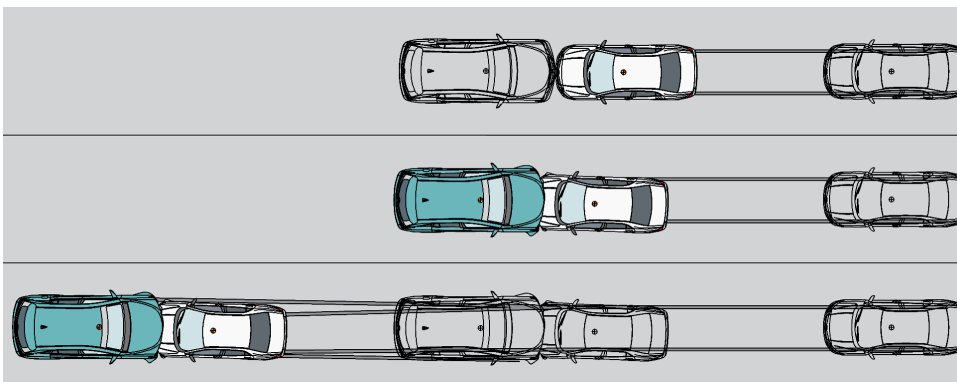
The figure below illustrates examples of front and side impacts, with C-Measurements marked to show how crush depth is recorded and analyzed.



With all key variables identified, a reconstructionist can determine impact speeds, changes in velocity (Δv), and apply additional analytical methods—such as Force Balance, or narrow-object impacts (e.g., utility poles or small trees). This energy-based approach can also be used to support or validate findings from a momentum analysis, and event data recorder information.

As previously discussed, if all energy components within the system are properly accounted for, the reconstructionist can use methodology to accurately estimate the impact speeds of the vehicles involved. The following example illustrates how an energy-based analysis is applied in practice.

A green SUV is stopped in traffic facing eastbound when it is struck head-on by a westbound white car. Before the collision, the white car skidded a short distance. After impact, the fronts of the green and white vehicles were damaged due to the collision, and the vehicles were moved westbound to their final rest location.

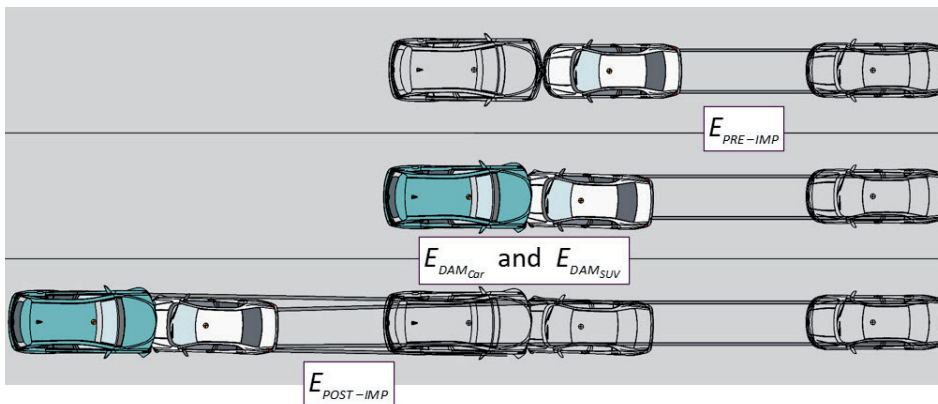


Crash Reconstruction Analysis

Previously, it was noted that a reconstructionist must account for all energy components involved in a collision to determine the total kinetic energy the white car had at the moment of impact or just before skidding. In this scenario, there are four distinct energy components:

- E_1 —Energy transformed as the white car skidded prior to impact.
- E_2 —Energy dissipated in damaging the front of the white car.
- E_3 —Energy dissipated in damaging the front of the green SUV.
- E_4 —Post-impact energy dissipated as both vehicles slid to their final resting positions.

By analyzing these components, a reconstructionist can accurately estimate the speed of the vehicles involved at various stages of the collision.



$$E_{Total} = E_{PRE-IMP} + E_{DAM_{Car}} + E_{DAM_{SUV}} + E_{POST-IMP}$$

One of the key strengths of energy analysis is that it functions as an independent method, providing a valuable point of comparison against momentum analysis or digital data sources.

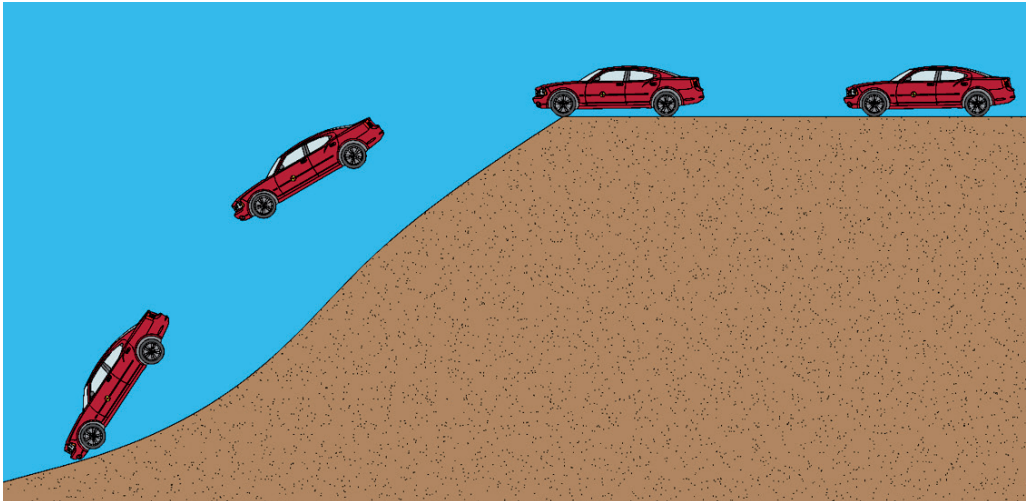
Special Velocity Situations

Certain types of collisions require specialized velocity analysis techniques. These include:

- Fall Situations—Estimating vehicle speed at the onset of a fall or airborne trajectory.
- Vaulting Situations—Analyzing cases where a vehicle becomes airborne due to vaulting over an object or terrain.
- Rollover Situations—Evaluating the dynamics of vehicles that roll or tumble during the incident.
- Yaw Situations—Determining critical velocity or sideslip conditions that lead to loss of control.

Fall Situation

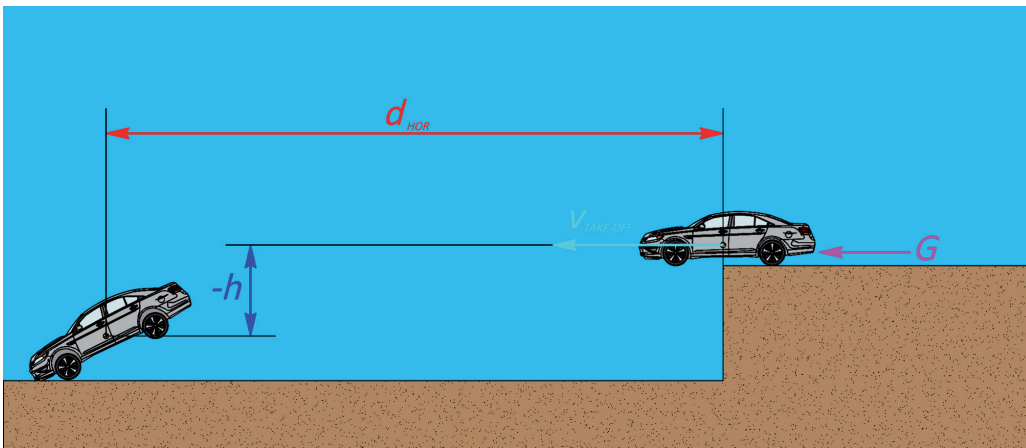
A fall occurs when a vehicle's tires lose contact with the supporting surface, causing it to travel through the air without support—commonly referred to as an “airborne” event. This typically happens when a vehicle departs from an elevated surface, such as a cliff or embankment, as illustrated in the image below.



In this scenario, the vehicle's motion can be broken down into two velocity components: horizontal and vertical. If the reconstructionist knows the vehicle's take-off angle, along with the horizontal and vertical distances traveled during the airborne phase, they can calculate the vehicle's speed at the moment it left the cliff.

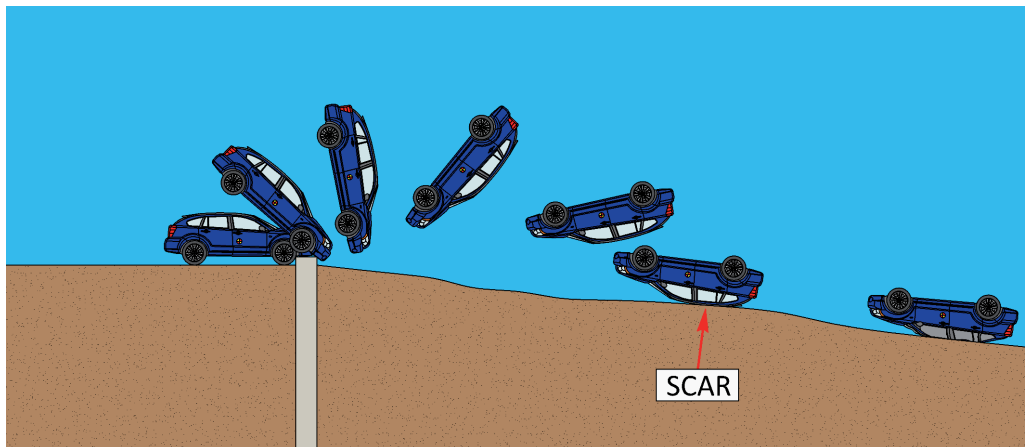
The image below illustrates these components:

- The red line represents the horizontal distance traveled.
- The blue line shows the vertical drop.
- The purple line indicates the grade or slope of the road at the take-off point.



Vault Situation

The second, less common scenario is a vault, which occurs when a vehicle's forward motion is suddenly obstructed below its center of mass. This causes the vehicle to rotate end-over-end, becoming airborne in a distinctive arc. The figure below illustrates a vaulting event, highlighting the vehicle's trajectory and the first touchdown point, where physical evidence—such as a ground scar—marks the initial impact.



Just like in a fall scenario, a vehicle's speed during a vault can be calculated using the same fundamental principles. If the reconstructionist has accurate measurements of the road grade and the horizontal and vertical distances the vehicle traveled—typically obtained from a scaled collision scene diagram—they can determine the vehicle's speed at takeoff.

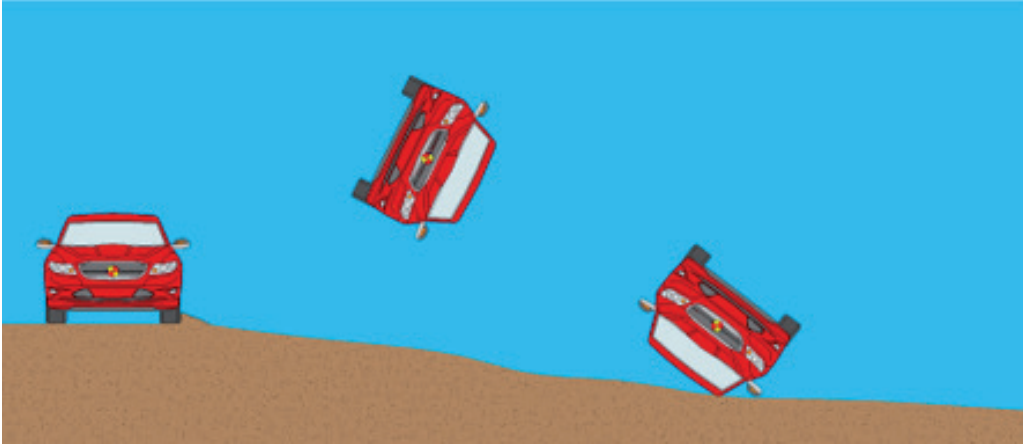
Rollover Situation

In a rollover event, a vehicle moving laterally is obstructed below its center of mass, causing it to trip and begin rolling. If the trip point—where the rollover initiates—and the first ground contact are known, a reconstructionist can calculate the vehicle's speed at the onset of the rollover. These events often follow sideslip or yaw conditions, which will be discussed in the next section.

Rollover dynamics typically unfold in three distinct phases:

- Pre-Trip Phase—The vehicle's movement leading up to the rollover.
- Trip Phase—The moment the vehicle leaves the ground and begins to roll.
- Roll Phase—The vehicle continues rolling until it comes to rest.

The image below shows the red car at its trip point, where it begins to furrow into the ground and enters the rollover phase.



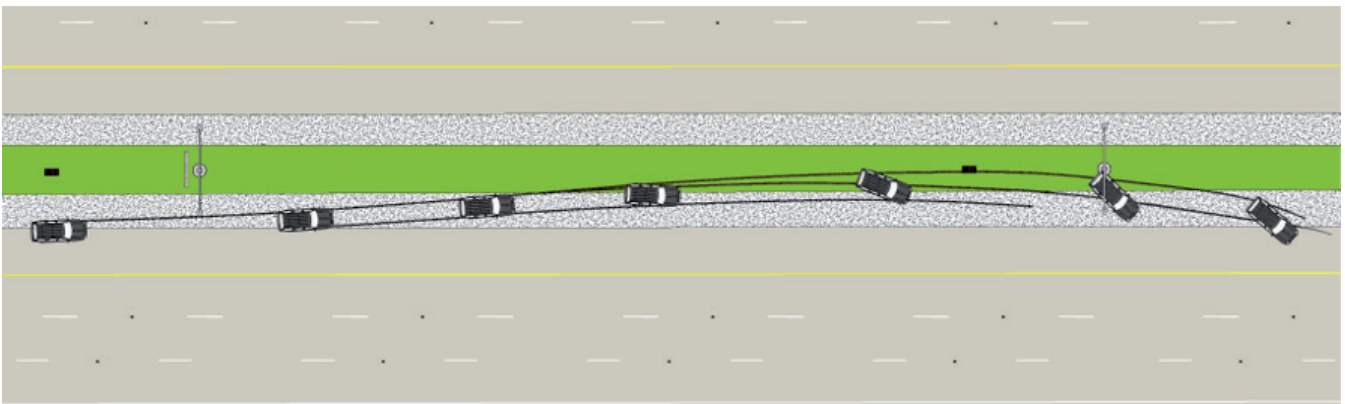
When a yaw precedes the rollover, the sequence of events may resemble the example shown below. In this case, the black car drifted off the left side of the roadway, prompting the driver to overcorrect to the right. This overcorrection caused the vehicle to rotate clockwise, re-enter the roadway, and then rotate again. As the vehicle furrowed into the pavement, it reached its trip point and began to roll over.

Critical Speed Yaws

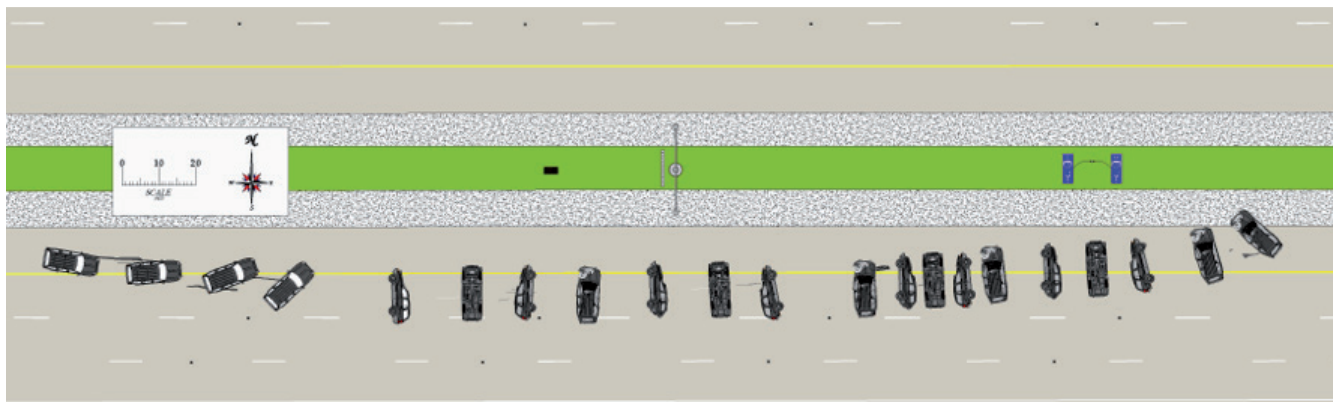
The final type of analysis is the critical velocity analysis, commonly referred to as a yaw analysis. This method is grounded in Newton's Laws of Motion and focuses on the relationship between a vehicle's speed and its ability to maintain a curved path without sliding.

On a level surface, the frictional force between the tires and the roadway provides the necessary centripetal force to keep the vehicle on its curved trajectory. However, when the required centripetal force exceeds the available friction, the vehicle begins to sideslip.

During a yaw event, the vehicle rotates, and a key indicator is that the rear tires begin to track outside the front tires, as illustrated in the image below. This behavior helps reconstructionists identify the onset of sideslip and calculate the critical velocity at which control was lost.



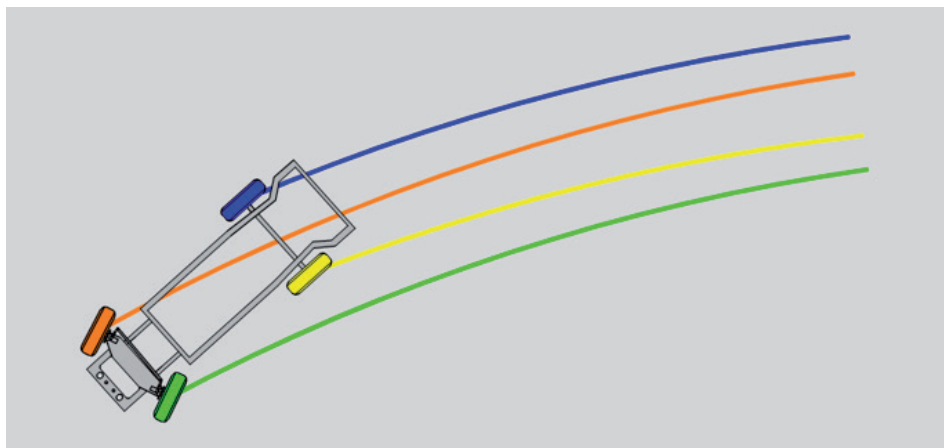
Crash Reconstruction Analysis



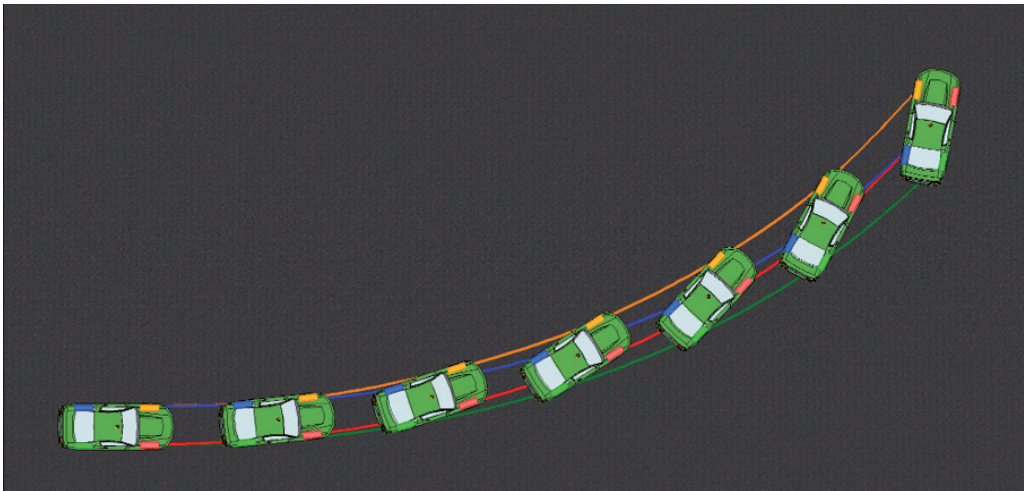
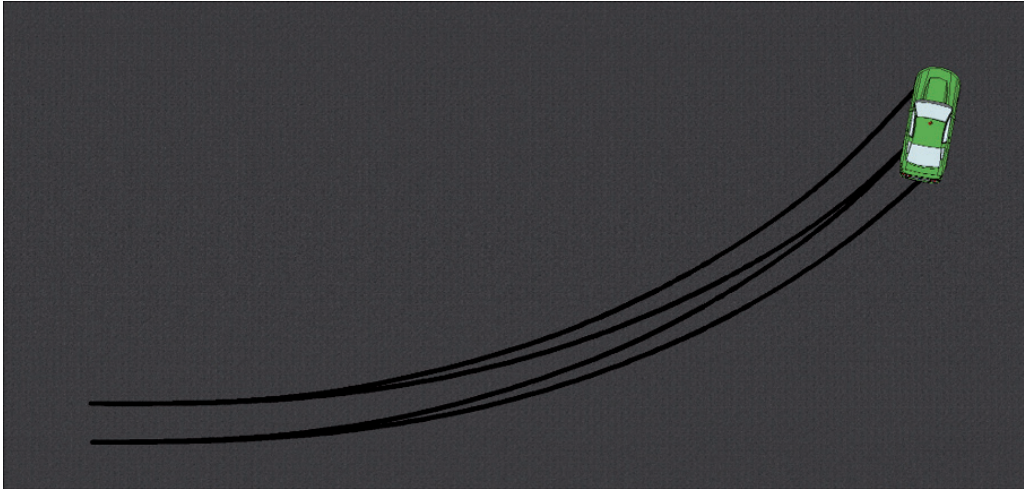
For an accurate critical velocity (yaw) analysis, the vehicle's center of mass must be tracked throughout the yaw event, the radius of curvature identified, and the critical speed calculated near the beginning of the yaw. These measurements are typically derived from physical evidence and scene diagrams.

The calculated speed can then be compared with the data from the Event Data Recorder (EDR) to validate or support the findings. It's important to note that this type of analysis should not be applied to post-collision rotation events, although this mistake is sometimes made. Critical velocity analysis is only valid when the yaw occurs prior to impact and reflects the vehicle's loss of directional control.

In the first image, the vehicle is sideslipping, with the rear wheels tracking outside the front wheels as the rear end swings outward—an indication of rotational motion and loss of directional stability.



The next image shows a green vehicle at rest following a yaw event, with visible roadway evidence left behind during its rotation. In the subsequent image, the corresponding tire marks have been highlighted in different colors to match the green vehicle's movement through the yaw, helping to visualize the path and orientation of each tire throughout the event.



Time-Distance Analysis Techniques

To complete a comprehensive reconstruction, the analysis should conclude with a time-distance analysis, which is often critical in legal proceedings. This method helps answer key questions—such as whether the collision would have occurred if a vehicle had been traveling at the posted speed limit—and illustrates the relative positions of vehicles, pedestrians, or other objects as they approached the area of impact.

Time-distance analysis enables the reconstructionist to map the movement of all involved parties—before, during, and after the collision—much like reviewing and rewinding a video of the event. When combined with Event Data Recorder (EDR) information, this analysis can be used to produce a detailed, time-synchronized diagram that visually supports the findings.

Crash Reconstruction Analysis

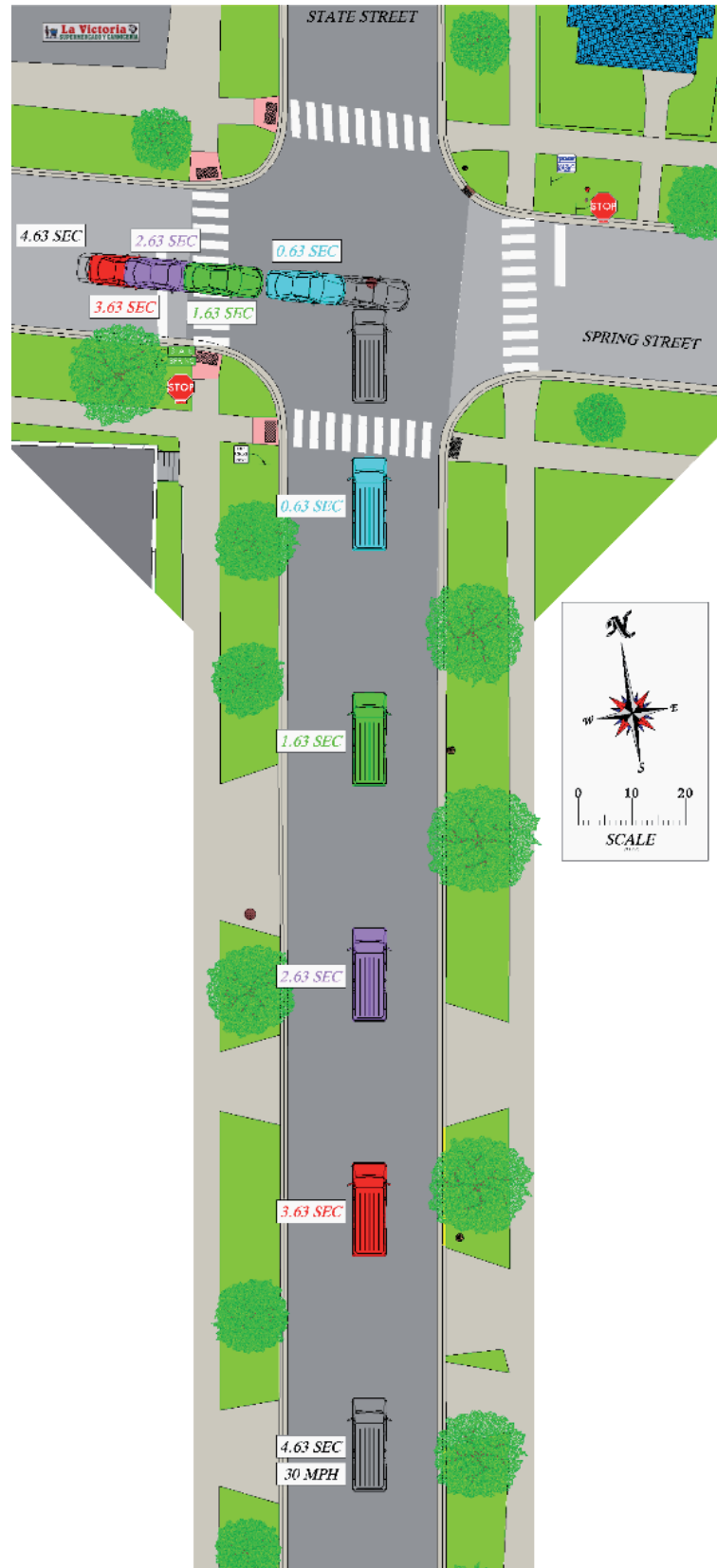
The time-distance analysis process involves a series of methodical steps that allow a reconstructionist to determine the timing and positioning of involved parties leading up to a collision. The typical steps include:

- Establish a reference point—Usually the area of impact, where both entities were present simultaneously.
- Identify the known entity—The object or person whose speed and movement are already established (independent variable).
- Identify the unknown entity—The object or person whose timing or position needs to be determined (dependent variable).
- Determine the starting point of the known entity—Based on physical evidence or data.
- Calculate the time it took the known entity to reach the reference point—Using speed and distance.
- Apply that time to the unknown entity—To determine its position or speed at the same moment.

The key link between the known and unknown entities in this analysis is time.

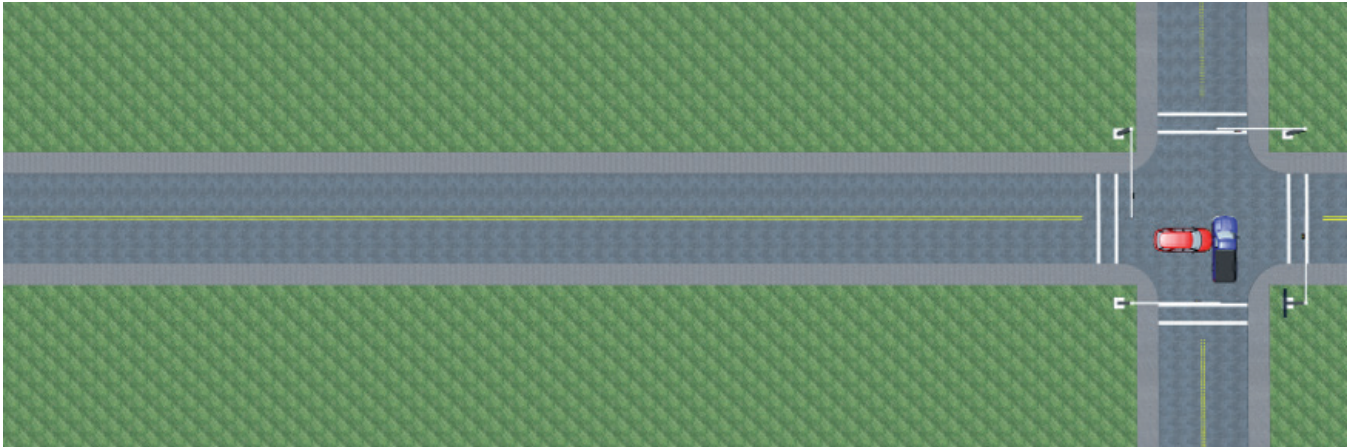
In the example shown at right, vehicles are color-coded at specific time intervals leading up to the collision. This visual representation illustrates how each vehicle approached the reference point (the impact location) as the incident unfolded. It serves as a powerful piece of demonstrative evidence, helping the trier of fact better understand the timing, positioning, and dynamics of the collision sequence.

A common application of time-distance analysis is to evaluate whether a collision could have been avoided—such as determining if the crash would still have occurred had a vehicle been traveling at the posted speed limit.

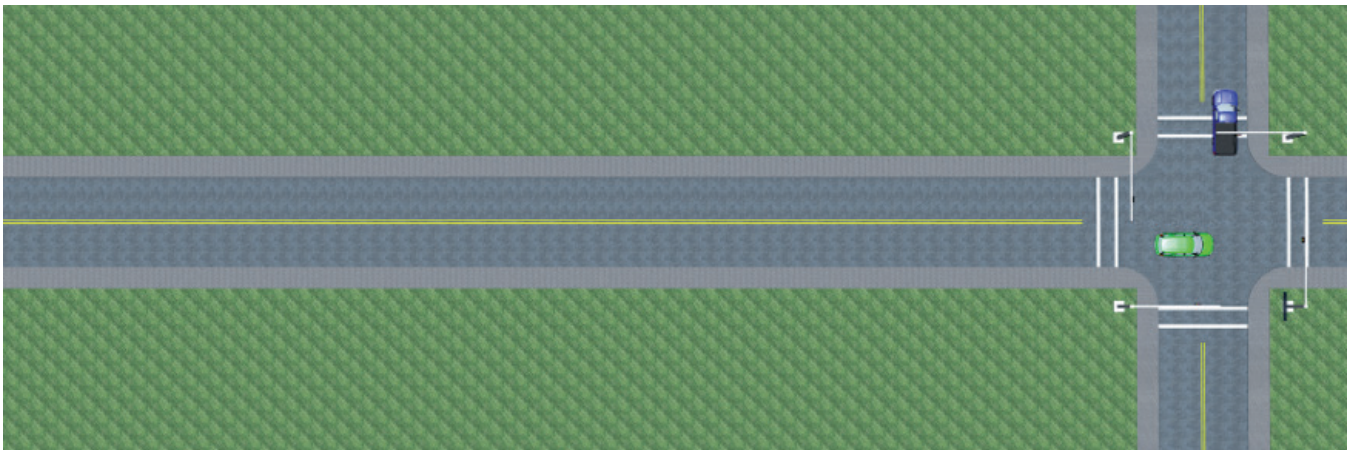


Crash Reconstruction Analysis

In the example below, a northbound blue pickup entered an intersection from a stop sign and was struck by an eastbound red car traveling 20 mph over the speed limit. After conducting a momentum analysis to determine the impact speeds, the investigation progressed to a time-distance analysis to assess the timing and positioning of both vehicles leading up to the collision. The time-distance analysis will ultimately answer the question, would the crash have occurred if the red car was driving at the posted speed limit?



Further analysis revealed that if the red car had been traveling at the posted speed limit, it would have arrived at the impact zone later, allowing the blue pickup more time to clear the intersection and avoid the collision.

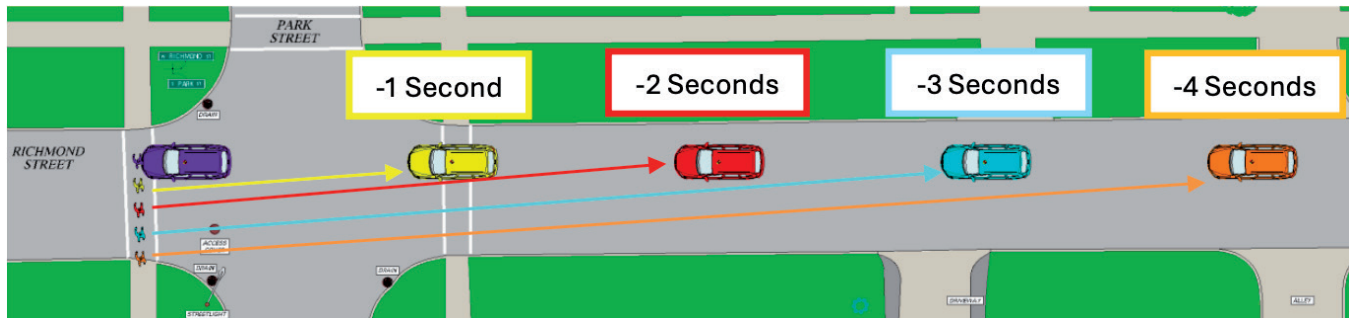


The image below illustrates this scenario: the green vehicle represents the red car's position at the moment it would have reached the impact point had it been traveling at the legal speed. The blue truck's position at that same moment shows it had already cleared the path of impact, indicating the crash could have been avoided under those conditions.

The same time-distance analysis principles apply to pedestrian-vehicle collisions. Starting from the area of impact, the positions of both the vehicle and the pedestrian are traced backward in time to reconstruct their movements leading up to the collision.

Crash Reconstruction Analysis

In the example below, the analysis determines the location of the vehicle at the moment the pedestrian entered the crosswalk. Each colored vehicle corresponds to a specific moment in time, matched to the pedestrian's position, beginning four seconds before impact. This visual timeline helps illustrate how the collision unfolded and whether it could have been avoided.



Perception Response Time (PRT) is a vital component in crash reconstruction, referring to the interval between a driver's initial recognition of a hazard and the onset of a physical reaction, such as braking or steering. This period involves a sequence of cognitive and motor processes—including hazard detection, decision-making, and response initiation—that collectively influence the driver's ability to avoid or mitigate a collision.

Crash reconstructionists draw on extensive research to estimate Perception Response Time (PRT) across various driving scenarios. The analysis typically begins by pinpointing the moment a hazard enters the driver's field of view—marking the onset of detection. Following this, the driver must interpret the hazard as a threat that demands immediate action. Each phase of this process—detection, recognition, and response—can vary significantly based on situational factors such as lighting, road conditions, and driver-specific characteristics like age, experience, and cognitive state.

Historically, a Perception Response Time (PRT) of approximately 1.5 seconds was widely accepted, based on early research. However, this generalized value should not be applied indiscriminately in crash reconstruction analyses. Contemporary studies have deepened the understanding of PRT by accounting for a range of environmental and human factors, including lighting conditions, visibility and contrast, sightline limitations, scene complexity, and driver-specific attributes. Given this variability, reconstructionists must base PRT estimates on contextually relevant research rather than relying on outdated or generic assumptions. Selecting appropriate PRT values is essential for accurately modeling the sequence of events leading to a collision and ensuring that conclusions are both scientifically valid and legally defensible.

Available Evidence in a Crash Case

When investigating a collision-related crime, it is crucial to look beyond the immediate crash scene. A comprehensive understanding often requires thinking creatively and exploring unconventional sources of evidence. This broader perspective can be key to building a strong, well-supported case. Additionally, in many jurisdictions, prosecutors have an ethical duty to disclose all relevant evidence to the defense, ensuring a fair and transparent legal process. Information in crash investigations generally comes from three sources: People, Vehicles, and Roads.

Evidence from People

Witnesses at the scene are among the most important sources of evidence in crash cases. Prosecutors often rely on lay witnesses—such as individuals involved in or who observed the crash—and law enforcement officers. While these are critical sources, they represent only part of the broader evidentiary picture. A more complete understanding of the incident can be gained by considering additional witnesses, including:

- Patrons and employees of establishments the suspect visited prior to the crash (e.g., restaurants, bars, gas stations, convenience stores).
- First responders, such as fire department personnel, EMTs, and ambulance staff, who may have observed the suspect's behavior or condition immediately after the crash.
- Assisting law enforcement officers from other agencies who may have relevant observations or interactions.
- Medical professionals, including doctors and nurses who treated victims or the suspect, and may provide insight into physical or behavioral indicators of impairment or injury.
- Family members of both victims and suspects, who may offer context regarding the suspect's condition, behavior, or activities leading up to the incident.

By broadening the scope of witness identification, prosecutors can develop a more comprehensive and credible narrative, strengthening the case and ensuring that all relevant perspectives are considered.

In crash cases, it is essential for prosecutors to recognize that critical evidence often exists beyond the immediate scene of the incident. A thorough investigation should consider the full timeline of events—both before and after the crash.

Pre-crash evidence can be especially valuable, particularly when charges involve alcohol or drug consumption. Locations the suspect visited prior to the incident—such as bars, restaurants, gas stations, and convenience stores—may offer key insights. Interviews with bartenders, servers, employees, and patrons can reveal the suspect's behavior, demeanor, and possible substance use. Many of these establishments also have video surveillance that can visually document the suspect's actions and interactions.

Receipts for food and drink purchases can help establish timelines and quantify consumption, potentially contradicting statements made by the suspect. This type of evidence not only strengthens the factual foundation of the case but also enhances credibility and helps prosecutors build a more complete and persuasive narrative.

Just as pre-crash evidence can help establish a suspect's behavior, post-crash investigations should extend to subsequent locations—particularly medical treatment facilities. Ambulance and emergency medical personnel are often the first responders to arrive, sometimes even before law enforcement. These individuals can provide valuable observations about the suspect's physical and mental condition immediately following the crash.

Medical reports and documentation from these responders are critical, as suspects may be more willing to speak candidly with medical personnel than with police. Statements made during treatment, along with behavioral indicators noted by EMTs, paramedics, and hospital staff, can offer important insights into impairment, injury severity, or other relevant factors. Prosecutors should prioritize obtaining these records and interviewing medical personnel to ensure a complete and accurate understanding of the incident.

Hospitals are a critical source of evidence in crash investigations. Medical records not only document the extent of victims' injuries but can also provide toxicology results and help verify—or challenge—claims made by the defendant at the scene. Suspects may be more focused on receiving treatment than on the legal implications of their statements, making medical personnel key witnesses and their documentation highly valuable.

It is important to note that the admissibility of medical records and statements varies by jurisdiction. Prosecutors must ensure that the process used to obtain and introduce these records complies with all applicable legal standards, including privacy laws and evidentiary rules.⁵

In cases involving fatalities, establishing causation is essential. Autopsy reports or coroner's findings are often required to confirm that the crash directly caused the victim's death. Additionally, understanding the victim's medical history is important, as jurisdictions differ in how they treat pre-existing conditions—some applying a “take your victim as you find them” standard, which can eliminate certain defenses.

As a best practice, prosecutors should speak directly with the medical professional who conducted the autopsy to ensure consistency between the report and any anticipated testimony. This step helps avoid surprises in court and strengthens the reliability of the evidence presented.

Evidence from the Roadway

In a detailed crash reconstruction, physical evidence on the roadway serves as a crucial foundation for understanding how the incident unfolded. Skid marks can reveal when and where a driver attempted to brake, helping to estimate vehicle speed and may be used in a time-distance analysis related to a driver's reaction time. Yaw marks—curved tire marks—may indicate a vehicle was rotating or sliding sideways, often pointing to loss of control. Gouge marks, typically found in the pavement, are indications of the area of maximum engagement of the collision, and can help determine the relative positions of vehicles during the collision event. Scratches and scrapes on the road surface can show the path of a vehicle post-impact,

⁵ For additional information, see *Hospitals, HIPAA, and Impaired Driving Cases—A Guide for Law Enforcement and Prosecutors* (2024) available at www.ndaa.org/news/hospitals-hipaa-and-impaired-driving-cases.

especially if it rolled or was dragged. Debris patterns, including shattered glass, broken plastic, or metal fragments, help map out the direction of the crash, while fluid spills like oil or coolant can trace vehicle movement after the collision, and all assist an investigator during the reconstruction to determine the area of first contact between the vehicles. Investigators also look for tire impressions in soft surfaces like grass or dirt near the roadway, which can provide additional clues about evasive maneuvers or off-road travel. Together, these elements form a physical narrative that, when combined with witness statements and digital evidence, allows for a comprehensive reconstruction of the crash.

Skid Marks

Skid marks are a vital form of physical evidence in crash reconstruction, as they offer key insights into a vehicle's speed, direction, and driver behavior prior to impact. By analyzing the length, shape, and location of skid marks, investigators can estimate how fast a vehicle was traveling when the brakes were applied and determine whether the driver attempted to avoid a collision. The presence of straight, curved, or overlapping skid marks can also help identify the type of maneuver performed—such as sudden braking, swerving, or loss of control—making them essential for reconstructing the sequence of events leading up to a crash.

Yaw Marks

Yaw marks are curved tire marks left on the roadway when a vehicle rotates while moving. Yaw marks may be evidence of loss of traction, or they may be from a collision-induced rotation of the vehicle. These marks are highly relevant in crash reconstruction because they can indicate that a vehicle was rotating or in a state of uncontrolled motion before impact. By analyzing the curvature, length, and direction of yaw marks, investigators can determine the vehicle's speed and path. They may assist an investigator with determining the vehicle's movement and its possible pre-collision maneuvers. This information helps reconstruct the dynamics of the crash and assess contributing factors such as driver input, road conditions, and vehicle stability.

Gouge Marks

Gouge marks are deep scrapes or indentations in the roadway surface caused by the impact of vehicle components—such as suspension parts, wheels, or undercarriage—during a collision. These marks are especially valuable in crash reconstruction because they provide the investigator with evidence of the area of maximum engagement, or the area where the collision forces between the vehicles was the greatest. This information then helps investigators determine the area of impact and the relative positions of vehicles at that moment. The depth, direction, and location of gouge marks can also provide clues about the force of the crash and the movement of vehicles after impact, making them a critical piece of physical evidence in accurately reconstructing the event.

Scratches and Scrapes

Scratches and scrapes on the roadway are subtle yet significant forms of physical evidence in crash reconstruction. These marks are typically caused by vehicle components—such as bumpers, undercarriages, or metal edges—dragging across the pavement during or after a collision. Their direction, length, and location can help investigators trace the path of a vehicle post-impact, indicating how it moved after the collision to its final rest spot. Scrapes can provide a clearer understanding of how the crash occurred.

Debris Pattern

Debris patterns are a key element in crash reconstruction, offering valuable clues about the severity, direction, and dynamics of a collision. These patterns typically include broken glass, vehicle parts, paint chips, and personal items scattered across the roadway. By analyzing the distribution and spread of debris, it may aid an investigator with determining the area of impact and the movement of vehicles after the crash. The location and type of debris can also help identify which vehicle sustained more damage and whether any secondary impacts occurred, making debris analysis an essential part of reconstructing the crash scene accurately.

Fluid Spills

Fluid spills—such as oil, coolant, brake fluid, or transmission fluid—are important indicators in crash reconstruction, as they can help trace the movement and final resting positions of vehicles involved in a collision. These spills often occur when a vehicle’s mechanical systems are damaged upon impact, leaving behind distinctive trails or pools on the roadway. Investigators analyze the location, shape, and direction of fluid stains to determine how far a vehicle traveled after the crash, and where the impact likely occurred. Fluid evidence, when combined with other physical markers, contributes to a more complete and accurate reconstruction of the incident.

Tire Impressions in Soft Surfaces

Tire impressions in soft surfaces—such as grass, dirt, or gravel—are valuable clues in crash reconstruction, especially when vehicles leave the paved roadway. These impressions can reveal the path a vehicle took before, during, or after a collision, helping investigators determine steering input, speed, and whether evasive maneuvers were attempted. The characteristics can also indicate acceleration, braking, or loss of control. When combined with other physical evidence, tire impressions in soft terrain contribute to a more complete understanding of vehicle dynamics and the sequence of events leading up to the crash.

Evidence from Vehicles

After a crash, the interior of a vehicle can offer critical clues about whether the driver was impaired at the time of the incident. Investigators often look for physical evidence that suggests alcohol or drug use, such as open containers of alcohol, drug paraphernalia, or prescription medications not stored properly. The presence of these items—especially if they are within reach of the driver—can support a theory of impairment and may prompt further toxicological testing. Additionally, the odor of alcohol or cannabis, observed by first responders or documented in police reports, can be a significant indicator.

Other signs may be more subtle but equally telling. For example, investigators may find spilled drinks, partially consumed substances, or items that suggest recent use, such as an open, cold, and half-empty can of beer or a recently lit joint. The condition of the vehicle can also provide context—burn marks, residue, or even erratic placement of personal items may point to distracted or impaired behavior. Combined with behavioral observations, field sobriety tests, and toxicology results, this in-vehicle evidence helps prosecutors build a comprehensive picture of the driver’s state of mind and physical condition leading up to the crash.

Vehicles often serve as a rich source of other evidence in crash investigations. As the physical link between the driver and the roadway, the vehicle must be examined methodically and thoroughly. The information obtained from a vehicle typically falls into four key categories: identification, description, condition before the crash, and condition after the crash.

While post-crash condition often receives the most attention, each category plays a vital role in understanding the full context of the incident. Identification confirms ownership and connection to the suspect; description provides details such as make, model, and modifications; pre-crash condition can reveal mechanical issues or maintenance history; and post-crash condition helps reconstruct the dynamics of the collision. A comprehensive evaluation of all four areas is essential to building a complete and accurate case.

Identification

Even seemingly straightforward, factual data must be recorded with precision. Properly identifying the vehicle involved in a crash is essential. This includes documenting the make, model, and, most importantly, the Vehicle Identification Number (VIN). These details are critical when referencing published specifications such as curb weight, crashworthiness, or stiffness coefficients.

The VIN is more than just a unique identifier—it encodes valuable information about the vehicle, including its country of origin, manufacturing plant, trim level, and production sequence. Decoding the VIN can reveal specifications that may be highly relevant to the investigation. The National Highway Traffic Safety Administration (NHTSA) website provides a free VIN decoder tool.

A simple but important question to ask the investigator is: “Are we certain this is the vehicle involved in the crash?” Confirming this early ensures that all subsequent analysis is based on accurate and verified information.

Description

Describing a vehicle goes beyond basic identification and often includes optional configurations that can significantly affect crash dynamics. While the make, model, and Vehicle Identification Number (VIN) provide foundational information, they do not always capture key features that may be relevant to an investigation.

For example, Anti-Lock Braking Systems (ABS) were not standard on all vehicles historically and may not be reflected in the VIN. Similarly, upgrades such as dual rear wheels (DRW) on a pickup truck—achieved by modifying hubs, springs, and the truck bed—can dramatically alter the vehicle’s handling and performance. Simply identifying a vehicle as a “2021 Chevy Silverado” is insufficient. It is critical to specify whether it is, for instance, a Silverado K3500 Crew Cab with an 8-foot bed and DRW, versus a single-cab C1500. (In GM nomenclature, “C” denotes rear-wheel drive, while “K” indicates four-wheel drive.)

Because not all of this information is encoded in the VIN, a thorough visual inspection and documentation of the vehicle’s configuration are essential. These details can influence everything from braking distance to crash energy distribution and must be accurately captured for a complete and credible reconstruction.

Many aspects of a vehicle’s design fall under the category of “Description” and are critical to understanding how the vehicle functions—or fails to function—in a crash scenario. Prosecutors and investigators should be familiar with these design systems to accurately interpret vehicle behavior.

While lights and tires are commonly evaluated, numerous other specifications can influence crash dynamics. For example:

- Horsepower and acceleration affect how quickly a vehicle can move or respond.
- Steering ratios and wheelbase determine maneuverability and turning radius.

Available Evidence in a Crash Case

- Ground clearance and center of mass height influence a vehicle's stability and its likelihood of rolling over, especially in off-road or evasive situations.
- Driver visibility can be impacted by structural features such as pillar thickness, window size, and overall vehicle height.

Understanding these design elements helps paint a clearer picture of what the vehicle was capable of doing—and what limitations may have contributed to the crash. These factors should be documented and considered alongside other evidence to support a thorough and credible reconstruction.

A vehicle's safety features are an important part of its overall description and can significantly influence both crash dynamics and legal outcomes. While modern vehicles typically include seatbelts, airbags, tire-pressure monitoring systems, backup cameras, and electronic stability control (often integrated with anti-lock braking systems), many serious crashes still involve older vehicles that may lack some or all of these features. It is essential for both investigators and prosecutors to identify which systems are present and whether they were functional at the time of the crash.

In addition to built-in safety features, aftermarket modifications—commonly referred to as “bolt-on” additions—should not be overlooked. Items such as pickup toppers, custom bumpers, roof racks, oversized tires, and slide-in campers can alter a vehicle's handling, visibility, and crash behavior. These modifications should be documented thoroughly, as they may affect the vehicle's performance and contribute to the circumstances of the crash.

Investigators should be encouraged to consider how a vehicle's configuration may influence its handling and performance. For example, asking a question such as, “So, the defendant was driving a large truck with oversized tires and a slide-in camper—does that handle like a standard vehicle?” can help frame the significance of vehicle modifications in understanding driver control and crash causation. These types of inquiries prompt a deeper evaluation of how non-standard features may have contributed to the incident and ensure that vehicle description is not treated as a mere formality, but as a meaningful component of the investigation.

Condition Before

Determining a vehicle's pre-crash condition can be challenging, but it remains a vital part of a thorough investigation. In some cases, investigators may locate recent photographs from unrelated investigations, dealership records, or even casual images posted by the vehicle's owner—such as social media posts or online listings. These sources can provide valuable insight into the vehicle's appearance and condition prior to the incident.

When such documentation is unavailable, investigators often turn to physical indicators like rust and dust. A detailed inspection at the crash scene may reveal areas of the vehicle that are unusually clean—suggesting recent contact—or exposed metal that has not yet developed rust, indicating fresh damage. These subtle clues can help establish the timing and nature of the damage.

Timeliness is critical. Ideally, the vehicle should be examined before it is moved or towed, especially if it will be transported along dusty roads or through conditions that could obscure or alter key evidence. Early and accurate documentation of the vehicle's condition helps ensure that the facts of the case are preserved and properly interpreted.

When evaluating a vehicle's internal systems, one of the few reliable indicators of pre-crash condition may be Diagnostic Trouble Codes (DTC) stored in the vehicle's electronic systems. These codes are often accessible through imaging the Event Data Recorder (EDR), or from a mechanical scan of the vehicle systems, which can provide insight into system status and potential malfunctions leading up to the crash.

Operational settings should also be carefully considered. For example, determining whether windshield wipers were activated at the time of the crash can help assess visibility conditions. Similarly, systems such as four-wheel drive may not be electronically recorded and must be manually inspected. This is especially important before the vehicle is moved or altered by a tow company, which may change settings during recovery.

Timely and thorough documentation of these internal and operational systems is essential to preserving accurate evidence and understanding the vehicle's behavior during the incident.

Another valuable, though less commonly used, investigative tool is the execution of a search warrant to obtain vehicle maintenance records, tire replacement receipts, or other documentation that may help establish the vehicle's condition prior to the crash. These records can also demonstrate whether the driver was—or reasonably should have been—aware of any mechanical defects or safety issues.

CARFAX, for example, collaborates with many law enforcement agencies and can provide information about service establishments that have worked on the vehicle. This can be a useful starting point for identifying potential sources of maintenance history. Also, the National Insurance Crime Bureau (NICB) provides prior vehicle incident involvement, which may assist during an investigation. Such data includes prior crashes, theft, and salvage details.

Investigators should be prompted with questions such as: "Did you inspect the vehicle's functional equipment?" and "Did everything appear to be in good repair prior to the crash?" These inquiries help ensure that mechanical condition is not overlooked and that any contributing factors related to vehicle maintenance are properly documented and considered.

Condition After

The post-collision condition of a vehicle often serves as emotionally impactful evidence that is easily understood by laypersons. Photographs capturing extensive vehicle damage and debris scattered across the crash scene can powerfully convey the severity of the incident—without the need for technical data or mathematical analysis. This visual evidence helps jurors and other observers grasp the real-world consequences of the crash, making it a valuable tool in both investigation and prosecution.

Contact Damage

The post-collision condition of a vehicle encompasses a wide range of elements, but one of the most critical for investigators is Contact Damage. As the name suggests, contact damage refers to the specific areas where physical contact occurred during the collision—whether between two vehicles, a vehicle and a fixed object, or a vehicle and a pedestrian.

This type of damage provides essential clues about the dynamics of the crash, including impact angles, force distribution, and points of initial contact. Proper documentation and analysis of contact damage are vital for accurate crash reconstruction and can significantly influence both investigative findings and prosecutorial decisions.

Available Evidence in a Crash Case

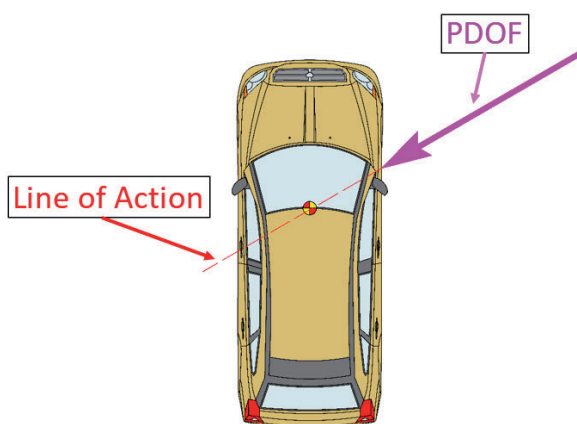
Contact damage plays a crucial role in identifying the vehicles involved in a collision and understanding how they interacted. According to Locard's Exchange Principle, every interaction between objects leaves trace evidence on both. This concept is especially relevant in crash investigations, where contact damage not only confirms involvement but also helps clarify the relative positions and movements of the vehicles—or other impacted objects—at the time of the collision.

By analyzing the location, shape, and characteristics of contact damage, investigators can reconstruct the dynamics of the crash, determine points of impact, and assess contributing factors. This evidence is foundational in establishing the sequence of events and supporting accurate, defensible conclusions.

One important aspect of post-collision vehicle analysis is the evaluation of the area of overlap—the region where contact occurred between the units involved in the crash. This may involve two vehicles, a vehicle and a fixed object, or a vehicle and a pedestrian. The extent of this overlap helps define the scope and severity of the impact.

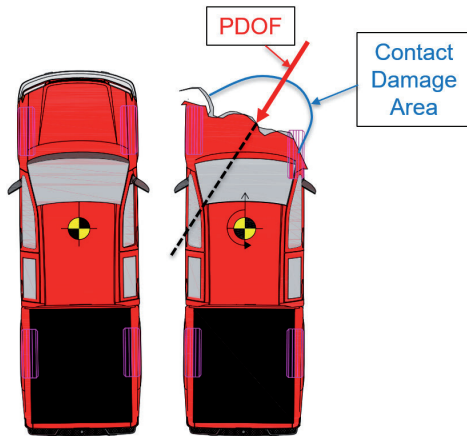
Within the contact damage area, investigators often identify the point of greatest penetration, which is particularly significant. This location provides insight into the Principal Direction of Force (PDOF). Understanding the PDOF is essential for reconstructing the dynamics of the crash and determining how the vehicles or objects interacted at the moment of impact. During a collision, there are forces that occur between the vehicles or objects. The PDOF is a summation of those forces acting on the vehicle during the duration of the contact, the crash impulse from first contact through maximum engagement. The PDOF is represented visually with an arrow within the contact damage area of the vehicle, through the damage centroid, with the tip of the arrow at or near the deepest penetration area. The angle of the arrow is determined by the direction in which significant vehicle components moved during the impact.

In systematic crash reconstruction procedures, the Principal Direction of Force (PDOF) is often illustrated as an arrow pointing into the vehicle's outline. The orientation of this arrow is critical to understanding vehicle dynamics. When the PDOF points directly toward the vehicle's center of mass, such as in the example below of the tan colored car, minimal rotational movement is expected. In this case, the PDOF is represented by the purple arrow and the force line of action is the red dotted line. However, when the force vector is offset from the center of mass—creating a longer perpendicular lever arm—it generates greater rotational motion. This rotational effect depends on the relative masses and velocities of the units involved and can significantly influence the post-impact trajectory and damage patterns.



Available Evidence in a Crash Case

There are two vehicles depicted in the following image. The red pickup truck on the left is the undamaged exemplar vehicle, while the red pickup truck on the right is the post-crash damaged vehicle. Represented on the damaged vehicle is the contact damage area, noted with the blue colored oval. The PDOF is located within the contact damage area and is noted by the red arrow.



As it is not a centered force, the vehicle will rotate counterclockwise, as represented by the black rotational arrow surrounding the center of mass location.

The alignment of vehicles at first contact provides critical insight into encroachment and helps determine which traffic unit may have violated another's right of way. Analyzing the relative positions and angles of impact allows investigators to reconstruct the sequence of events and assess fault with greater accuracy.

Induced Damage

Induced damage refers to vehicle damage other than contact damage. It is typically characterized by crumpling, distortion, or bending and may result from impact by another part of the same vehicle. For example, when an airbag deploys and strikes the windshield, the resulting damage—though involving contact—is classified as induced damage because the airbag is part of the vehicle itself. Recognizing and documenting induced damage is essential for a complete crash reconstruction, as it provides insight into the internal response of the vehicle and the behavior of its occupants.

While contact damage typically results from an object outside the vehicle, that is not always the case. Unrestrained occupants can move during a collision—usually opposite and parallel to the PDOF and strike the vehicle's interior. This interior damage often corresponds with injury patterns and provides valuable evidence for determining seating positions or identifying the driver. One of the most common examples is damage caused by an unrestrained occupant's movement, which can leave physical evidence that helps investigators reconstruct occupant dynamics at the time of impact.

Other Damage Considerations

While checking tires, mirrors, windows, lights, and safety equipment is standard practice, more detailed inspections—such as fluid levels or brake pad thickness—are typically reserved for when the investigation suggests a possible failure in those systems. These deeper checks should be guided by evidence, not performed arbitrarily.

Investigators should always remember that a vehicle has seven areas to examine: front, back, left, right, top, bottom, and inside. Unfortunately, interior photographs are often overlooked, yet they can be incredibly revealing. Interior images may show:

- Seatbelt usage
- Airbag deployment
- Seat positions
- Headlight switch settings
- Speedometer needle position (which can lock in place at impact if the battery is destroyed)

To ensure a comprehensive and accurate reconstruction of a vehicle collision, investigators should be asked targeted questions that go beyond surface-level observations. A prosecutor should consider asking the investigator:

- “How were the vehicles aligned at the moment of collision?”

This question prompts the investigator to consider the orientation, angle, and relative positions of the vehicles at the time of collision. Understanding alignment helps clarify the dynamics of the crash, such as direction of travel, point of contact, and potential evasive maneuvers.

- “Can you accurately position the vehicles using the physical road evidence?”

Encourage the use of tangible markers such as skid marks, gouge marks, fluid trails, debris fields, and final rest positions. These elements can be used to triangulate vehicle positions and validate or challenge witness statements and event data recorder (EDR) outputs.

- “Have you documented the scene in a way that allows for reconstruction?”

This includes taking measurements, mapping evidence, and capturing photographs from multiple angles—including aerial views if possible. Scene diagrams and 3D scans can also be invaluable.

- “Is there evidence that supports or contradicts the proposed sequence of events?”

This helps ensure that the analysis is not biased or based solely on assumptions. Investigators should be encouraged to look for inconsistencies and alternative explanations.

Asking these questions promotes a more disciplined and evidence-based approach to collision investigation—one that supports accurate conclusions and defensible findings.

Evidence from Modern Vehicle Technology

Today's vehicles are no longer just mechanical machines designed for transportation—they are sophisticated, mobile data centers equipped with advanced computer systems. These systems continuously record and transmit millions of data points that support safety, performance, diagnostics, and convenience features. Additionally, with integrated cellular, Wi-Fi, and Bluetooth connectivity, vehicles actively communicate with external devices, infrastructure, and cloud-based services. This connectivity enables real-time data exchange, including GPS location, speed, braking patterns, steering inputs, and system alerts.

In the context of modern crash reconstruction, digital data has become increasingly valuable and a powerful tool for investigators seeking to understand the dynamics of a collision. Today's vehicles often contain a wealth of embedded technology that can provide insight into driver behavior, vehicle performance, and environmental conditions leading up to a crash.

One of the most valuable sources is the Event Data Recorder (EDR), which captures critical pre-crash information such as speed, braking, throttle position, and seatbelt usage. This data can help reconstruct the final seconds before impact with remarkable precision.

Beyond EDRs, telematics systems offer a broader view of vehicle behavior over time. These logs can reveal patterns such as speeding, harsh braking, or erratic driving, which may support or contradict witness statements and expert analysis.

Infotainment systems also play a role, often storing recent call logs, navigation routes, and information about connected devices. This can help establish timelines, determine whether the driver was distracted, or confirm the vehicle's location prior to the crash.

Additionally, Advanced Driver Assistance Systems (ADAS) provide records of safety interventions—such as lane-keeping alerts, forward collision warnings, or automatic emergency braking. These systems can indicate whether the vehicle attempted to avoid the crash or if the driver failed to respond to warnings.

Together, these technologies offer a layered and increasingly indispensable view of crash events, allowing investigators to move beyond traditional physical evidence and into the realm of digital reconstruction. Understanding and leveraging this digital footprint allows for more precise reconstructions, supports or refutes witness statements, and helps identify contributing factors that may not be visible through physical inspection alone.

Vehicle data forensics involves the extraction, preservation, and analysis of the digital information stored within a vehicle's electronic systems. For investigators and prosecutors handling vehicular crimes—such as fatal crashes, hit-and-runs, and illegal street racing—this data can be critical in reconstructing events, identifying contributing factors, and establishing causation. Key vehicle systems often examined include Event Data Recorders (EDRs), infotainment and telematics systems, and connected car technology.

Proper handling of this digital evidence ensures its integrity and admissibility in court, while also enabling investigators to build a more complete and accurate picture of what occurred before, during, and after a crash.

Event Data Recorders (EDRs)

EDRs, commonly known as “black boxes,” are typically integrated into a vehicle’s Airbag Control Modules. Their primary function is to manage the deployment of airbags and other restraint systems during a crash. Their secondary function is to record critical crash-related data when specific conditions are met.

An EDR is triggered when the vehicle experiences a rapid change in velocity—commonly defined as a delta- v of approximately 8 km/h (5 mph) within 150 milliseconds. Once this threshold is reached, the EDR captures a snapshot of key pre-crash and crash event data, which may include:

- Vehicle speed
- Brake and throttle application
- Seatbelt status
- Airbag deployment timing
- Steering input
- Engine RPM
- Delta- v (change in velocity during impact)

This information can be invaluable in reconstructing the sequence of events leading up to a collision and assessing vehicle and occupant dynamics. While vehicle speed often draws the most attention, a comprehensive analysis of multiple data points—such as steering input and brake usage—provides a much richer understanding of the driver’s actions, vehicle dynamics, and potential evasive maneuvers.

By examining these variables in context, investigators can better determine contributing factors, assess driver intent, and evaluate the mechanical response of the vehicle during critical moments.

Infotainment and Telematics Systems

Modern infotainment and telematics systems serve dual functions: enhancing the driving experience through connectivity and entertainment, while also acting as rich sources of forensic data during investigations. These systems can record and retain a wide range of user interactions and vehicle telemetry, including:

- Phone call logs and text messages
- Navigation routes and destination history
- Bluetooth and Wi-Fi connections
- Device identifiers and contact lists
- Media playback and voice command usage

Available Evidence in a Crash Case

Telematics platforms—such as OnStar, Uconnect, or BMW Assist—maintain real-time communication with external services, enabling features like emergency response, remote diagnostics, and vehicle tracking. These systems can also log:

- Vehicle speed and location
- Driving behavior and patterns
- Crash detection and timestamps

Infotainment systems connect via embedded cellular modems or by tethering to personal mobile devices through Bluetooth, Wi-Fi, or USB. These connections allow access to personal data such as media files, call logs, incoming SMS messages, and navigation inputs, which can be critical in reconstructing timelines, verifying witness accounts, or challenging suspect narratives.

One of the most valuable outputs from these systems is geolocation data. Navigation logs may include tracklogs with timestamps, velocity, and route history, offering a digital trail of the vehicle's movement. Even without active route execution, saved destinations or recent inputs can provide insight into driver intent or planned travel paths.

When combined with data from EDRs, ADAS, and other onboard systems, infotainment and telematics data significantly enhance the ability to reconstruct events with precision—making them indispensable tools in modern vehicle investigations.

Advanced Driver Assistance Systems

Many modern vehicles are equipped with Advanced Driver Assistance Systems (ADAS), which utilize a combination of forward-facing cameras, radar sensors, and other modules to monitor and respond to driving conditions. These systems support features such as:

- Lane keeping and departure warnings
- Adaptive cruise control and vehicle spacing
- Pedestrian detection
- Traffic sign recognition
- Collision avoidance and emergency braking

When a safety system is triggered, some forward-facing camera modules may store still images or short video clips, depending on the manufacturer and system configuration. These recordings can capture critical moments such as:

- Lane departure events
- Sudden braking or evasive maneuvers
- Proximity alerts involving other vehicles, pedestrians, or obstacles

This sensor data can provide valuable context to crash dynamics, especially in cases involving pedestrian impacts, autonomous driving features, or disputed driver actions. When integrated with the vehicle's Event Data Recorder (EDR) or telematics systems, ADAS data enhances the ability to reconstruct events with greater precision.

For investigators, accessing and interpreting ADAS data can reveal not only what happened, but also how and why the vehicle responded the way it did—offering deeper insight into both human and system behavior in the moments leading up to a collision.

As vehicle forensics continues to evolve, the need for comprehensive training and multidisciplinary expertise becomes increasingly important. A well-rounded approach that integrates digital forensics, crash dynamics and reconstruction, and legal and ethical considerations is essential for producing reliable, defensible, and admissible conclusions. Proper use of these tools—combined with sound investigative judgment—can significantly enhance the accuracy and credibility of crash analyses.

Evidence from Other Types of Modern Technology

Other types of modern technology play a pivotal role in enhancing the accuracy and depth of a crash reconstruction investigation. Tools such as police body-worn cameras, cell phone data, and surveillance footage provide real-time evidence and contextual insights that help investigators piece together events with greater precision and reliability.

Cameras and Videos

Today, cameras are virtually everywhere—from traffic intersections and storefronts to smartphones and dash cams—creating a vast network of visual data. This widespread proliferation of cameras has become a powerful asset in crash investigations, offering objective, time-stamped footage that can clarify the sequence of events, identify contributing factors, and support accurate reconstructions of incidents.

Police Body Cams and Dash Cams

Police body-worn cameras and dash-mounted cameras are vital tools for capturing real-time audio and visual documentation during traffic stops, crash responses, and initial scene assessments. These devices provide an unfiltered record of:

- Driver behavior and demeanor
- Environmental and road conditions
- Vehicle damage and positioning immediately post-collision
- Interactions between officers, drivers, and witnesses

This footage preserves critical context that may otherwise be lost or altered over time. It can help investigators verify timelines, assess the severity of impact, and identify contributing factors such as weather, lighting, or roadway obstructions. In many cases, these recordings serve as objective evidence that supports or challenges statements made by involved parties.

When properly secured and reviewed, body cam and dash cam footage can significantly enhance the accuracy and integrity of crash investigations.

Ring/Doorbell Cams and Surveillance Cameras

Residential and commercial surveillance cameras, including doorbell cams like Ring and Nest, are increasingly valuable in vehicle crash investigations. These systems often capture footage of:

- Crashes as they occur
- Vehicle movements before and after impact
- Pedestrian activity and traffic flow
- License plates and vehicle identifiers

Such footage can help verify impact timing, vehicle speeds, right-of-way violations, and even identify hit-and-run suspects. In many cases, these recordings provide unbiased, time-stamped evidence that complements or clarifies witness statements and physical scene documentation.

Investigators should consider canvassing nearby homes and businesses for potential footage, especially in urban or residential areas where surveillance coverage is common. Even brief clips can offer critical insights into crash dynamics and driver behavior.

Vehicle Cameras

Many modern vehicles are equipped with built-in camera systems, such as Tesla's dash cam and Sentry Mode, which continuously record the vehicle's surroundings from multiple angles. These systems can capture:

- Pre-collision behavior (e.g., lane changes, braking, acceleration)
- Impact details from various perspectives
- Road and environmental conditions
- Interactions with other vehicles, pedestrians, or obstacles

Footage is often timestamped and may be linked to GPS data, providing a synchronized view of location, speed, and vehicle movement. This combination of visual and positional data offers investigators a powerful tool for reconstructing events with precision.

In cases involving disputed fault, hit-and-runs, or autonomous driving features, vehicle camera footage can serve as objective, high-resolution evidence—clarifying driver actions, vehicle responses, and external conditions leading up to and following a crash.

Modern Cell Phones and Cell Towers

Cell phone data plays a pivotal role in modern crash analysis, offering insights into driver distraction, location, and movement timelines. Investigators can examine:

- Call and text activity to determine potential distraction or communication during key moments
- GPS data and app usage to trace routes, stops, and behavioral patterns
- Device interactions that may indicate manual phone use while driving

In addition to device-level data, cell tower pings can be used to corroborate a driver's location or path of travel, helping to reconstruct timelines and verify or challenge statements. These pings can also assist in occupant identification, especially in multi-passenger or disputed-driver scenarios.

More broadly, cell tower dumps—which capture all devices connected to a tower during a specific time window—can be instrumental in identifying vehicles or individuals involved in crashes, particularly in hit-and-run cases or incidents with limited eyewitness accounts.

When combined with vehicle data sources like EDRs, ADAS, and surveillance footage, mobile device data provides a powerful layer of context that strengthens investigative accuracy and evidentiary support.

V2V and V2I Tech (Vehicle-to-Vehicle/Vehicle-to-Infrastructure)

V2V and V2I technologies enable vehicles to communicate with each other and with surrounding infrastructure such as traffic signals, road sensors, and signage. These systems are designed to improve safety, traffic flow, and situational awareness by sharing real-time data across the transportation network.

In the context of crash investigations, logs from V2V and V2I systems can provide valuable insights, including:

- Pre-crash speed and heading
- Braking and acceleration events
- Lane changes and turn signals
- System-generated warnings or alerts

This data can help reconstruct the moments leading up to a collision, revealing whether evasive actions were attempted, whether warnings were issued, and how vehicles responded to dynamic road conditions. In cases involving autonomous or semi-autonomous features, V2V/V2I data can also clarify the role of automated systems versus human input.

When integrated with other sources—such as EDRs, ADAS, and surveillance footage—V2V and V2I logs contribute to a more complete and accurate understanding of crash dynamics, especially in multi-vehicle incidents or intersections with smart infrastructure.

Drone Technology

Drones have become an invaluable tool in crash investigations, offering rapid, high-resolution aerial imagery and video of collision scenes. Their ability to capture overhead perspectives allows investigators to:

- Document evidence with minimal disruption to the scene
- Map vehicle positions, debris fields, and roadway markings with precision
- Create accurate 2D maps and 3D reconstructions of the crash site
- Assess large or complex scenes that may be difficult to capture from ground level

This technology is especially useful in multi-vehicle collisions, rural or hard-to-access locations, and intersections with complex geometry. Drone footage can also be synchronized with other data sources—such as EDRs, surveillance cameras, and scene measurements—to enhance the accuracy of crash reconstructions and support legal proceedings.

Passive Alcohol Sensors

Some modern vehicles and roadside enforcement tools are equipped with ambient air alcohol detection systems, designed to sense the presence of alcohol in the air surrounding the driver. These systems offer a non-invasive method for preliminary screening of potential impairment.

While not confirmatory—and therefore not a substitute for formal breath or blood tests—ambient sensors can:

- Detect alcohol vapor near the driver
- Trigger alerts or safety protocols in certain vehicle systems
- Prompt further investigation or field sobriety testing by law enforcement

These tools are particularly useful at crash scenes, where quick screening can help determine whether impairment may have been a contributing factor. When combined with other evidence, such as body cam footage, witness statements, and vehicle data, ambient alcohol detection can support a more complete and timely assessment of driver condition.

Ignition Interlock Devices

Ignition interlock devices are designed to prevent a vehicle from starting if alcohol is detected on the driver's breath. These systems are commonly installed in vehicles of individuals with prior DUI offenses and serve as both a deterrent and a compliance tool.

In crash investigations, interlock data can be critical in determining:

- Whether the driver attempted to circumvent the system (e.g., using another person to provide a breath sample)
- Whether the device failed to operate properly
- Whether the driver was impaired despite the presence of the interlock

This information is especially relevant in repeat offender cases, where system logs can reveal patterns of misuse, tampering attempts, or non-compliance. Investigators may also use interlock records to establish timelines of vehicle use, correlate failed breath tests with crash timing, and assess whether the device was active and functioning at the time of the incident.

When combined with other data sources—such as EDRs, cell phone records, and surveillance footage—interlock device logs contribute to a more complete understanding of driver behavior and accountability.

Commercial Motor Vehicle (CMV) Technology

Commercial Motor Vehicles (CMVs) are increasingly equipped with dash cams and a suite of advanced technologies that serve both operational and safety functions. These include:

- Electronic Logging Devices (ELDs)
- Telematics systems
- Advanced braking systems
- Lane-keeping assist
- Forward-collision warning systems

These systems collectively record critical data such as:

- Vehicle speed and braking activity
- Driver hours and duty status
- Safety alerts and system activations
- Location tracking and route history

This information is invaluable for analyzing crash causation, assessing driver behavior, and verifying compliance with Federal Motor Carrier Safety Administration (FMCSA) regulations. ELDs, for example, help determine whether a driver was operating within legal hours-of-service limits, while telematics can reveal patterns of aggressive driving or mechanical faults.

When integrated with other data sources—such as EDRs, ADAS, and surveillance footage—CMV technology provides a robust framework for reconstructing incidents and identifying regulatory violations or operational failures.

Legal Issues with Vehicle Technology

Since the 1990s, vehicles have increasingly integrated advanced technologies, beginning with Powertrain Control Modules and Airbag Control Modules. Today, electronic data collection is a standard feature, with Event Data Recorders (EDRs) mandated under 49 CFR §§ 563.1–563.12 for certain vehicles. The regulations mandate that EDRs record a minimum set of crash-related data elements in a consistent format, and that manufacturers make data retrieval tools commercially available to investigators to access this data.

As of 2022, over 90% of new vehicles sold in the U.S. are equipped with EDRs that comply with these standards. With the rapid advancement of forensic hardware and software, law enforcement and crash investigators now have access to sophisticated tools capable of identifying, extracting, and interpreting data across a wide range of vehicle platforms. These technologies can recover information from systems such as EDRs, infotainment units, telematics modules, and ADAS components—providing critical insights into vehicle behavior and occupant actions. One of the most widely used tools for accessing EDR data is Bosch's Crash Data Retrieval (CDR) system, which allows investigators to extract information directly from a vehicle's diagnostic port or control modules. The system includes specialized hardware and software designed to interface with a broad range of vehicle makes and models.

However, the effectiveness of these tools depends not only on the investigator's technical proficiency but also on a clear understanding of the legal frameworks governing data access and privacy. Investigators must be aware of jurisdictional laws, consent requirements, and evidentiary standards to ensure that data collection is both lawful and admissible in court.

Importantly, electronic data stored within the vehicle is not accessible without proper legal authority, even in jurisdictions that allow warrantless inspection of mandatory safety equipment (e.g., tires, lights, brakes). While some states permit inventory searches or rely on the automobile exception to the Fourth Amendment—allowing warrantless searches when a vehicle is mobile or impounded—these exceptions do not extend to electronic data unless separate probable cause exists.

While investigators may prefer to conduct examinations with the consent of those involved, obtaining a search warrant is often the most prudent and legally sound approach—especially when prosecutors are engaged in the case. To avoid legal challenges and ensure admissibility of evidence, the recommended best practice is for investigators to obtain court authorization before accessing any electronic data. In some jurisdictions, investigators may have standing authority to inspect mandatory safety equipment without a warrant. However, this authority does not extend to accessing electronic data stored within the vehicle, such as information from Event Data Recorders (EDRs).

However, access to EDR data is governed by the Driver Privacy Act of 2015, which establishes that the data recorded by an EDR is the property of the vehicle's owner or lessee. Retrieval of this data is legally restricted and may only occur under the following conditions:

- With the owner's or lessee's consent (written, electronic, or recorded audio).
- By court order or administrative authority with jurisdiction.
- For authorized federal investigations, provided personally identifiable information is protected.
- To facilitate emergency medical response following a crash.
- For traffic safety research, with anonymization of personal and vehicle identifiers.

These protections ensure that while EDR data can be a powerful tool for crash analysis and safety research, its use respects individual privacy and legal boundaries.

Modern vehicles go far beyond EDRs. Many are equipped with onboard cameras, radar, lidar, and a wide array of sensors that continuously monitor driving behavior, vehicle performance, and environmental conditions. Additionally, vehicles have become part of the Internet of Things (IoT)—connected to cloud services, mobile apps, and even offering built-in Wi-Fi hotspots. This connectivity enables features like remote diagnostics, over-the-air updates, and smart charging, but it also introduces significant data privacy concerns.

Vehicles now collect sensitive information such as:

- Driving patterns (speed, braking, acceleration)
- Location data via GPS
- Biometric inputs (e.g., voice recognition, facial ID)
- Telematics and system diagnostics (battery usage, software versions)

These capabilities raise questions about who owns the data, how it is stored, and who can access it. Risks include unauthorized surveillance, identity theft, and misuse of personal data. As a result, manufacturers are increasingly subject to privacy regulations such as the Driver Privacy Act of 2015, GDPR, and other international frameworks.

Considerations Unique to Rural Crashes

Serious crash investigations and crash-related criminal prosecutions often differ significantly between rural and urban settings. These differences stem not only from geography and population density, but also from the availability of resources, infrastructure, and investigative support.

While definitions of “rural” and “urban” vary widely across federal and state agencies—and have evolved over time—it is not necessary to rigidly define these terms to understand the challenges unique to rural crash investigations. For the purposes of this discussion, “rural” refers to areas with relatively low population density and limited access to large-scale institutional services, such as hospitals, universities, and major entertainment venues.

To illustrate the contrast:

- Cheatham County, Tennessee, the second-most populous county in the five-county 23rd Judicial District, spans 302 square miles and had an estimated population of 42,254 in 2024.
- In comparison, the five boroughs of New York City also cover 302 square miles, but had an estimated population of 8,478,072 in 2024.

Clearly, New York City is urban, while Cheatham County is rural—despite occupying the same land area.

This distinction matters. Rural investigations often face challenges such as:

- Longer response times for emergency services
- Limited access to specialized crash reconstruction experts
- Fewer surveillance systems or eyewitnesses
- Greater reliance on physical evidence and scene documentation

Understanding these contextual differences is essential for tailoring investigative approaches, allocating resources, and ensuring equitable legal outcomes across diverse geographic regions.

Emergency Response Delays

In serious crash cases, large geographic areas with sparse populations can lead to significant delays in emergency response. In rural settings, it is not uncommon for a crashed vehicle to remain undiscovered for extended periods, especially when the incident occurs on remote roads or during off-peak hours.

Even vehicles equipped with advanced features—such as infotainment systems and telematics platforms like OnStar, which are designed to automatically notify emergency services—may fail to transmit alerts due to connectivity issues. In areas with limited cellular coverage, these systems may be unable to establish a signal, rendering their automated crash notification capabilities ineffective.

When a passerby eventually encounters the crash scene, they may also be unable to contact authorities due to the absence of cell service. In some cases, individuals have had to seek higher elevation or travel several miles to find a signal strong enough to place a call—even to 911. Prosecutors and investigators working in districts with known “dead zones” are often familiar with these challenges.

Beyond initial response delays, rural law enforcement agencies may face resource limitations. Local officers—who may lack formal training in crash investigation—are often the first to secure the scene. Advanced crash reconstruction typically requires assistance from state-level experts or neighboring jurisdictions, which can further delay the investigative process and complicate evidence preservation.

These realities underscore the importance of tailoring investigative protocols to the unique demands of rural environments, ensuring that critical evidence is not lost and that victims receive timely aid.

In rural crash scenarios, where geographic isolation and delayed response times are common, establishing clear evidence maintenance protocols with local agencies is essential. These protocols ensure that critical scene evidence is preserved for later marking, photographing, measuring, and analysis—often performed by crash reconstructionists who must travel from distant locations.

When electronic data sources such as infotainment systems, telematics, or cellular signals are unavailable or unreliable due to connectivity issues, basic crash reconstruction principles become even more vital. Physical evidence—such as skid marks, debris fields, vehicle rest positions, and environmental conditions—must be documented thoroughly and accurately by first responders.

In these cases, there is no substitute for the 24/7 availability of crash-trained prosecutors who can field calls from local law enforcement as incidents are discovered and investigated. These prosecutors play a critical role in:

- Guiding evidence preservation efforts
- Coordinating with state-level crash reconstruction experts
- Mobilizing specialized resources in real time
- Ensuring legal protocols are followed from the outset

Given that rural law enforcement may lack formal crash investigation training or access to advanced tools, early involvement from knowledgeable prosecutors helps bridge the gap—protecting the integrity of the investigation and supporting successful prosecution when warranted.

Connectivity and Communication Barriers

One of the key challenges in rural crash investigations is the limited density of cell towers, which directly affects both emergency response and digital evidence reliability. For example, in 2024:

- Cheatham County, Tennessee had only 24 registered cell towers, according to the Tennessee Secretary of State.
- In contrast, New York City had 772 registered towers, per the Federal Communications Commission (FCC), along with thousands of additional antennas that provide signal coverage but fall below the threshold for FCC registration.

This disparity has significant implications for geolocation accuracy. In rural areas, where towers are sparse and widely spaced, geolocation based on cell tower hits—even when enhanced by timing advance data (which estimates distance from a tower)—is often imprecise and unreliable. In contrast, urban environments benefit from dense tower networks and overlapping signals, allowing for more accurate triangulation, especially when supplemented by nearby Bluetooth and Wi-Fi devices.

Even commonly referenced “ping” data—used to estimate a phone’s location based on its connection to a tower—can be notoriously inaccurate in rural regions. A phone may appear to be located near a tower that is actually many miles away from its true position.

As a result, crash investigators working in rural areas must often rely on traditional investigative methods—such as physical evidence, witness statements, and scene measurements—to establish pre-crash timelines and driver behavior. When cell phone data is available, it must be interpreted with greater caution, acknowledging the limitations imposed by low tower density and signal coverage.

Limited Access to Trauma Care

In the U.S. medical system, hospitals are designated across five levels of trauma care, ranging from Level I and II—which offer comprehensive treatment for all types of injuries—to Level IV and V, which focus primarily on initial stabilization and triage. Lower-level centers may lack the capability to perform even basic emergency procedures, such as resetting broken bones.

High-level trauma centers (Level I and II) are typically located in urban areas and are rare or entirely absent in rural regions. This disparity has serious implications for crash victims in remote communities.

For example, in Tennessee’s 23rd Judicial District, which includes Cheatham County, there are five hospitals:

- Three have no trauma designation at all—not even Level V.
- The remaining two are rated Level III, meaning they can provide emergency care but lack the full resources of higher-level trauma centers.

By contrast, New York City’s five boroughs, which occupy the same land area (302 square miles) as Cheatham County, are home to at least 70 hospitals, including 11 Level I and II trauma centers—fully equipped to handle any type of injury.

This stark difference highlights the critical challenges faced in rural crash investigations and emergency response. Victims in rural areas may experience:

- Longer transport times to appropriate care
- Limited access to life-saving procedures
- Greater reliance on air medical services or transfers to urban hospitals

Understanding these disparities is essential for prosecutors, investigators, and policymakers working to improve outcomes and ensure equitable access to trauma care across geographic regions.

In serious rural crash cases, victims and at-fault drivers are often medically evacuated outside the jurisdiction before a full on-scene investigation can be completed. This creates immediate logistical challenges for law enforcement and prosecutors. Investigators may need to travel to distant trauma centers to conduct initial interviews, collect evidence, or verify medical conditions relevant to the case.

When the at-fault driver is seriously injured, both the investigation and any potential arrest may be delayed, sometimes by days or weeks. These delays can complicate evidence collection, especially if physical or digital evidence is time sensitive.

Additionally, legal procedures governing the issuance of search warrants and judicial subpoenas can present jurisdictional hurdles. Prosecutors and investigators must ensure that judicial officers, such as judges or magistrates, from the crash jurisdiction possess the legal authority to issue warrants that can be lawfully executed at medical facilities located outside their jurisdiction. If not, they must establish working relationships with judicial officials in the jurisdiction where the trauma center is located—a process that can be time-consuming and unfamiliar to rural agencies.

These challenges highlight the need for inter-jurisdictional coordination, proactive planning, and clear protocols to ensure that critical evidence is preserved, and legal processes are properly followed, even when investigations extend beyond the boundaries of the crash location.

In rural crash scenarios, especially those involving seriously injured at-fault drivers, the collection of intoxication-related evidence can be significantly delayed. When a driver is medically evacuated—often by helicopter—to a facility outside the jurisdiction, the opportunity to obtain timely blood samples or conduct field sobriety assessments may be lost or substantially postponed.

These delays raise important legal and procedural considerations:

- Exigent Circumstances and the Fourth Amendment:

The urgency created by medical evacuation may support an exigency exception to the Fourth Amendment's warrant requirement. Investigators and prosecutors should evaluate whether the circumstances justify immediate evidence collection without a warrant, particularly when waiting would risk the loss of critical blood alcohol or drug concentration data.

- Expert Testimony on Intoxicant Dissipation:

Given the potential for extended delays, the state may need to retain expert witnesses capable of explaining how intoxicant levels in the blood change over time. These experts can help establish whether delayed samples still reflect impairment at the time of the crash, or whether dissipation may have obscured the true level of intoxication.

Prosecutors working in jurisdictions with large geographic coverage and limited medical infrastructure should be prepared to address these challenges proactively—ensuring that investigative protocols account for both legal thresholds and scientific limitations in rural crash cases.

Sparse Infrastructure and Witnesses

While rural crash investigations present distinct challenges—such as delayed emergency response and limited resources—they also offer unique advantages not typically found in urban environments.

In densely populated urban areas, the abundance of roads, businesses, drinking establishments, and residences makes it nearly impossible to fully canvass all possible routes a driver may have taken before a crash. The sheer volume of potential witnesses and surveillance sources can overwhelm investigators and dilute the focus of pre-crash analysis.

In contrast, rural areas often have only one or two viable routes leading to a crash location. These limited trajectories typically pass by a small number of businesses, farms, or residences, making it far more feasible—even with minimal manpower—to identify and visit potential witnesses. The lower density of traffic and infrastructure simplifies the task of tracing a vehicle's path and gathering firsthand accounts of pre-crash driving behavior.

This investigative clarity can be a powerful asset in rural cases, allowing for more targeted canvassing, efficient witness identification, and stronger contextual evidence—despite the logistical challenges that rural environments may pose.

As camera technology has become more affordable, compact, and weather-resistant, its use has expanded significantly—even in rural communities. Devices such as Ring doorbell cameras, trail cameras, and other property surveillance systems are now commonly installed at homes, farms, and roadside residences, often for security and theft prevention.

These cameras can inadvertently capture pre-crash footage of both at-fault and victim vehicles as they travel toward the crash scene. In some cases, they may even record the crash itself, providing invaluable visual evidence that can help establish:

- Vehicle trajectories and speeds
- Right-of-way violations
- Environmental conditions
- Precise timing of the incident

Investigators can often uncover this footage by speaking directly with property owners near the crash site. In addition to video evidence, these conversations may reveal eyewitness or earwitness accounts, which are especially valuable in rural areas where formal surveillance infrastructure is limited.

This type of evidence is particularly useful when there is a delay between the crash and the first emergency call, helping to reconstruct timelines and clarify the sequence of events. As such, canvassing nearby properties should be a standard part of rural crash investigations.

In rural crash investigations, it is critical that investigators promptly engage with property owners along the likely routes to the crash site. Many privately owned camera systems—whether digital or cloud-based—retain only limited footage before automatically overwriting it. Delays in conducting interviews can result in the permanent loss of potentially vital video evidence.

Investigators should not assume the absence of surveillance cameras simply because none are immediately visible. Modern camera systems are often compact, discreet, or intentionally concealed, making them difficult to detect during a cursory scene assessment.

In cases involving suspected alcohol impairment, investigators should also canvass all drinking establishments within the jurisdiction. Identifying where the at-fault driver consumed intoxicants can help establish a likely route to the crash site. This route may be narrow and well-defined, increasing the chances of locating surveillance footage that captures the driver's behavior before the crash.

When post-crash toxicology results are expected to be delayed, establishing a pre-crash timeline becomes even more essential. Documenting the timing and location of intoxicant consumption can provide critical context for assessing the driver's level of impairment at the time of the incident.

Evaluating Crash Reports and Investigations

To build a strong prosecution in crash-related cases, it is essential that a prosecutor not only understand the investigative process but also actively identify and address any shortcomings early on. Gaps in the investigation can introduce reasonable doubt at trial, potentially undermining the case.

Early involvement by the prosecutor can significantly reduce the time and effort required later in the process and ultimately lead to a more robust and defensible case. While it may not be possible to anticipate every challenge that may arise, proactive engagement allows for timely course correction and evidence preservation.

Below are several practical considerations for prosecutors to keep in mind during the investigative phase.

Understanding the Investigative Process

Prosecutors must recognize that crash investigations present distinct challenges not typically encountered in other types of criminal cases. Unlike traditional crime scenes, crash scenes are dynamic and often rapidly changing. Environmental factors such as weather, traffic flow, and emergency response activities can quickly alter or destroy critical evidence, making comprehensive documentation difficult.

The public nature of crash scenes adds another layer of complexity. Law enforcement must balance the need for thorough evidence collection with the imperative to reopen roadways. Extended road closures increase the risk of secondary collisions and disrupt public safety, placing investigators in a difficult position: should they take the time necessary to fully document the scene, or expedite clearance to restore traffic flow, potentially compromising the integrity of the investigation?

This dilemma is unique to crash investigations and underscores the importance of early prosecutorial involvement. Understanding these constraints allows prosecutors to better evaluate the quality of evidence and advocate for investigative practices that preserve key details without unduly delaying public safety operations.

Becoming an Active Partner in the Investigation

Prosecutors should engage with crash investigators as early as possible—ideally by responding to the scene when feasible. Early involvement ensures that evidence is lawfully collected, properly preserved, and thoroughly analyzed from the outset. It also allows prosecutors to visualize the scene firsthand, which can be invaluable for identifying investigative gaps and strengthening the case as it progresses.

Initiating early discussions about potential charges and anticipated defenses can help guide the direction of the investigation, ensuring that critical elements are addressed before evidence is lost or overlooked. Additionally, prosecutors play a key role in supporting law enforcement by facilitating search warrants for vehicle inspections, event data recorder (EDR) downloads, mobile devices, surveillance footage, and other relevant evidence.

Critically Assessing the Investigation

Prosecutors should feel empowered to ask probing and sometimes difficult questions of investigators. While law enforcement professionals are to be trusted in their roles, it is prudent to assume that any questions a prosecutor has about the investigation may also be raised by defense counsel or jurors later in the case.

By adopting a critical, “devil’s advocate” mindset, a prosecutor can help identify gaps or weaknesses in the investigation that may require further inquiry or analysis. This proactive approach not only strengthens the case but also ensures that potential vulnerabilities are addressed before they become obstacles in court.

Identifying Common Investigative Pitfalls

While every crash case presents unique circumstances, prosecutors should remain vigilant for recurring issues that can weaken a case. Awareness of these common pitfalls allows for early intervention and strengthens the overall prosecutorial strategy:

Biased or Premature Conclusions

Although well-intentioned, investigators may sometimes form early assumptions about a crash—such as who was at fault, what caused the incident, or whether criminal conduct was involved—before all evidence has been collected and the reconstruction is complete. These premature judgments can misdirect the investigation, compromise the integrity of the case, and lead to missed opportunities for uncovering critical facts.

Prosecutors who engage early in the investigative process can play a key role in preventing these missteps. By encouraging an evidence-driven approach and challenging assumptions, prosecutors help ensure that conclusions are based on verified facts rather than initial impressions. This collaborative scrutiny strengthens the investigation and supports a more credible and compelling case in court.

Incomplete Scene Documentation

As discussed earlier, the fluid nature of crash scenes—combined with the competing demands placed on law enforcement—can significantly hinder evidence collection. Environmental conditions, traffic pressures, and the urgency to reopen roadways often limit the time available for thorough documentation.

To mitigate these challenges, prosecutors should collaborate closely with investigators to ensure that all physical evidence is either collected or properly documented before it is lost or altered. Without this evidence, a complete and accurate reconstruction may be impossible, increasing the likelihood of reasonable doubt at trial.

Early prosecutorial involvement can help prioritize evidence preservation and reinforce the importance of comprehensive scene documentation, ultimately strengthening the case and supporting a more reliable narrative in court.

Failure to Tailor Reconstruction to the Case

Not every crash requires the same level or type of reconstruction analysis. The scope should be determined by the specific facts and circumstances of the incident. For example, in a rollover crash involving occupant ejections, the defense may center on identifying who was driving. In such cases, a speed analysis alone is insufficient, as speed is unlikely to be the central issue at trial. Instead, an occupant kinematics analysis may be necessary to address the defense effectively.

Early collaboration between prosecutors and investigators is key to identifying the appropriate type and depth of reconstruction needed. By becoming involved at the outset, prosecutors can help ensure that the investigative strategy aligns with the evidentiary needs of the case, ultimately strengthening the prosecution and reducing the risk of overlooked or irrelevant analysis.

Failure to Identify and Preserve Witness Statements

Crash scenes are often chaotic, and bystanders not directly involved are frequently encouraged to leave the area for safety and logistical reasons. However, prosecutors should ensure that all potential witnesses have been identified and interviewed—not just those directly involved in the crash, but also individuals who witnessed the incident or its aftermath.

Importantly, first responders and rescue personnel should not be overlooked as potential witnesses. Their observations can provide valuable insight into the condition of the vehicles, the behavior of involved parties, and the overall scene dynamics.

The earlier witnesses are identified and interviewed, the more reliable their accounts will be. Memories fade quickly, and timely documentation of witness statements is essential to preserving critical details that may influence the outcome of the case.

Failure to Consider Mechanical Defects

Although mechanical defects are relatively uncommon, they can cause or contribute to a crash. Prosecutors should ensure that a mechanical inspection is conducted on every vehicle involved, regardless of whether a defect is initially suspected. Even in the absence of early indicators, a thorough inspection helps preempt future claims by the defense and strengthens the evidentiary foundation of the case.

By proactively ruling out mechanical failure, prosecutors and investigators can focus on the true contributing factors and avoid unnecessary complications at trial. This step reinforces the integrity of the investigation and supports a more comprehensive and defensible prosecution.

Failure to Ensure Comprehensive Data Collection

Prosecutors should ensure that all available data sources have been thoroughly examined during the crash investigation. While law enforcement routinely retrieves evidence from the Event Data Recorder (EDR), many other valuable sources must also be considered. These include:

- Infotainment systems
- Dash cameras
- GPS units
- Advanced Driver Assistance Systems (ADAS)
- Manufacturer-collected data
- Traffic cameras
- Private surveillance footage

Failure to promptly preserve this data can result in its loss, as many systems automatically overwrite stored information. Early prosecutorial involvement can help ensure that investigators pursue all relevant data sources and take necessary steps to secure and preserve digital evidence before it is erased or becomes inaccessible.

Misinterpreted EDR or Other Technological Data

Ensuring Competent Data Interpretation

Prosecutors should verify that investigators are properly trained not only in retrieving digital crash data but also in accurately interpreting it. While these systems—such as EDRs, infotainment units, and ADAS—can capture a wealth of valuable information, the data is highly technical and prone to misinterpretation if not analyzed correctly.

Errors in data interpretation can seriously compromise the reconstruction and weaken the case. It is essential that investigators cross-reference digital findings with the physical evidence at the scene to ensure consistency and reliability. When necessary, prosecutors should advocate for the involvement of qualified experts to assist in the analysis and presentation of complex data.

Failure to Maintain Evidentiary Integrity

As with any criminal case, maintaining the integrity of evidence is essential. Prosecutors should ensure that there are no gaps in the chain of custody for any physical or digital evidence. Breaks in documentation or handling can open the door to suppression motions or impeachment at trial, potentially undermining the case.

By proactively verifying that all evidence has been properly collected, preserved, and tracked, prosecutors help safeguard its admissibility and credibility in court.

Conclusion

Effective prosecution of crash cases requires more than a post-investigation review—it demands early, active involvement from prosecutors who understand the unique complexities of crash scenes. By partnering with investigators from the outset, prosecutors can help shape the direction of the investigation, critically assess emerging evidence, and address common pitfalls before they become case vulnerabilities.

A proactive approach not only strengthens the evidentiary foundation but also helps close gaps that could lead to reasonable doubt. Early engagement ensures that the investigation remains focused, thorough, and aligned with the legal standards necessary for a successful prosecution—ultimately serving the interests of justice.

Prosecutor Considerations for a Crash Case

Crash cases are often emotionally intense and difficult to prosecute. The grief and trauma experienced by victims and their families can take a significant emotional toll on a prosecutor.

Amidst this emotional intensity, it is easy to overlook critical details while focusing on building the case. That is why it is both wise and essential for a prosecutor to develop a detailed outline or checklist of case elements from the outset. Doing so ensures the case is thoroughly prepared before filing and reduces the likelihood of oversights and procedural errors during collaboration with law enforcement and investigators.

Establishing Mental Culpability

Crash cases often involve complex questions of mental culpability, making it essential for prosecutors to understand the various levels of criminal intent. Terms like *criminally negligent*, *reckless*, *purposely*, and *knowingly* can be confusing, especially since their legal definitions vary across jurisdictions. A solid working knowledge of these distinctions is critical when reviewing and prosecuting cases. A prosecutor must be familiar with the statutes and case law in their jurisdiction and consult with the state Traffic Safety Resource Prosecutor (TSRP), who may offer assistance and insights from similar cases.

Mental state is a key element that is sometimes overlooked, yet it can be one of the most decisive factors in determining appropriate charges. Prosecutors must be prepared to clearly explain these legal concepts to a jury, simplifying complex definitions to avoid confusion.

Another layer of complexity involves distinguishing between voluntary and involuntary acts—terms that also differ in meaning depending on the statute and jurisdiction. While vehicle crashes are rarely “voluntary” in the everyday sense, legal definitions of voluntary and involuntary conduct can guide charging decisions, such as between voluntary and involuntary manslaughter. Generally, a voluntary act is one done knowingly and intentionally, with awareness of consequences, while an involuntary act occurs without intent, often under duress or without control. These distinctions underscore the importance of closely examining statutory language and relevant court interpretations when building a case.

Proving Vehicle Operation

While it may seem straightforward, proving vehicle operation can often become a significant challenge in crash cases. Definitions of “operation” vary across jurisdictions, with case law and state statutes offering differing interpretations. Generally, “operation” implies that the suspect maintained some level of physical control over the vehicle. Although actively driving is the most obvious example, other actions—such as having the keys in the ignition, the engine running, or even using accessory features like the radio or turn signals—can also constitute operation. In some jurisdictions, even being asleep in a running vehicle may qualify.

Establishing operation through direct observation—whether by witnesses or circumstantial evidence—is crucial. A common defense, such as “the driver fled the scene after the crash,” can often be anticipated and countered if the circumstances allow. While witness testimony is valuable, it is equally important to examine physical evidence. Investigators should consider factors like seat positioning relative to the suspect’s height, obstructions in the passenger seat, and inconsistencies between the suspect’s statements

and the physical evidence. These details can be critical in identifying the driver and proving operation. (For additional information about proving operation, see also “Proving Operation Without Direct Evidence” in Defense Strategies and Countermeasures below.)

Demonstrating Impairment

Proving impairment—particularly in cases where it is a required element of the offense—has become increasingly complex over time, especially with the growing prevalence of drug-related impairment. While alcohol impairment is well-established through field sobriety tests, officer observations, and chemical analyses, drug impairment presents unique challenges. Different substances affect individuals in varied ways, and the signs of impairment can differ significantly depending on the drug involved.

As a result, drug impairment investigations demand a more nuanced approach. While the foundational elements—field sobriety testing, officer observations, and toxicology reports—remain essential, they often need to be supplemented with specialized expertise. Drug Recognition Experts (DREs) are highly valuable in these cases. Trained to identify impairment across seven major drug categories, DREs can provide critical investigative insight and expert testimony, even in the absence of confirmatory chemical tests. Toxicologists also play a key role in explaining the physiological effects of substances and interpreting lab results for judges and juries.

In addition to expert testimony, physical evidence—such as drug paraphernalia, open containers, or behavioral indicators—can further support the impairment element. These items are discussed in the “Evidence from Vehicles” section above. Prosecutors must remain vigilant and avoid assuming impairment is self-evident; establishing this element clearly and thoroughly is essential to building a strong, defensible case.

Proving Distraction

Prosecuting distracted driving cases often requires proving inattention beyond a reasonable doubt, which can be a complex task. Building a strong case typically involves gathering evidence from multiple sources to demonstrate the driver’s distraction at the time of the incident. Eyewitness testimony—especially from passengers, bystanders, or other drivers—is among the most compelling, as they may have observed the defendant texting, holding a phone, eating, or engaging in other distracting behaviors.

Law enforcement observations, documented in crash reports or captured via body-worn cameras, can provide critical context, particularly if officers noted the driver’s demeanor, the presence of an active phone, or recorded admissions made at the scene. Video evidence from dashcams, traffic cameras, Flock systems, or nearby business surveillance can also be invaluable in showing the moments leading up to the crash.

Cell phone records, obtained through subpoena or search warrant, can confirm recent calls, texts, or app usage and help pinpoint the timing of distraction. Vehicle infotainment systems may reveal whether the driver was interacting with onboard technology at the time of the incident. Additionally, crash reconstruction experts can analyze the absence of evasive maneuvers or delayed braking—using both traditional methods and Event Data Recorder (EDR) data—to support the inference of inattention.

By combining direct and circumstantial evidence, prosecutors can construct a compelling narrative that clearly illustrates the role of distraction in the crash, helping jurors understand the full scope of the driver’s behavior and its consequences.

Ethical Considerations in Crash Prosecution

When filing charges related to traffic crashes, prosecutors must carefully balance the pursuit of justice with their duty to act with fairness, integrity, and restraint. Many traffic-related behaviors—such as speeding, distraction, or momentary inattention—are actions that nearly every driver may commit at some point. Weighing these common behaviors against the emotional impact of serious injuries or fatalities presents a complex challenge, and there is no legal formula to guide these decisions.

Prosecutors must ensure that any charges filed are supported by sufficient admissible evidence and meet the legal standards of probable cause and ethical discretion. The mere fact that a crash resulted in serious injury or death does not, on its own, justify criminal prosecution. It is the prosecutor's responsibility to distinguish between tragic incidents and criminal conduct involving the requisite mental culpability. Charging decisions must be based on an objective assessment of the driver's behavior, mental state, and the totality of circumstances—not on public pressure, media attention, or even the understandable emotions of victims and their families.

Ethical prosecution also requires full disclosure of exculpatory evidence and a commitment to avoiding overcharging or pursuing unsupported allegations. Prosecutors must focus on what can be proven and ensure that the law is applied consistently and fairly, without unjust punishment. In crash cases—especially those involving fatalities—ethical prosecutors must demonstrate both compassion for victims and a steadfast commitment to due process and the presumption of innocence.

Victim-Centered Considerations

Prosecutors handling vehicular crimes must not only grasp the technical intricacies of crash investigation and reconstruction—they must also guide victims through a complex and emotionally taxing legal process. These cases are uniquely tragic and challenging. Unlike many criminal prosecutions, defendants in vehicular homicides often lack malicious intent, yet their actions result in consequences as devastating as those in intentional crimes.

What sets these cases apart is the nature of the victims. Families affected by vehicular homicide—especially in multi-vehicle collisions—often have little to no prior experience with the criminal justice system. Prosecutors frequently work with secondary victims: individuals whose lives are permanently altered by the loss of a loved one, even though they were not directly involved in the crash. Their grief is profound, and the slow, methodical pace of the legal process can feel like an additional burden.

Crash investigations and reconstructions take time, and while justice must be thorough, it must also be compassionate. Prosecutors play a vital role in helping victims navigate this journey, ensuring they feel seen, heard, and supported every step of the way.

Beyond the frustration caused by delays inherent in the legal process, many victims of vehicular crimes struggle to understand why these cases are treated differently from intentional crimes—particularly regarding bail, sentencing, and punishment. The absence of clear criminal intent often leads to outcomes that feel misaligned with the gravity of the harm caused. Victims are frequently disheartened by plea agreements and sentencing recommendations, which may seem too lenient. In many cases, they hope for penalties far harsher than what the law allows.

This places prosecutors in a difficult position: they must pursue justice on behalf of the State while also navigating the deep emotional needs of victims and their families. Balancing legal realities with human grief requires empathy, transparency, and careful communication. Prosecutors must help victims understand the constraints of the law while validating their pain and ensuring their voices are heard throughout the process.

Supporting victims in vehicular crime cases requires a thoughtful balance of professionalism, empathy, and strategic legal action. While no single approach fits every situation, prosecutors can benefit from practical, victim-centered strategies tailored to the unique challenges these cases present. Below are key considerations to help guide effective and compassionate prosecution in vehicular crime cases.

Understanding Victimization in Crash Cases

Recognize and validate the psychological trauma victims endure and consistently acknowledge the emotional dimension of their experience throughout the case. Understand that their need for truth, validation, and closure often exists on a timeline that does not align with the pace or outcomes of the legal process. Meeting victims where they are emotionally—early and often—helps build trust and fosters a more compassionate approach to justice.

Trauma-Informed Communication

Prosecutors must remember that victims are grieving—and that grief often manifests as anger, confusion, withdrawal, or silence. Understanding how trauma affects behavior, memory, and communication is essential. Educating oneself on the psychological impact of loss can help prosecutors engage more effectively and compassionately with victims.

While bereavement is a natural response to loss, the sudden and violent nature of vehicular homicides significantly increases the risk of complicated grief, including post-traumatic stress disorder (PTSD), depression, and prolonged grief disorder.⁶ Families facing these tragedies often experience heightened emotional distress, especially when children are among the deceased or when the case receives media attention, which can intensify feelings of exposure and helplessness.^{7,8}

In moments of profound loss, prosecutors must approach victims with sensitivity, patience, and respect. Their role extends beyond legal advocacy to include emotional support and clear, compassionate communication. Understanding the impact of trauma is not optional—it's essential. Trauma-informed practices help prosecutors respond appropriately to victims' needs, recognizing that grief and trauma can affect how individuals process information, recall events, and engage with the legal system.

By adopting a trauma-informed approach, prosecutors can foster trust, reduce re-traumatization, and ensure that victims feel heard and supported throughout the legal process. In cases where the justice system intersects with deep personal tragedy, empathy and education are as critical as legal expertise.

Bereaved individuals often experience cognitive impairments like those seen in people with head trauma. This can affect their ability to concentrate, recall details, and communicate effectively. Prosecutors must approach victims with patience, empathy, and an understanding of how grief and trauma shape behavior.

The following guidance—adapted from a table of Dos and Don'ts originally created for primary care providers working with recently bereaved patients⁹—offers a helpful starting point for prosecutors engaging with victims. While tailored to the legal context, these principles can support trauma-informed, compassionate interactions that honor victims' emotional needs while navigating the demands of the justice system.

⁶ See Green BL, Krupnick JL, Stockton P, et. al.: Psychological outcomes associated with traumatic loss in a sample of young women. *American Behavioral Science* 44(5):817-837, 2001; Kaltman S, Bonanno GA: Trauma and bereavement: examining the impact of sudden and violent deaths. *Journal of Anxiety Disorders* 17(2):133-147, 2003; Kristensen P, Weisaeth L, Heir T: Bereavement and mental health after sudden and violent losses: a review. *Psychiatry* 75(1):76-97, 2012.

⁷ See Charles F. Reynolds, III, MD, et. al.: Grief and Prolonged Grief Disorder, American Psychiatric Association, p. 12, 2023, citing to Kristensen P, et. al.: Media exposure and prolonged grief: a study of bereaved parents and siblings after the 2011 Utoya Island terror attack. *Psychological Trauma* 8(6): 661-667, 2016.

⁸ See Charles F. Reynolds, III, MD, et. al.: *Grief and Prolonged Grief Disorder*, American Psychiatric Association, p. 11, 2023.

⁹ See Charles F. Reynolds, III, MD, et. al.: *Grief and Prolonged Grief Disorder*, American Psychiatric Association, Table 3-2, p. 58, 2023.

- DO pause and listen.
- DO ask for the victim's favored name and use that name from that point on.
- DO inquire about the victim.
- DO inquire about their relationship with the victim.
- DO inquire about their grief.
- DO be human.
- DON'T keep typing or writing when the person is talking.
- DON'T try to fix it.
- DON'T make "at least" statements, such as "at least they died peacefully" or "quickly."
- DON'T say you fully understand or that time heals all wounds.
- DON'T say that everything happens for a reason or has a purpose (or any other such platitude).
- DON'T use "should" statements.
- DON'T ask "why."

The initial contact with victims' families sets the tone for the entire case. Consistent, proactive communication—early and often—is essential. Early outreach by a victim advocate, when available, followed by timely engagement from the prosecutor, can ease anxiety and begin building trust.

Victim advocates and prosecutors should collaborate with families to develop a communication plan tailored to their preferences—whether that means regular email updates, scheduled in-person meetings, or designating a small number of consistent points of contact. Calls and messages should be returned promptly; victims should never feel they must chase down information or track the prosecutor's whereabouts.

Offer victims choices in how and when they receive updates. Create space and time for meaningful meetings and remain flexible to accommodate the family's needs. Come prepared—keep case files and notes accessible to ensure accurate, clear communication. Thoughtful, reliable contact helps victims feel respected, informed, and supported throughout the legal process.

Managing Expectations and Participation

Honest and transparent communication is essential from the outset. Prosecutors should clearly explain the legal process, timelines, potential challenges, and possible outcomes—even when those outcomes may be disappointing. When discussing limitations or setbacks, it's important to clarify that acknowledging a legal possibility does not mean endorsing the defendant's position. Prosecutors, trained to argue from multiple perspectives, must be mindful that such explanations can unintentionally signal alignment with the defense, potentially straining relationships with victims.

As difficult as these conversations may be, delaying the delivery of “bad news” only compounds victims’ trauma and makes future discussions more painful. If a motion is denied, a continuance is granted, or any other development affects the case’s progress, victims should be informed promptly and respectfully. Early expectation management fosters trust, reduces confusion, and helps victims feel more prepared for the road ahead.

Victims deserve to be heard—and to know that their voices matter. Prosecutors should create meaningful opportunities for family members to share their perspectives, going beyond the minimum requirements of victim rights laws. This includes inviting input at key stages of the case and ensuring victims feel empowered to express their views, even when those views differ from the prosecution’s approach.

It is important to make clear that victims are not expected to agree with every decision. One of the most respectful ways to demonstrate this is by listening without interruption or argument. When a victim expresses disagreement, the prosecutor should allow space for that expression without becoming defensive. The prosecutor’s position can be communicated clearly and respectfully, without diminishing the victim’s experience or emotions. This approach fosters trust, validates grief, and reinforces the prosecutor’s role as both advocate and ally.

Keeping Victims Informed

Many victims seek to understand what happened—how their loved one died, and why. While legal, ethical, or strategic considerations may limit what can be shared, prosecutors should strive to communicate investigative findings as openly as possible within the boundaries of office policy and professional standards. Establishing a shared understanding of the facts helps prevent confusion and tension in future interactions and fosters trust between prosecutors and victims.

Transparent communication not only builds credibility—it can also lead to unexpected benefits. In smaller communities, victims’ families may offer insights or information that open new investigative avenues or strengthen the case. When victims feel informed and included, they are more likely to remain engaged and supportive throughout the prosecution process.

Conclusion

Vehicular crime cases are among the most challenging in the criminal justice system—technically complex and emotionally charged. Their victims are everyday people whose lives were shattered in an instant while doing something routine: traveling on the road. These cases demand more than legal expertise; they require empathy, patience, and a deep understanding of trauma.

Prosecutors who approach these cases with both legal acumen and human compassion can offer families not only justice, but also a measure of peace. By honoring the emotional weight of these tragedies and committing to clear, respectful communication, prosecutors can help victims feel seen, heard, and supported throughout the process.

Presenting Crash Evidence at Trial

Crash cases often hinge on intricate technical evidence—ranging from reconstruction methodologies and Event Data Recorder (EDR) downloads to toxicology reports and forensic analyses of mobile devices and Infotainment systems. For prosecutors, the challenge lies not only in understanding this information, but in translating it into a form that jurors—typically unfamiliar with scientific or engineering concepts—can comprehend, trust, and use to reach a verdict.

To present technical evidence effectively to a jury, prosecutors must be thoroughly prepared for trial. The following general principles can help guide that preparation and ensure the evidence is communicated clearly and persuasively.

Preparing Expert Witnesses

Expert witnesses play a pivotal role in crash cases, but technical accuracy alone is not enough—they must also be clear, relatable, and persuasive. If an expert cannot communicate their findings effectively, it is as if the reconstruction never happened. Prosecutors should prepare experts to present their conclusions in plain language, using analogies, visuals, and storytelling to make complex concepts accessible. Prosecutors should encourage them to channel a teacher from their past—someone who made difficult subjects understandable and engaging.

Experts should speak *to* jurors, not *at* them. Jurors respond best to experts who combine confidence with humility, and who try to connect rather than impress. To prepare, experts should rehearse their testimony—either through a mock direct examination with the prosecutor or by explaining their findings to someone without a technical background, such as a friend or family member. These exercises help ensure the experts' message is logical, relatable, and memorable.

Depending on the jurisdiction's rules of evidence, establishing foundation for expert testimony typically does not require admitting all the underlying facts and data that support the expert's conclusion. For example, under Federal Rule of Evidence 703, an expert may base their opinion on facts or data that are not themselves admissible, provided they are of a type reasonably relied upon by experts in the field. Instead, the foundation for admitting expert opinion generally requires demonstrating four key elements, as outlined in Federal Rule of Evidence 702: that the expert's specialized knowledge will assist the trier of fact in understanding the evidence or determining a fact in issue; the testimony is based on sufficient facts or data; the testimony is the product of reliable principles and methods; and the expert has reliably applied those principles and methods to the facts of the case.

In practice, once the expert has been qualified, foundation is often established by having the expert summarize how their testimony satisfies Rule 702. At that point, the expert may offer their opinion. A strategic approach involves introducing the expert's conclusion early in their testimony, followed by a detailed explanation of how that conclusion was reached. This "front-loading" technique can be especially effective in maintaining juror attention, allowing the expert to repeatedly reference their conclusion while walking through the supporting methodology. Such repetition reinforces the key takeaway and enhances juror retention.

Given the complexity of certain mathematical concepts, it is often more effective to avoid delving into detailed calculations during direct examination. Instead, these concepts can be briefly introduced and summarized to provide context without overwhelming the jury. If the defense raises these issues, they can be fully explored during redirect, allowing for a more targeted and necessary explanation.

Simplifying Technical Evidence for Jurors

Crash prosecutions inevitably involve technical evidence—but the key is not avoiding complexity, it is making it understandable. While law enforcement and prosecutors may grow comfortable with the specialized language and concepts used by crash reconstruction experts, most jurors will not share that familiarity. For many, even a passing reference to physics or mathematical formulas can feel overwhelming or alienating.

That is why prosecutors must be intentional in how they present reconstruction evidence. Breaking down complex ideas into manageable, bite-sized pieces, using plain language wherever possible, and drawing on relatable analogies from everyday life can make a significant difference. When jurors can connect technical evidence to their own experiences, they are more likely to understand it, trust it, and apply it in their deliberations.

Consistency in terminology is essential throughout a case—from jury selection through closing arguments—as even minor variations in language can lead to confusion or undermine the credibility of the prosecution. To avoid this, it is advisable for the prosecutor to collaborate with the crash investigator early in the process to establish and align on the specific terms that will be used consistently throughout the proceedings.

For example, consider a case involving a speeding vehicle that enters a curve and loses control. When a vehicle takes a turn too fast, it may begin to slide sideways due to the lateral force exceeding the tire's grip on the road surface. Crash investigators can often estimate the vehicle's speed at the moment it lost traction by analyzing physical evidence at the scene and applying specific calculations.

To help jurors grasp the underlying physics, a simple analogy can be effective. For example, “Imagine swinging a bucket of water over your head using a string. As the bucket moves faster in a circular path, the force needed to keep it on that path increases, creating more tension in the string. If the tension exceeds the string's strength, it snaps—and the bucket flies off. Similarly, a crash investigator can calculate the amount of force, or speed, required for a vehicle to lose traction while navigating a curve. This helps determine the minimum speed at which the vehicle must have been traveling to veer off its intended path.”

Using Visual Aids and Demonstrations

Jurors absorb information more effectively when it's both seen and heard. To enhance understanding and retention, prosecutors should integrate visual aids—such as photographs, diagrams, maps, animations, videos, and timelines—throughout the trial. Because visual evidence can be complex, it's essential to guide jurors through each element deliberately and clearly, using witness testimony to highlight key details and explain their relevance. This strategic combination of visual and verbal evidence significantly increases the likelihood that jurors will grasp and remember critical facts.

When preparing for a crash case, a prosecutor should consider using illustrative or demonstrative visual aids, which are both cost-effective and impactful in helping jurors understand complex evidence. Under Federal Rules of Evidence Rule 107, these aids are admissible if they assist the trier of fact in understanding the evidence or argument, and if their usefulness is not substantially outweighed by risks such as unfair prejudice, confusion, or undue delay. It is important that witnesses are prepared to clearly explain any differences between the illustrative aid and the actual item or event it represents. Collaboration between the prosecutor and the crash investigator is essential to effectively incorporate these visual tools into testimony, as they can significantly enhance juror comprehension of technical concepts. For prosecutors who frequently handle crash cases, investing in a small collection of model vehicles—ideally at 1/24 scale—can be especially helpful. These models are large enough for jurors to see clearly, yet small enough to be easily handled during courtroom demonstrations.

Acknowledging Limitations of Reconstruction Evidence

Defense attorneys may challenge reconstruction evidence as inconclusive, flawed, or misapplied. They might argue that the expert used incorrect methods or formulas or misinterpreted the data. To prepare, prosecutors should work closely with their expert witnesses before trial to anticipate these lines of attack and proactively address any limitations or assumptions. It is often strategic to raise potential weaknesses during direct examination, giving the witness an opportunity to explain and neutralize them before the defense can frame them as negligence or bias. Transparency about margins of error and data limitations—paired with a clear emphasis on the overall reliability and consistency of the findings—can strengthen the credibility of the evidence and the expert.

In crash reconstruction cases, it is important for the prosecutor to not be discouraged by imperfections in the evidence. Defense strategies often focus on challenging the assumptions, measurements, or data used by the crash investigator in their calculations. However, most crash reconstruction formulas are designed to be robust, meaning they remain reliable even when inputs are slightly inaccurate—especially when considered within the framework of the legal burden of proof. Minor discrepancies rarely alter the overall outcome of the analysis. For instance, if a patrol officer measures a skid mark at 85 feet and the crash investigator uses that to estimate the vehicle was traveling approximately 42 mph when braking began, the defense might argue the measurement was incorrect and that the skid was only 65 feet long. Even if that claim is valid, the revised estimate would still place the vehicle's speed at around 37 mph. If the posted speed limit is 25 mph, the difference between 42 and 37 mph is legally insignificant—either way, the driver was substantially exceeding the limit, supporting a charge of careless driving.

Connecting Reconstruction to Testimony and Law

Witness statements play a vital role in crash reconstruction. While technical evidence—such as EDR data, dashcam footage, and forensic analysis—provides objective insights, its impact is amplified when aligned with human observations. Prosecutors can build a more persuasive narrative by showing how the data supports or contradicts what witnesses report. For instance, if a driver claims they braked and swerved to avoid a collision, EDR data can confirm or refute that action. Likewise, a witness's account of reckless driving becomes more credible when corroborated by vehicle telemetry or video evidence.

Prosecutors should take every opportunity throughout the trial—not just during closing argument—to highlight how crash investigation evidence supports favorable testimony or undermines unfavorable accounts. Waiting until the end may be too late to make a lasting impression on the jury. These connections should begin as early as opening statements. For example, a prosecutor might say: “In addition to Crash Investigator 1, you’ll hear from three eyewitnesses—other motorists who saw the crash unfold. As they testify, pay close attention to how their observations about the defendant’s speed and driving behavior align with the objective speed calculations provided by the crash investigator. As jurors, you’ll be asked to assess the credibility of each witness. If an eyewitness’s account is supported by the crash investigator’s data, does that make their testimony more reliable? And if the investigator’s findings are echoed by multiple eyewitnesses, does that increase your confidence in the accuracy of the investigation?” By drawing these connections early and often, prosecutors can help jurors better understand and retain the significance of the technical evidence presented.

Jurors must understand not just *what* the reconstruction evidence shows, but *why* it matters under the law. Prosecutors should clearly explain how each piece of evidence connects to the legal elements of the charged offenses. This relevance should be emphasized from opening statements through closing arguments, ensuring that jurors can see how the technical findings support the prosecution’s case and guide their application of the law.

Building a Persuasive Narrative

Jurors do not render verdicts based on science alone—they respond to stories. While it is easy for prosecutors to get immersed in the technical details, especially when facing a defense expert, it is crucial to remember that evidence must serve the broader narrative. Whether the case centers on speed, impairment, or distraction, ensure that every piece of technical evidence reinforces a clear, cohesive, and emotionally resonant story that supports the theory of the case.

Practical Application and Case Strategy

The application of these principles will vary significantly depending on a prosecutor's workload, workflow, case specifics, and communication style. To help integrate them effectively into trial preparation, the following step-by-step process offers a flexible framework for tailoring these general concepts to the unique demands of a prosecutor's case.

Identifying Complex Issues

Pinpoint any aspects of the case that may be counterintuitive, unexpected, or difficult for a jury to grasp. Are there scientific principles or technical concepts that must be understood to fully appreciate the evidence? Recognizing these challenges early allows a prosecutor to prepare clear, accessible explanations that support juror understanding and strengthen the case.

Building Foundational Knowledge

A prosecutor cannot effectively explain complex concepts to a jury without first understanding them personally. Developing expertise takes time and deliberate effort. Over the course of a career, prosecutors should strive to deepen their understanding of technical and scientific evidence.

This includes consulting reference materials—such as this monograph and relevant textbooks—engaging with fellow prosecutors, attending continuing education courses, and most importantly, learning directly from case-specific experts. Acknowledging gaps in knowledge and asking thoughtful follow-up questions is essential to growth. Building and maintaining relationships with professionals who regularly collaborate with prosecutors—such as medical examiners, state crime lab scientists, and law enforcement crash investigators—is invaluable for long-term professional development.

Using Relatable Analogies and Visuals

Analogies and real-world examples are powerful tools for helping jurors grasp complex concepts. By framing technical evidence in familiar, everyday terms, prosecutors can make abstract or scientific ideas more accessible and memorable. When preparing for trial, a prosecutor should take time to brainstorm comparisons that are broadly relatable and aligned with the jury's likely experiences or common sense.

Whenever possible, show the jury what a concept looks like—not just describe it. Visual aids can make abstract or technical information far more accessible. Effective tools include live demonstrations with model vehicles, pre-recorded videos, illustrative photographs, diagrams, animations, and any other creative visual that helps clarify the evidence. A well-chosen visual can bridge the gap between expert testimony and juror comprehension.

Practicing with Real Audiences

Testing explanations with real people—such as family, friends, or support staff—can be an invaluable part of trial preparation. These individuals serve as effective stand-ins for jurors and can help identify areas that need greater clarity. Their feedback should be taken seriously, especially when it challenges what may feel like a “perfect” presentation. Prosecutors should resist the urge to dismiss critiques and instead use them to refine their messaging and improve juror comprehension.

Step-by-Step Presentation Example

Case Summary. The defendant (driving a light-colored vehicle) rear-ended the victim’s dark-colored vehicle and subsequently fled the scene. The area of impact on the victim’s vehicle was *lower* than the corresponding damage on the defendant’s vehicle, suggesting a collision from behind. Multiple eyewitnesses confirmed that the defendant’s vehicle struck the rear of the victim’s vehicle.



Identifying Issue(s)

The defendant denies involvement in the crash, claiming that the damage to his vehicle resulted from an unrelated fender bender. He further argues that the relative height of the impact areas between the vehicles proves his car could not have been involved, as the damage does not align. This creates a conflict between eyewitness accounts and the physical evidence, leaving the prosecutor uncertain about how to proceed.

Consulting with the Crash Investigator to Resolve Apparent Contradictions

Faced with conflicting evidence, the prosecutor consults the crash investigator for clarification. The investigator explains that the apparent mismatch in impact height is a result of vehicle dynamics—specifically, inertia. Prior to the collision, the defendant’s vehicle was moving forward and attempted to stop abruptly, as indicated by skid marks at the scene. This sudden braking caused the lower portion of the vehicle to decelerate rapidly, while the upper portion continued its forward motion due to inertia.

This imbalance in forces created a rotational effect around the vehicle’s center of mass, effectively pulling the top of the car forward and downward at the moment of impact. The result is a misalignment in damage height that, while seemingly contradictory, is consistent with the physics of sudden deceleration.

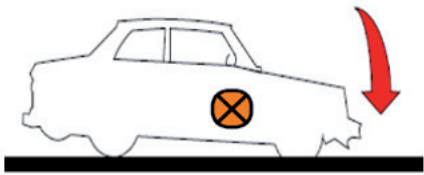


Using Familiar Analogies to Clarify Complex Concepts

Analogies help jurors connect unfamiliar technical ideas to everyday experiences. For example, most jurors have ridden a bicycle and can relate to the sensation of abruptly braking and being thrown forward—possibly over the handlebars. This simple comparison can effectively illustrate the physics of sudden deceleration and momentum in a crash, making the concept more intuitive and memorable.

Presenting the Concept Visually to the Jury

When the expert provides an illustration from a crash investigation textbook, a prosecutor should consider using it as a demonstrative exhibit to help jurors visualize the concept. Visual aids like diagrams, charts, and textbook illustrations can bridge the gap between technical testimony and juror understanding, making abstract ideas more concrete and accessible. Ensure the image is clear, relevant, and properly introduced to maximize its impact in court.



Using model cars, a prosecutor can collaborate with the crash investigator to visually demonstrate relative vehicle movement. This hands-on approach can help jurors better understand key concepts such as speed, direction, impact angles, and reaction times. Simple, tangible demonstrations often make abstract reconstruction evidence more relatable and memorable.

Explaining the Concept

In preparation for trial, a prosecutor might rehearse their explanation of a complex issue with a trusted partner or friend. For example, during a casual dinner a few weeks before trial, the prosecutor may ask their partner to listen as they walk through the issue using an illustration and toy cars. Explaining the concept in their own words helps identify areas that need clarification. When the partner asks follow-up questions—such as pointing out inconsistencies in terminology—the prosecutor can refine their explanation, ensuring it is clearer and more consistent before presenting it in court.

Conclusion

Effectively presenting reconstruction evidence at trial is crucial to securing convictions in crash cases. To make complex technical concepts accessible and persuasive, prosecutors should simplify the science, incorporate compelling visuals, and prepare expert witnesses to serve as educators. Integrating reconstruction evidence into both the narrative arc of the case and its legal framework strengthens its relevance and resonance. Acknowledging limitations while emphasizing the evidence's strengths builds credibility with the jury. When presented clearly and cohesively, reconstruction evidence becomes not just informative—but compelling and decisive.

Defense Strategies and Countermeasures

Crash cases often face a wide range of defense challenges, and it is essential for prosecutors to anticipate these early in their case review. Proactive preparation allows prosecutors to address potential weaknesses well before trial, strengthening the overall presentation of the case. This section outlines common defense strategies in vehicular crime cases and offers practical guidance on how prosecutors can respond effectively. By understanding and preparing for these challenges in advance, prosecutors can ensure they are ready to counter defense arguments with clarity, confidence, and credibility.

Addressing Causation Challenges

Causation is one of the most frequently litigated issues in crash cases involving serious injury or death—particularly in jurisdictions where causation is a required element of the charged offense. Prosecutors must be prepared to address this issue early in case development, as it often becomes a focal point for the defense.

When external factors such as weather, road conditions, or mechanical failures are present, the defense may argue that these elements—or even a third party or the victim themselves—were the true cause of the crash, rather than the defendant. Anticipating these arguments allows a prosecutor to build a stronger case by reinforcing the link between the defendant's conduct and the resulting harm. This includes working closely with reconstruction experts, gathering supporting evidence, and clearly articulating how the defendant's actions were a substantial factor in causing the injury or death.

Causation is a foundational concept in criminal law. To establish causation, the prosecution must demonstrate that the defendant's operation of the vehicle directly caused the harm in question. In cases involving multiple victims, causation must be proven individually for each person injured or killed. At trial, this means showing a clear and credible causal link between the defendant's actions and the resulting injury or death. Put simply, the prosecution must prove that the harm was a direct and foreseeable consequence of how the defendant operated the vehicle. This requires careful preparation, including expert testimony, thorough crash reconstruction, and a clear narrative that connects the defendant's conduct to the outcome.

Factual and Proximate Causation in Criminal Cases

In criminal law, causation is divided into two essential components: factual causation and proximate causation.¹⁰ To establish factual causation, the prosecution must demonstrate that the defendant's operation of the vehicle was a necessary condition for the injury or death—commonly framed as the “but for” test: *But for the defendant's conduct, would the harm have occurred.*¹¹ This step is often straightforward.

¹⁰ See, for example, *People v. Schaefer*, 473 Mich. 418, 435–36, 703 N.W.2d 774, 785 (2005), holding modified by *People v. Derror*, 475 Mich. 316, 715 N.W.2d 822 (2006).

¹¹ *Id.*

Proving factual causation alone, however, is not sufficient. The prosecution must also establish proximate causation, which ensures that the defendant's actions are closely and reasonably connected to the outcome. For conduct to qualify as a proximate cause, the injury or death must be a *direct and natural result* of the defendant's behavior. This legal standard is designed to prevent criminal liability in cases where the consequences of the defendant's actions are too remote, unforeseeable, or disconnected from the conduct itself.¹²

Understanding and clearly articulating both aspects of causation is critical to building a strong case and withstanding defense challenges.

Intervening Causes

When causation is challenged, the defense often argues that an intervening factor broke the causal link between the defendant's operation of the vehicle and the resulting injury or death. These intervening causes can take many forms—such as adverse weather, poor road conditions, or even the victim's own actions.

For example, in a winter crash involving icy and snowy roads, the defense may claim that the hazardous conditions—not the defendant's driving—were the true cause of the incident. Similarly, a defendant who strikes a pedestrian while allegedly blinded by the morning sun may argue that the sun was a superseding cause that absolves them of liability.

Victim behavior is also frequently cited as an intervening cause. Common arguments include:

- A pedestrian walking in the middle of the street at night in poor weather while heavily intoxicated
- A vehicle occupant ejected during a crash due to not wearing a seatbelt
- A driver whose toxicology report reveals impairing substances in their system at the time of the crash

This form of "victim blaming" has become increasingly prevalent, especially as post-mortem toxicology results more frequently show the presence of drugs or alcohol.¹³ Prosecutors must be prepared to counter these arguments by reinforcing the legal standard for proximate causation and demonstrating that the defendant's conduct was a substantial and foreseeable factor in the harm caused.

Defense Argument: Something Else Broke the Causal Link

At trial, the defense may argue that an intervening or superseding cause broke the causal chain between the defendant's actions and the victim's harm. In many jurisdictions, courts apply the objective test of reasonable foreseeability to determine whether the intervening act should relieve the defendant of liability. This test asks whether a reasonable person could have foreseen the intervening event as a possible consequence of the defendant's conduct.

¹² *Id.* at 436–437.

¹³ Thomas, F. D., Darrah, J., Graham, L., Berning, A., Blomberg, R., Finstad, K., Griggs, C., Crandall, M., Schulman, C., Kozar, R., Lai, J., Mohr, N., Chenoweth, J., Cunningham, K., Babu, K., Dorfman, J., Van Heukelom, J., Ehsani, J., Fell, J., ... & Moore, C. (2022, December). Drug prevalence among seriously or fatally injured road users (Report No. DOT HS 813 399). National Highway Traffic Safety Administration.

Generally, acts of God, gross negligence, or intentional misconduct by the victim or a third party are considered intervening, superseding causes that break the causal link. In contrast, ordinary negligence—because it is reasonably foreseeable—is typically not sufficient to sever causation.

For example, in *Washington v. Frahm*,¹⁴ the court held that a drunk driver's actions were the legal cause of a Good Samaritan's death, even though a second vehicle struck the victim. The court emphasized that the foreseeability of subsequent harm was a question for the jury, and that ordinary negligence by others did not absolve the original defendant of liability.

Importantly, evidence of ordinary negligence or unrelated acts that do not affect causation should be excluded at trial under a relevancy analysis. Such evidence risks confusing the jury and detracting from the central issue of whether the defendant's conduct proximately caused the harm.

Identify and Address Potential Intervening Causes Early

A prosecutor should proactively scan for potential intervening or superseding causes during their initial review of a case. Addressing these issues early—ideally in the pretrial phase—can significantly strengthen the prosecution's position and reduce the risk of surprises at trial.

To do this effectively, a prosecutor must first become familiar with their jurisdiction's state-specific laws and terminology related to causation. While causation is a foundational concept in criminal law, the precise language and standards for proving it vary by jurisdiction. Most states require proof of both factual causation (using the "but for" test) and legal causation (often framed as proximate cause).

Legal causation hinges on foreseeability: courts generally ask whether the harm was a reasonably foreseeable result of the defendant's conduct. If an intervening act—such as a third party's intentional misconduct or a natural event—is deemed independent and unforeseeable, it may break the causal chain and absolve the defendant of liability. Ordinary negligence by the victim or others, however, is typically considered foreseeable and does not sever causation.

By reviewing relevant case law and understanding the burden of proof for causation in their jurisdiction, a prosecutor can assess whether causation may be contested and prepare accordingly. This includes identifying expert witnesses, gathering supporting evidence, and crafting arguments that reinforce the foreseeability and directness of the defendant's actions.

Addressing Causation Challenges Pretrial

If, after reviewing the case file and relevant case law, it appears that causation may be contested, a prosecutor should act early by filing a pretrial motion to preclude the defense from introducing arguments or evidence suggesting that another factor broke the causal link between the defendant's conduct and the resulting harm.

For example, consider a case where the defendant impaired driver was driving on the wrong side of the highway, collided with another vehicle, and killed a passenger. The victim was not wearing a seat belt and was ejected during the crash. The defense may attempt to argue that the victim's failure to wear a seat

¹⁴ *State of Washington v. Frahm*, 193 Wash.2d 590 (2019).

belt—not the defendant’s driving—was the direct cause of death. In such a scenario, the prosecutor should move to exclude any testimony or evidence about the seat belt, arguing that it is not relevant to the core issue of whether the defendant’s unlawful driving caused the fatal crash.

Filing a motion in limine on causation helps prevent the jury from being misled or confused by legally irrelevant arguments. Even if the court allows some causation-related evidence to be introduced, addressing the issue pretrial ensures the prosecutor is prepared to respond effectively.

Resolving causation questions before trial is a critical step that provides the prosecutor with a clear understanding of the case’s foundational issues. By addressing these questions early, the prosecutor can develop a focused strategy, anticipate potential defense arguments, and confidently present evidence that supports the theory of the case. This preparation not only strengthens courtroom performance but also enhances the prosecutor’s ability to guide the jury through complex technical and legal concepts, ultimately increasing the likelihood of a successful outcome at trial.

Contributory Negligence

A prosecutor should be alert to defense strategies that attempt to introduce contributory negligence in crash cases—a tactic that often amounts to victim blaming. While contributory negligence is a recognized concept in tort law, it is not a defense in criminal prosecutions, including vehicular homicide. Its purpose in civil court is to allocate losses between parties based on shared fault. In contrast, criminal law is concerned solely with the defendant’s conduct in relation to the State.

As Noah M. Kazis explains in the *Yale Law Journal*, “Tort uses contributory negligence because tort allocates losses from plaintiffs to defendants; both parties’ behavior is at issue. In contrast, criminal punishment is a matter between the state and the defendant; generally, only the defendant’s behavior is relevant.”¹⁵

Courts have consistently held that only gross negligence, intentional misconduct, or unforeseeable acts by the victim or a third party may qualify as intervening, superseding causes. For example, in *People v. Tims*, the Michigan Supreme Court emphasized that a defendant’s conduct needs only be a proximate cause, not the sole cause, of the victim’s death. While a victim’s negligence may be relevant during the causation analysis, it is not a legal defense to criminal liability.¹⁶

This distinction is reinforced in Massachusetts jury instructions for motor vehicle homicide, which explicitly state that principles of contributory or comparative negligence do not apply and are not a defense to the crime. The Commonwealth must prove that the defendant’s conduct was a factual and legal cause of death, and that the death was a reasonably foreseeable consequence of that conduct—not that the victim acted perfectly.¹⁷

¹⁵ Noah M. Kazis, *Comment: Tort Concepts in Traffic Crimes*, 125 *Yale L.J.* 1131, 1139-1140 (2016).

¹⁶ As previously mentioned, whether a victim’s negligent behavior is relevant to causation will depend on each state’s specific case law on the issue. For example, in Michigan a victim’s negligent behavior must rise to the level of gross negligence to be relevant to causation. Simple, ordinary negligence is not enough.

¹⁷ See, for example, *Commonwealth v. Carlson* 447 Mass. 79 (2006) and MGLA 90 § 24G—Homicide by motor vehicle.

Prosecutors must be prepared to actively challenge any attempt by the defense to shift blame onto the victim, particularly when such arguments are unsupported by evidence or designed to distract from the defendant's conduct. Filing motions in limine to exclude irrelevant or prejudicial material is a key strategy to maintain the integrity of the proceedings. These motions should be narrowly tailored, citing applicable case law and evidentiary rules, and clearly explain why the proposed evidence or argument lacks legal relevance and poses a risk of confusing the jury or unfairly shifting blame. By keeping the focus squarely on the defendant's actions, prosecutors help ensure that the criminal process remains fair, evidence-based, and centered on accountability.

Proving Operation Without Direct Evidence

One of the most common—and potentially frustrating—challenges in vehicular crime cases is proving that the defendant was operating the vehicle at the time of the crash. A prosecutor should never assume this element is self-evident. This issue becomes especially complex when the defendant falsely claims that a deceased victim was the driver, and no eyewitnesses are available to refute the allegation.

To effectively counter this defense, early and thorough investigation by law enforcement is essential—particularly while the vehicle remains in state custody. The sooner investigators begin gathering evidence related to vehicle operation, the more reliable and, therefore, persuasive the prosecution's case will be. When operation is likely to be contested, investigators and reconstructionists should pursue the following lines of inquiry:

- Is the vehicle secured and under state control?
- Are there detailed photographs of the vehicle's interior, including seat positions and airbag deployment?
- Have the defendant's clothing and shoes been collected and preserved?
- Are there comprehensive photographs of the defendant's injuries, including areas of the body that show no trauma?
- Has the clothing of the alleged operator (as claimed by the defense) been secured?
- Are autopsy or medical photographs available that document the alleged operator's injuries?

These pieces of evidence can help reconstruct seating positions, injury patterns, and other forensic indicators that support or refute claims about who was driving. A proactive approach to this issue can prevent the defense from exploiting gaps in the investigation and help ensure accountability.

Expanding the Investigation: Building a Strong Case for Operation

The investigation into who was operating the vehicle should not stop with basic observations. A prosecutor must ensure that law enforcement conducts a thorough and methodical investigation to gather evidence capable of proving operation beyond a reasonable doubt. This is especially critical in cases where the defense may falsely claim that a deceased victim was driving and no eyewitnesses are available to refute the claim. The following types of evidence can be instrumental in confirming that the defendant was the driver:

- Eyewitness testimony: Individuals who saw the defendant operating the vehicle before or after the crash.
- First responders: Emergency personnel who heard the defendant admit to driving or observed indicators placing them behind the wheel.
- Medical personnel: Hospital staff who documented admissions or injuries consistent with driving (e.g., seatbelt marks, steering wheel impact).
- Medical records: Notes or reports containing admissions or injury patterns consistent with being the driver.
- Vehicle interior damage: Evidence such as head strike marks or seatbelt tensioners that align with the defendant's injuries.
- Forensic evidence: Fingerprints, hair, blood, or fibers on the driver's side or controls.
- Ownership and usage: Vehicle registration, insurance, or other documentation showing the defendant as the primary user.
- Personal belongings: Items in the vehicle that clearly belong to the defendant.
- Occupant protection systems: Seatbelt use, airbag deployment, and related forensic data.
- Seat position: Driver's seat adjusted in a way consistent with the defendant's height and build.
- Footwear evidence: Brake pedal indentation or scuff marks matching the defendant's shoes.
- Infotainment system data: GPS, Bluetooth, or user profiles linking the defendant to the driver's seat.
- Surveillance footage: Video from nearby businesses or residential cameras showing the defendant entering or exiting the driver's seat.
- Exclusionary evidence: Proof that other occupants could not have been driving (e.g., victim lacked the ability to operate a manual transmission).

By proactively gathering and preserving this evidence, a prosecutor can build a compelling case that withstands defense challenges and clearly establishes the defendant as the vehicle's operator.

Using Medical and Forensic Evidence to Establish Vehicle Operation

Medical records, coroner reports, and autopsy findings can provide critical evidence to support expert testimony about who was operating the vehicle at the time of the crash. These documents often contain injury patterns and forensic details that, when properly interpreted, can help establish operation beyond a reasonable doubt.

Investigators and prosecutors should look for the following types of evidence in these reports:

- Pattern injuries:
 - Chest injuries consistent with steering wheel impact
 - Leg injuries from contact with the shift lever or door handle
 - Knee trauma from dashboard impact
 - Rib injuries from striking the door panel
 - Facial lacerations from windshield contact
 - Abrasions from contact with the headliner
 - Teeth impressions on vinyl dashboard material
- Forensic indicators:
 - Blood smears on interior surfaces
 - Hair embedded in the windshield
 - Clothing fibers in broken dashboard components
 - Clothing fused to the seat
 - Fabric fusion on seat belts or dashboard
 - Damage to the rear-view mirror from head impact
 - Brake pedal damage consistent with leg injury
 - Forensic analysis of deployed airbags
 - Spider-web fractures in the windshield with corresponding injury patterns
- Seatbelt and occupant protection evidence:
 - Seatbelt marks or abrasions consistent with use
 - Evidence from airbags and seatbelt tensioners
- Vehicle configuration and personal fit:
 - Driver seat position consistent with the defendant's height
 - Brake pedal indentation matching the defendant's footwear

This evidence, when combined with expert analysis, can be powerful in rebutting defense claims and establishing the defendant as the vehicle's operator. Prosecutors should work closely with forensic experts to ensure these findings are clearly presented and tied directly to the narrative of the case.

Absence of Evidence Does Not Equal Evidence of Absence

It is important to understand that the absence of specific injury patterns or forensic indicators should not be taken as definitive proof that a particular individual was not operating the vehicle. In many cases, relevant evidence may simply be missing—not because it does not exist, but because it was not documented by law enforcement, observed by witnesses, or even produced by the crash itself. Crash scenes can be chaotic, and not all physical or biological evidence survives or is properly preserved. Conclusions about driver identity must therefore be based on a comprehensive evaluation of all available evidence, rather than relying solely on the presence or absence of certain forensic markers.

The list of potential indicators is intended to serve as a flexible guide rather than a rigid checklist that must be fully satisfied in every case. Because each crash presents unique circumstances, the presence or absence of specific types of evidence will naturally vary. Prosecutors and investigators should prioritize gathering and preserving as much relevant information as possible, recognizing that the absence of certain markers does not automatically rule out a person as the driver. A comprehensive and context-sensitive approach to evidence collection ensures that conclusions are based on the totality of the circumstances, rather than the presence of any single factor.

Countering Post-Crash Drinking Claims

Another common defense strategy in impaired driving cases is the claim that the defendant consumed alcohol after the crash, during the time gap before law enforcement arrived. This argument tends to surface when there is a noticeable delay between the collision and initial police contact, creating a window in which the defense can suggest post-crash drinking occurred. By asserting that the defendant was sober while driving and only became impaired afterward, the defense aims to cast doubt on the prosecution's impairment evidence and shift the timeline of intoxication. This tactic can be particularly effective if not countered with strong investigative findings and timely witness accounts, making it essential for prosecutors to anticipate and address such claims early in the case.

To effectively counter potential defense narratives, it is essential that the investigating officer conducts a prompt and thorough roadside interview. By asking focused, strategic questions early on, the officer can secure the defendant's statements before there is time to craft an alternative version of events. Capturing these statements in a clear and well-documented manner not only preserves the integrity of the investigation but can also serve as compelling evidence at trial, particularly if the defendant later attempts to contradict or revise their account. Key questions officers should ask the defendant include:

- How much alcohol did you consume before arriving at this location?
- When was your last drink before the crash?
- Did you consume any alcohol after the crash? If so, what, when, and how much?

- If drugs are suspected, adapt the questions to determine:
 - What substance was used?
 - When was it last used?
 - In what form was it taken (e.g., smoked, ingested, injected)?
 - Was any substance used after the crash?

To preserve the integrity of a crash investigation, key questions should be asked as early as possible and thoroughly documented in both written reports and body-worn camera footage. Early documentation helps capture the defendant's initial statements before they have an opportunity to adjust their account to align with a potential legal defense. This proactive approach not only strengthens the evidentiary record but also enhances the credibility of the investigation by ensuring that the defendant's responses are spontaneous and unfiltered.

Responding to Common Defense Tactics

A defense strategy in crash cases often depends heavily on the specific facts and the strength of the reconstruction. A thorough and well-documented investigation—covering scene processing, vehicle examinations, witness interviews, and technical analysis—can significantly limit the defendant's ability to challenge the prosecution's case. The more complete the investigative work, the fewer opportunities exist for the defense to exploit gaps or inconsistencies. In many instances, the quality and depth of the reconstruction directly influence whether the defense can credibly argue alternative theories or raise reasonable doubt, making meticulous preparation essential to a strong prosecution.

In any vehicular homicide or serious crash case, the integrity of the investigative process is critical. Prosecutors must be vigilant in identifying and addressing potential weaknesses before they become focal points for the defense. Even minor gaps, errors, or omissions can be magnified in court, casting doubt on the prosecution's case and undermining the credibility of its experts.

One of the most frequent areas of contention involves eyewitness testimony. The defense may highlight inconsistencies between different accounts or point out discrepancies between what witnesses observed and what the reconstruction suggests. These conflicts can raise questions about the reliability of both the witnesses and the investigative conclusions.

Speed calculations are another common battleground. If the methodology used to estimate vehicle speed is unclear, disputed, or based on incomplete data, the defense may argue that the findings are speculative or flawed. Similarly, determining the precise point or area of impact can be contentious, especially if the evidence is ambiguous or if the expert failed to consider alternative scenarios.

Mechanical failure is often raised as a possible contributing factor. The defense may suggest that the crash resulted from a defect in the vehicle—such as a malfunction in the suspension, steering, or fuel injection system—or point to anomalies in airbag deployment or cruise control operation. If these possibilities were not thoroughly investigated, they can introduce reasonable doubt.

Preservation of evidence is also crucial. If the vehicle was not made available for defense inspection, or if key components were altered or destroyed before analysis, the defense may argue that their ability to conduct an independent evaluation was compromised. Likewise, a shallow or incomplete investigation into driver impairment—whether due to alcohol, drugs, or fatigue—can leave the prosecution vulnerable to criticism.

Physical evidence must be carefully measured and interpreted. Mistakes in documenting skid marks, debris patterns, or vehicle damage can lead to flawed conclusions. The defense may also argue that the defendant had no opportunity to take evasive action, especially if visibility was limited or if the pedestrian was not easily seen due to poor lighting or clothing.

Environmental factors, such as defective signage, poor roadway design, or surface hazards, may be introduced to shift blame away from the defendant. In hit-and-run cases, challenges in vehicle identification can further complicate matters, particularly if surveillance footage is unclear or if witness descriptions conflict.

To counter these challenges, prosecutors must work closely with investigators and experts from the outset. Every aspect of the case—from scene documentation to vehicle analysis—should be conducted with precision and transparency. This collaborative approach ensures that the investigation is thorough, the evidence is clearly presented, and any technical or factual vulnerabilities are minimized before trial. A well-prepared case anticipates defense strategies and is supported by evidence that is not only scientifically sound but also consistent and easy for jurors to understand. This level of preparation strengthens the prosecution's position and reinforces the credibility of the investigative findings in court. By anticipating the defense's arguments and proactively addressing potential weaknesses, the prosecution can present a compelling, well-supported narrative that stands up to scrutiny.

Preparing to Challenge Defense Experts

In crash cases, it is common for the defense to retain an expert witness to challenge the prosecution's reconstruction and offer alternative interpretations of the evidence. Effectively countering such testimony requires thorough preparation and strategic planning. One of the prosecutor's first priorities should be to gather detailed information about the defense expert, including their background, qualifications, and potential biases. Key considerations include whether the expert has a broad but shallow understanding of the technical issues, whether they are a retired law enforcement officer now working in private practice, and whether they have a pattern of routinely testifying for the defense.

To build a strong cross-examination strategy, prosecutors should review transcripts or summaries of the expert's prior testimony to identify inconsistencies or recurring weaknesses. Verifying credentials such as education, certifications, and professional affiliations is essential, as is analyzing any publications, presentations, or interviews that may reveal the expert's methodologies or opinions. Consulting with the prosecution's own expert can help identify technical flaws or questionable assumptions in the defense expert's analysis. Additionally, searching public records and expert witness databases can uncover relevant background information that may be useful in court. By investing time in this research, prosecutors can more effectively challenge the credibility and conclusions of the defense expert, presenting a stronger, more persuasive case to the jury.

To effectively challenge a defense expert at trial, prosecutors should leverage every available resource to uncover valuable insights and build a strong cross-examination strategy. One of the most effective starting points is consulting with the prosecution's own expert. Often, the state's expert may have prior experience with the defense expert or know where to find relevant information and can help identify weaknesses in the defense expert's methodology or conclusions.

Networking with fellow prosecutors is another powerful tool. Colleagues who have encountered the same expert in previous cases may offer useful feedback, share transcripts, or provide strategic advice. Prosecutor forums or listservs can be excellent platforms for gathering this kind of intelligence.

Additionally, national organizations such as the National District Attorneys Association and its National Traffic Law Center maintain cross examination resources on experts who have testified in traffic safety cases. These resources are available to prosecutors and can provide detailed background information, including prior testimony and known biases.

State-level resources, including a prosecutor's state's prosecuting attorney's association or designated Traffic Safety Resource Prosecutor (TSRP), can also assist in locating expert witness records, even from out-of-state cases. If a prosecutor is unsure of their state's TSRP, the National Traffic Law Center maintains a current list at <https://www.ndaa.org/traffic-safety-resource-prosecutors>.

Finally, the State Police crash reconstruction unit may be familiar with the defense expert, especially if the expert has testified in multiple jurisdictions. Because these units operate statewide, they often have broader exposure to recurring expert witnesses than local investigators.

By tapping into these networks and tools, prosecutors can thoroughly investigate the defense expert's background and credibility, ultimately strengthening their position in court.

Reviewing Materials to Prepare for Cross-Examination

Once background information on the defense expert has been gathered, the prosecutor should conduct a thorough review of all available materials to prepare for a focused and effective cross-examination. Start with the expert's curriculum vitae (CV), which provides insight into their qualifications, experience, and claimed areas of expertise. Next, carefully analyze the expert's report in the case, paying close attention to their conclusions, methodology, and any underlying assumptions. Working notes and calculations should also be reviewed—ideally with the assistance of the prosecution's own expert—to check for accuracy, consistency, and potential flaws.

Relevant publications authored by the expert, such as articles or papers on crash reconstruction, can reveal their professional viewpoints and preferred methodologies. Prior transcripts of courtroom testimony are especially valuable for identifying patterns, contradictions, or areas of vulnerability in the expert's presentation style or opinions. Additionally, prosecutors should examine any supporting research or technical references cited by the expert to assess whether they are credible, current, and appropriately applied.

By thoroughly reviewing these materials, prosecutors can identify key areas for challenge, expose weaknesses in the expert's analysis, and craft a cross-examination strategy that is both precise and persuasive.

Strategic Preparation with the State's Expert

In crash cases, where expert testimony often plays a central role, early and strategic collaboration with the state's expert is essential. These cases frequently evolve into a "battle of the experts," requiring the jury to assess which expert is more credible, thorough, and persuasive. To effectively counter the defense expert's testimony, prosecutors should meet with their own expert to analyze the defense report, understand the opposing theory, and craft a targeted rebuttal.

This collaboration helps shape a comprehensive trial strategy, including a focused cross-examination plan. Key areas to explore when challenging the defense expert may include:

- **Lack of Direct Involvement:** Determine whether the expert personally visited the crash scene, collected evidence, or simply relied on the police investigation without independent verification.
- **Limited Investigation:** Assess whether the expert failed to interview key individuals such as the investigating officer, the defendant, or eyewitnesses, and whether they conducted their own reconstruction.
- **Questionable Qualifications or Bias:** Scrutinize the expert's specialization, publication history, and professional affiliations. Consider whether they routinely testify for the defense or are receiving a substantial fee under a retainer agreement.
- **Methodological Weaknesses:** Identify any reliance on unverifiable assumptions, unpublished studies, or personal testing. Evaluate whether their conclusions diverge from the state's evidence without sound justification or peer review.

By identifying and exposing these vulnerabilities, prosecutors can effectively challenge the defense expert's credibility, methodology, and impartiality—ultimately reinforcing the strength and reliability of the state's case in the eyes of the jury.

Strengthening the State's Expert Testimony

In cases where expert testimony is pivotal, prosecutors must do more than challenge the defense's reconstructionist—they must also rigorously prepare their own expert to withstand scrutiny. The credibility of the state's expert can be the linchpin of a successful prosecution and reinforcing that credibility requires strategic foresight and thorough preparation.

Defense attorneys often attempt to undermine the state's expert by attacking their qualifications, methodology, and handling of evidence. For instance, they may highlight a lack of authoritative citations, published research, or peer-reviewed work. If the expert cannot explain the equations used in their reconstruction or lacks ACTAR certification, these gaps may be exploited to cast doubt on their competence.

The handling of the crash scene and physical evidence is another common area of attack. Delays in visiting the scene, failure to calibrate measuring equipment, or neglecting to inspect the defendant's vehicle for mechanical issues can all be portrayed as oversights. Similarly, if visibility tests were conducted under different conditions than those present at the time of the crash, or if the expert failed to return to the scene during daylight hours following a nighttime incident, these details may be used to question the reliability of their conclusions.

Analytical shortcomings can also be damaging. An expert who cannot pinpoint the area of impact, who overlooks key materials, or who alters their report after reviewing the defense's findings may appear uncertain or biased. The absence of photographic documentation, sensitivity analyses, or a complete reconstruction of the victim's vehicle motion can further erode confidence in their testimony.

Peer review and verification are equally critical. If the expert has never conducted relevant tests, failed to consult with colleagues, or omitted significant findings from their report, the defense may argue that their conclusions lack scientific rigor and objectivity.

To counter these potential vulnerabilities, prosecutors should engage in early and frequent collaboration with their expert. This includes reviewing possible weaknesses, crafting a direct examination that emphasizes the expert's qualifications and impartiality, and rehearsing responses to anticipated cross-examination. Every step of the investigation should be meticulously documented and disclosed to demonstrate transparency and thoroughness.

By proactively addressing these issues, the prosecutor can present a well-prepared, credible expert whose testimony resonates with the jury and withstands the challenges posed by the defense.

Conclusion

Crash reconstruction is more than a technical exercise—it is a powerful storytelling tool that helps prosecutors explain how and why a crash occurred. By translating physical evidence, vehicle data, and expert analysis into a clear narrative, prosecutors can bridge the gap between science and the law. Understanding the phases of a collision, the role of modern vehicle technology, and the methodologies used by reconstructionists allows prosecutors to ask the right questions, challenge flawed defense theories, and present compelling, fact-based arguments in court.

As traffic fatalities remain a persistent public safety concern, the ability to effectively prosecute crash cases is more important than ever. Prosecutors who are well-versed in crash reconstruction can better advocate for victims, hold dangerous drivers accountable, and contribute to broader efforts to improve roadway safety. With the right knowledge and preparation, crash reconstruction becomes not just a technical resource, but a cornerstone of justice in traffic-related prosecutions.

Appendix A—Glossary of Terms

A

ABS (antilock brake system). A braking method in which wheel sensors prevent the wheels from locking, producing a greater drag factor and allowing vehicle steering during the braking.

ABS scuff marks. The tire mark evidence of braking made by ABS, the tires never lock up (sometimes called “ABS skid marks”). These marks are usually much lighter than locked-wheel skid marks and are very short-lived as they are worn away by travel.

Acceleration. A change in linear velocity with respect to time; change of velocity divided by time; a vector quantity measured in ft/s/s (ft/s²) or m/s/s (m/s²); expressed as a decimal fraction of acceleration of gravity ($a = fg$). Positive acceleration increases velocity of a body; negative acceleration decreases the velocity of a body. Acceleration can also be change in angular velocity with respect to time measured in radians/s/s and degrees/s/s.

Acceleration of gravity. The acceleration of a falling body due to the force of gravity (its weight); a standard of comparison for acceleration; usually taken as 32.2 ft/s/s or 9.81 m/s/s, g .

Acceleration scuff. A scuff mark made when sufficient power is applied to the driving wheels to make at least one of them spin on the road surface.

Accelerometer. An instrument that is attached to a vehicle to assess the road-tire drag factor when emergency braking is applied (this instrument is susceptible to user manipulation).

Acquaintance. Any person other than a driver, passenger, or witness who is acquainted with people or vehicles connected with the collision or knows some of the results or other circumstances of the collision.

After collision situation map. A scale drawing of the scene after a traffic collision situation has stabilized; a graphic summary of collision results without indication of any assumed events of the collision or other inferential elements.

Airbag control module (ACM). A generic term for the Electronic Control Unit (ECU) within a vehicle that controls the supplemental restraint systems, including airbag deployment and seatbelt pretensioners. A component within the ACM is the event data recorder (EDR). See **event data recorder (EDR)**.

Air brakes. Brakes that utilize compressed air instead of fluid.

Air compressor. A device to build up and maintain required air pressure in the air brake system reservoir.

Air lines. Used to carry compressed air from one part of the air brake system to another and from tractor to the trailer. One line is called the emergency or supply line and is always charged with compressed air. The other line is called the service or control line. When the air brake treadle valve is depressed, air flows from the supply reservoir through the service line and causes the brakes to apply.

Air pressure gauge. Measures pressure of air in air tanks in lbs per inch² (psi). If the pressure drops below 60 psi, a low-pressure warning device (buzzer or light) will operate, indicating unsafe vehicle. Sometimes there are two. The second gauge indicates pressure used during braking.

Air reservoir. A storage tank for compressed air.

Angle collision. A collision between two traffic units approaching on separate roadways or other paths that intersect.

Angular acceleration. The time rate of change of angular velocity, radians/s/s and/or degrees/s/s. See **acceleration**.

Angular velocity. The time rate of change of rotational displacement, radians/s and/or degrees/s.

Animation. The process by which the movement of objects is illustrated.

Apex. The point at which two sides of an angle meet or cross.

Approach speed. The vehicle travel speed relative to the road prior to the first significant event in the collision sequence.

Arc. Part of a curve, especially part of a circle, between two points on the curve.

Articulated vehicle. See **truck**.

At-scene investigation. Examining and recording results of a traffic collision and obtaining additional information at the scene of the collision that may not be available later and which supplements data obtained for the collision report. The information obtained is factual, as far as possible.

Attribute. Any inherent characteristic of a road, a vehicle, or a person that affects the probability of a traffic collision.

Available path. The entire area in a trafficway in which a traffic unit may maneuver without interfering with other traffic units. Available path is not the same as the road space a vehicle is legally entitled to travel.

B

Backlite. The rear or back window which spans from the driver's to passenger's side of the vehicle.

Backlite header. The structural body member which connects the upper portions of the rearmost driver and passenger pillars and forms the top edge of the backlite.

Bank. See **superelevation**.

Barrier equivalent velocity (BEV). The speed of a vehicle at 90 degrees into a fixed flat barrier which would give a similar amount of crush or equivalent work done in deformation as to the equivalent energy dissipated and experienced by the damaged collision vehicle. See **equivalent barrier speed (EBS)**.

Bicycle. A two-wheeled pedalcycle.

Bituminous concrete. Concrete cemented with a bituminous material such as tar or asphalt.

Bobtail. A tractor without a trailer, not a straight truck.

Body type. The general configuration or shape of a vehicle distinguished by characteristics such as number of doors, seats, or windows, roof line, hardtop, convertible, etc.

Brake efficiency (brake percentage). The percentage of braking that was developed by the weight distribution on wheels with operative brakes or brakes that are out of adjustment.

Braking distance. The distance through which brakes are applied to slow a vehicle; the shortest distance in which a particular vehicle can be stopped by braking from a specified speed on a particular surface; the distance from application of brakes to collision.

Braking time. The time required to traverse the braking distance.

B-trains. A combination consisting of a tractor and two semi-trailers, the second trailer coupled to the first trailer by use of a fifth wheel, which is mounted directly behind the cargo body on the lead semitrailer.

Bus. Any motor vehicle designed for carrying more than 10 passengers and used for transportation of persons; and every motor vehicle, other than a taxicab, designed and used for the transportation of persons for compensation.

C

Cab-alongside-engine. A tractor in which the cab is located alongside the engine (abbreviated CAE). Same as **cab-beside-engine**.

Cab-behind-engine. A tractor on which the cab is located behind the engine (a conventional cab).

Cab-beside-engine. Same as **cab-alongside-engine** (abbreviated CBE).

Cab-conventional. A tractor on which the cab is behind the engine.

Cab-over-engine. A tractor on which the cab is located over the engine (abbreviated COE).

Car. Every motor vehicle, except motorcycles and motor-driven cycles, designed for carrying 10 passengers or less and used for the transportation of persons.

Car line. A name denoting a family of vehicles within a make which has a degree of commonality in construction such as body, chassis, etc.

Cause analysis. The effort to determine, from whatever information is available, including results of collision reconstruction, why the collision occurred, that is, the complete combination of circumstances that caused the highway transportation system to break down at the time and place of the collision. Cause analysis has been referred to as determining “indirect” or “condition” causes.

Center of gravity. The singular point of a body where the resultant gravity force (weight) acts without respect to its orientation.

Center of mass. See **center of gravity**.

Central impact. An impact in which the impulse (Principal Direction of Force, PDOF) passes through the center of mass.

Change in momentum. The (vector) difference of mv of each vehicle during the impact phase.

Change in velocity (Δv). The difference in the magnitude and direction of velocity vectors between two points in time. See **delta-v**.

Check valve. Device to automatically isolate one part of air brake system from another. A one-way check valve provides free air flow in one direction only. A two-way check valve permits actuation of the brake system by either of two brake application valves.

Chip. A short, deep gouge; a hole in pavement made by a strong, sharp, pointed metal object under great pressure, usually without striations.

Chop. A broad shallow gouge, beginning with an even, regular, deeper side and terminating in scratches and striations on the opposite shallower side; a depression in pavement made by strong, sharp metal edge moving under heavy pressure. More commonly occurring at the impact event as opposed to post-impact trajectory.

Chord. A straight line connecting the ends of an arc or two points on a curve. A chord is never greater than the diameter of a circle of which the arc is a part.

Closing velocity. The vector difference between the velocity of the vehicle and the vehicle/object struck immediately before impact.

Coefficient of friction. A number representing the resistance to sliding of two surfaces in contact; the drag factor of a vehicle or other object *sliding* on a roadway or other surface which is *level*; the force parallel to a surface required to keep in motion an object sliding on that surface, divided by the force of the object against that surface; measured in pounds per pound; often designated by the Greek letter Mu (μ).

Coefficient of rolling resistance. The ratio of the rolling resistance to the vertical load.

Collision. That occurrence in a sequence of events which usually produces unintended injury, death or property damage.

Collision data retrieval (CDR) system. The tool used to image crash data that has been recorded in the EDR system within the vehicle; it is the link between the EDR and a computer.

Collision reconstruction. The effort to determine, from whatever information is available, how the collision happened. Reconstruction was formally referred to as determining “behavioral” or “mediate” causes of a **collision**.

Collision scene. The area of a traffic collision before vehicles and people involved have left. Compare with **collision site**.

Collision scrub. A short, usually broad, skid mark or yaw mark made during engagement of the vehicles in a **collision**.

Collision site. The place where a traffic collision occurred after vehicles and people involved have left the scene. Compare with **collision scene**.

Complex reaction. A choice between two or more possible reactions to an unexpected hazard.

Concrete. A paving material consisting of an aggregate of stones of assorted sizes held together with a cement binder; bituminous concrete; Portland cement concrete.

Condition factors. Deficiencies in basic attributes of roads, vehicles, or people, as related to highway transportation and permanently or temporarily modified, that contribute to operational factors.

Conservation of energy. The principle of physics stating that the amount of energy in a closed system is constant regardless of the changes in the form of that energy. Used in collision investigation in estimating vehicle speed from the distance required to slide to a stop and other applications, such as speed from damage.

Conservation of momentum. The principle of physics that the sum of all vehicle before-collision momentum must equal the sum of all vehicle after-collision momentum.

Contact damage. Deformation or defacement resulting from direct pressure of another object or surface in an impact, direct damage. Compare with **induced damage**.

Converter gear or dolly. The coupling device composed of one or two axles and a fifth wheel by which a semitrailer can be coupled to the rear of a tractor-trailer combination, forming a double-bottom rig.

Coordinate measurements. A method of locating any spot in an area by two measurements from the nearest point to the spot on a specified reference line: 1) the distance and direction from that point to the spot, and 2) the distance and direction from that point to a specified reference point on the reference line.

Critical speed yaw. When a vehicle in a turning motion is traveling too fast for the road condition and the path of the turn, the vehicle can lose traction and go into a side-slipping motion called a critical speed yaw.

Critical velocity. A velocity above which a particular highway curve, or a curve demanded by a driver, could not be negotiated by a motor vehicle without exceeding the available traction force at the tires on a specific surface.

Crook. An abrupt change of direction of tire mark due to collision forces. The crook often indicates the position of a tire at first contact.

Crush area. Area defined by the original vehicle exterior and the crush profile.

Crush profile. The geometric shape in a specified plane (i.e., vertical, horizontal) which describes the vehicle damage resulting from the impact.

Curb weight. The total weight of a vehicle, including its fluids, cargo, and passengers.

D

Debris. Loose material scattered about at the scene as a result of a traffic collision: dirt, liquids, vehicle parts, cargo, personal belongings and other things.

Delta-t (Δt). Contact duration; the time duration of impulse.

Delta-v (Δv). The vector difference between first contact (impact) velocity and the separation velocity of the vehicle's center of mass. Note there is a change of speed and usually a change of direction during the impact.

Discriminative reaction. A reaction to perception of an unfamiliar hazard or other situation which requires additional information than that immediately available to make a decision or which presents several choices of possible evasive tactics.

Drag factor. A number representing the acceleration or deceleration of a vehicle or other body as a decimal fraction of the acceleration of gravity – $f = a/g$; the horizontal force needed to produce acceleration in the same direction divided by the weight of the body to which the force is applied. When a vehicle slides with all wheels locked, on a level surface, the coefficient of friction and the drag factor have the same value.

Drag sled. A device that facilitates the measurement of road friction (drag factor) by pulling the sled with a calibrated spring scale and then weighing the sled.

Dribble. Liquid debris from a vehicle or its cargo that drops to the ground, often leaving a trail, if the vehicle is moving, from a spatter area to a puddle.

Driver. Every person who drives or is in actual physical control of a vehicle.

Drone. An unmanned aerial device equipped with a camera, which can hover above a crash scene to take photographs of the scene evidence and produce data for a to-scale drawing.

Drop off. The edge of pavement where it is more than about 2 inches (about 5 cm) higher than the abutting shoulder.

Dry tank. Part of truck air brake system. Air passes from wet tank to dry tank. Dry tank is the air reservoir from which the air is drawn for operating the brake system.

Duals. A pair of wheels and tires mounted together on the same side of one axle.

Dynamic crush. The maximum vehicle deformation during impact; total of restitutional and residual crush.

E

Eccentric impact. When the Principal Direction of Force (PDOF) does not pass through the vehicle's center of mass. See **non-central impact**.

Edge line. A line which indicates the edge of the roadway.

Elastic deformation. The part of dynamic crush which is recovered after the collision force is removed. This is equal to the maximum dynamic crush minus the residual crush.

Elastic impact. An impact where the coefficient of restitution is approximately equal to one.

Electronic stability control (ESC). A system which distributes power to the tires of a vehicle based on the amount of individual tire slippage, to prevent loss of vehicle control.

Energy. Ability to do work or produce an effect such as damage; a unit of force operating through a unit of distance; for kinetic energy, half of the mass times velocity squared; force times distance, measure in ft-lbs.

Equivalent barrier speed (EBS). The speed of a vehicle at 90 degrees into a fixed flat barrier that would give a similar amount of crush or equivalent work done in deformation as to the equivalent energy dissipated and experienced by the damaged collision vehicle.

Event data recorder (EDR). A device or function in a vehicle that records the vehicle's dynamic time-series data during the time period just prior to a crash event (e.g., vehicle speed vs. time) or during a crash event (e.g., delta-v vs. time), intended for retrieval after the crash event. For the purposes of this definition, the event data do not include audio and video data.

F

Factor. Any circumstance contributing to a result without which the result could not have occurred; an element that is necessary to produce the result, but which is not, by itself, sufficient; operational factor; condition factor.

Fall. A downward and onward movement in the air under the force of gravity after forward momentum carries an object beyond its supporting surface. Rotation (pitch) during a fall is gradual and the object usually lands right side up.

Field sketch. A freehand map of the scene or site of a collision showing certain features of the collision or road configuration, usually for the purpose of recording measurements.

Fifth wheel. The coupling device located on the truck tractor's rear frame that is used to join the front end of the trailer to the tractor. It is a flat, rounded plate with a V-shaped notch in the rear.

Final position. The exact location of a vehicle or body after a traffic collision.

First contact position. The position of a vehicle or pedestrian at the time it first has contact with another body in a collision.

First contact velocity. The velocity of the center of mass of a vehicle or pedestrian at the time it first has contact with another body in a collision.

Fixed object. Stationary objects such as guardrail, bridge railing or abutments, construction barricades, impact attenuators, trees, embedded rocks, utility poles, ditches, steep earth or rock slopes, culverts, fences and buildings.

Flat-tire mark. A scuff mark made by an over-deflected tire; a mark made by a tire which is under-inflated or overloaded.

Flip. A sudden upward and onward movement off the ground when an object's horizontal movement is obstructed below its center of mass by an obstacle on the surface supporting the object. Rotation during a flip is rapid and the object usually lands upside down. Sometimes called vault. Compare with fall.

Force. That which influences motion or tends to do so; pressure, thrust; a vector quantity measured in pounds (lbs) and newtons (N).

Friction. The force, F , developed between two surfaces (usually the tire and the road) that acts against the motion of the vehicle to slow it down ($F = W f$).

Friction force. See **coefficient of friction**.

Friction mark. A tire mark made when a slipping or sliding tire rubs the surface of the road or another surface.

Frontal impact. An impact involving the front of the vehicle.

Full impact. An impact during which motion momentarily ceases between some areas of the colliding objects while they are in contact with each other; the damage centroids of two colliding objects attain a common velocity.

Furrow. A channel in loose or soft materials, such as snow or soil, made by a skidding or a scuffing tire or some other part of a moving vehicle.

G

Gap skid. Braking skid mark which is interrupted by release and re-application of brakes or which terminates by release of brakes before collision.

Gear ratio. The relationship of the number of teeth on or revolutions of one gear to the number of teeth on or revolutions of the gear with which it is engaged.

Glad hands. Connectors mounted on the front of a trailer for connecting air lines from the truck tractor.

Gore. The area immediately behind the bifurcation of two roadways, bounded by the edges of those roadways; the angle between two roadways where one roadway divides into two.

Gouge. A pavement scar deep enough to be easily felt with the fingers; chip, chop, or groove.

Governor, Air. A device to automatically control the air pressure being maintained in the air reservoirs. The device keeps air pressure between 90 and 120 psi and prevents excessive air pressure from building up.

Grade. The change in elevation in unit distance in a specified direction along the center line of a roadway or the path of a vehicle; the difference in level of two points divided by the level distance between the points. Grades are designated in feet (meters) of rise or fall per foot (meter) of level distance or in rise or fall as a percent of the level distance. Grade is positive (+) if the surface rises in the specified direction and negative (-) if it falls in that direction.

Groove. A long, narrow, pavement gouge or a channel in the pavement.

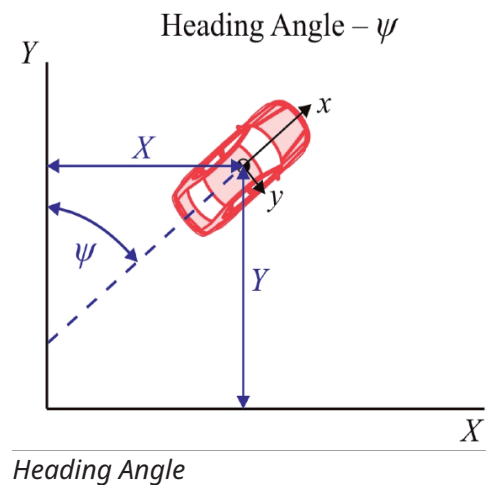
H

Heading angle (ψ). The horizontal angle between a reference axis fixed in the vehicle and a reference axis fixed in the roadway, giving a measure of vehicle yaw rotation or directional orientation relative to the roadway.

Highway. The entire width between the boundary lines of every way publicly maintained when any part thereof is open to the use of the public for purposes of vehicular travel; a street; a publicly maintained traffic-way.

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 braking mechanism at the wheel.



I

Identification. Designation of a road location, a vehicle, a person, or a traffic collision in such a manner as to positively distinguish it from all others of the same description. Identification is often accomplished by a unique number such as a Vehicle Identification Number (VIN), registration number, or driver's license number.

Identifying numbers. Numbers and letters, if any, on a vehicle designated by the department for the purpose of identifying the vehicles; Vehicle Identification Number (VIN) is not the registration number.

Impact. The striking of one body against another; a collision of a vehicle with another vehicle, a pedestrian, or some other object.

Impact force (lever arm) moment arm. The perpendicular distance from an object's center of mass to the line of action of the impulse (PDOF).

Imprint. A mark on a road or other surface made without sliding by a rolling tire or a person's foot. An imprint usually shows the pattern of the tire tread or shoe that made it.

Impulse. Quantity that as a result of a force system (colliding vehicles) during a time interval that is equal to the change in linear momentum of the system ($F\Delta t = m\Delta v$). During an impact, there are forces that occur between the vehicles which vary in position and time. The impulse is the summation of those forces over the contact duration expressed as a vector (the integral of $F dt$).

Induced damage. Damage to a vehicle other than contact damage. Often indicated by crumpling, distortion, bending, and breaking. Induced damage includes damage done by another part of the same vehicle. Compare with contact damage.

Informant. Any person who communicates information; not an informer.

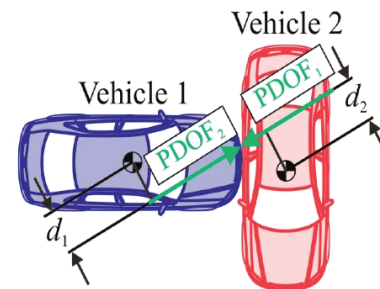
Information. Any knowledge received concerning a particular matter, such as a traffic collision, from any source, regardless of the reliability of the knowledge.

Intended course. The path that would have been followed by a traffic unit as a normal part of its trip had the situation hazard not led to evasive tactics or collision.

Interchange. A system of interconnecting roadways in conjunction with one or more grade separations, providing for the movement of traffic between two or more roadways on different levels. Compare with **intersection** and **junction**.

Interrogation. Formally examining a suspect by questioning.

Intersect. The point at which two straight lines, such as the extensions of two roadway edges, cross each other; the apex of the angle formed by two straight lines which cross. Also called point of **intersection**.

PDOF and Moment Arms (d_1 and d_2)

Impact Force Moment Arm

Intersection. The area embraced within the prolongation or connection of the lateral curb lines, or, if none, then the lateral boundary lines of the roadways of two highways which join one another at, or approximately at, right angles, or the area within which vehicles traveling upon different highways joining at any other angle may come in conflict. Where a highway includes two roadways 30 ft or more apart, then every crossing of each roadway of such divided highway shall be regarded as a separate intersection. In the event such intersecting highway also includes two roadways 30 ft or more apart, then every crossing of two roadways of such highways shall be regarded as a separate intersection. Compare with **junction**.

J

Junction. The general area where two or more highways join or cross within which are included the roadway and roadside facilities for traffic movements in the area. A junction may include several intersections of roadways.

K

Kinetic energy. See **energy**.

L

Lane line. A line separating two lanes of traffic traveling in the same direction.

Last contact. The final touching of objects in a collision before separation; the time and place on a traffic unit or trafficway where this touching occurs. If colliding objects do not separate, there is no last contact.

Leading edge. The foremost part of a vehicle with respect to the vehicle's motion and attitude.

Liquid debris. Scattered liquids from a vehicle or its cargo; spatter, dribble, puddle, runoff and soak-in.

M

Mapping. The documentation of evidence locations using a variety of methods—a laser or GPS measuring instrument, such as the Total Work Station, drone mapping, or scanning.

Maximum engagement. The greatest penetration of one body, such as a vehicle, by another during collision; instant of greatest force between colliding objects; time and place of this occurrence; position of bodies with respect to each other at this instant.

Median. That portion of a divided highway separating the roadways for traffic in opposite direction. If the median is more than about 100 ft (30 m), the area is usually considered as roadside.

Middle ordinate. The perpendicular distance between an arc and its chord at the middle of the chord.

Moment of inertia. The property of a body that measures its resistance to change in rotation rate; sum of the product of mass elements and the square of the distance from the axis of rotation ($\int r^2 dm$).

Momentum. Mass times velocity. Momentum is a vector quantity. See **conservation of momentum**.

N

Non-central impact. An impact in which the impulse (PDOF) does not pass through the center of mass, eccentric impact.

O

Oblique impact. An impact between two vehicles in which the velocities of the vehicles prior to impact are not parallel.

Occupant kinematics. A field of study focusing on how occupants of a vehicle move during a collision, usually for the purpose of identifying who was operating a vehicle.

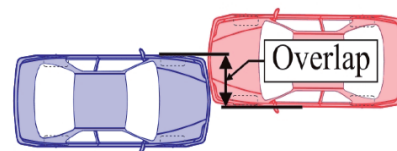
Opposite direction collision. A collision between two traffic units moving in opposite directions on the same roadway. Sometimes called head-on collision.

Overdeflected. A condition of a tire in which the force on the road is greater at the edges of the tread than in the middle; an overloaded or underinflated tire condition.

Overhang front and rear. The dimension measured longitudinally from the center line of the front/rear wheels to the foremost/rear-most point on the vehicle including bumper, bump guards, tow hooks, and/or rub strips if standard equipment.

Overlap. The length of mutual contact damage.

Overreaction. A driver's excessive reaction to a hazardous situation that produces another, or additional hazard. Overreaction is usually a matter of too much steering at high speeds, and often results in a yaw.



Overlap

Oversteer. A vehicle attribute where over-response to the steering input results, as by generation of excessive slip angle on rear wheels; response of vehicle to steering input, characterized by an incremental increase in yaw rate which necessitates a decrease in front steer angle to maintain the intended radius of turn with increased speed. Motor vehicles with more weight on the rear wheels than on the front, and with too little air pressure in the rear tires, are likely to oversteer. Oversteer is a vehicle attribute; overcorrection is a driver attribute.

P

Partial impact. An impact in which motion is continuous between the parts of colliding objects which are in contact with each other, sideswipe. The damage centroids of the damage areas of two colliding vehicles do not attain a common velocity. Compare with **full impact**.

Passenger. Any person in or on a vehicle involved in a collision other than the driver.

Peak longitudinal braking friction. The maximum longitudinal friction obtained between the tire and road surface.

Pedalcycle. A vehicle operated solely by pedals, and propelled by human power.

Pedestrian. Any person afoot; any person not in or upon a motor vehicle or other road vehicle.

Perception. The general process of detecting some object or situation and comprehending its significance.

Perception delay. The time from the point of possible perception to actual perception.

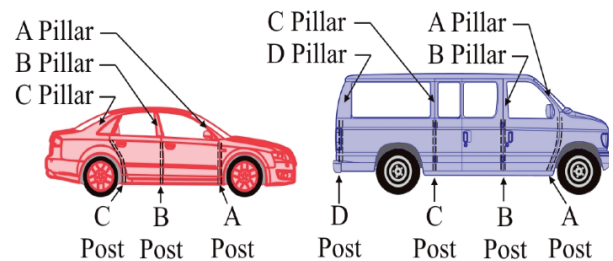
Perception-reaction time (PRT). The time required for the driver's brain to perceive, recognize, decide, and then initiate an action in response to an emergency situation; may also be called perception-response time.

Performance. The degree to which reaction corresponds to a decision relating to evasive tactics or driving strategy; how well the decision is executed. Performance is not necessarily the success of reaction, because an excellent performance of a bad decision may have an unfortunate result.

Perspective grid. A parallelogram of known size placed on a flat surface so as to appear in a photograph as a basis for locating marks or points which also show in the photograph of the surface.

Photogrammetry. The use of photographs in making maps.

Pillars and posts—A, B, C, D. The vertical pillars or posts of the vehicle forming the major vertical structural members of the body. The A post is the most forward vertical member which carries the front door hinges etc., the B post is the second most forward vertical member etc. Upper pillars normally support the roof and glazing, while lower posts support doors and side panels. Typically, the B posts support the front door striker and may not necessarily extend to the roof line.



Pillars and Posts

Pintle hook. A coupling device at rear of truck for the purpose of towing trailers.

Plastic impact. An impact where the coefficient of restitution is approximately equal to zero.

Pneumatic. A braking system that uses air as the fluid to transmit the necessary force to activate the braking mechanism at the wheel.

Point of possible perception. The place and time at which the hazard could have been perceived by a normal person. It precedes actual perception and is the beginning of perception delay.

Pole trailer. Any vehicle without motive power designed to be drawn by another vehicle and attached to the towing vehicle and ordinarily used for transporting long or irregularly shaped loads, such as poles, pipes or structural member, which are generally capable of sustaining themselves as beams between the supporting connection. See **truck**.

Portland cement concrete. A concrete made with Portland cement.

Primary cause. A misnomer loosely applied to the most obvious or easily explained factor in the cause of a collision or the most easily modified condition factor.

Principal direction of force (PDOF). The direction of impulse usually in vehicle-fixed coordinates; resultant force applied over the crash interval to produce the same crash impulse. The force against a traffic unit considered to be concentrated on a particular point of that unit at an instant during a collision; a single force that represents the net impact force applied to the traffic unit.

Print. An imprint of liquid or fine dust picked up by a tire or shoe sole at one place and left at another, usually showing the pattern of the tire or shoe that made it.

Puddle. A wet area on the road or roadside where dribble accumulates after a vehicle has come to rest. A puddle often marks the final position of a vehicle after a collision.

R

Reaction. A person's voluntary or involuntary response to a hazard or other situation that has been perceived; the response to a sensory stimulus. Reactions may be reflex, simple, complex, or discriminatory.

Reaction distance. The distance moved or traveled by a vehicle or other traffic unit during reaction time.

Reaction time. The time required from perception to start of vehicle control for tactical or strategic operations.

Recap (tires). The process of bonding new tread rubber to a used tire; a tire that has been recapped.

Reference line. A line, often the edge of a roadway, from which measurements are made to locate spots, especially spots along a roadway.

Reference point. A point from which measurements are made to locate spots in an area; sometimes the intersect of two reference lines; RP. A reference point is described in terms of its relation to permanent landmarks.

Regroove. The process of cutting new grooves into a tire. This can be done only on tires that are made specifically to be regrooved. They are marked regroovable.

Reporting. Basic data collection to identify and classify a motor vehicle traffic collision and the persons, property and planned movements involved. Only strictly factual information is wanted, no opinions. Level 1 of traffic collision investigation.

Residual crush. The amount of permanent displacement of a specific vehicle component caused by the impact.

Road. The part of a trafficway which includes both the roadway, which is the traveled part, and any shoulder alongside the roadway. Where there are unmountable curbs, the road and roadway are the same. If there is a guardrail, the road is considered to extend to the guardrail.

Roadway. The part of the road intended for vehicle travel. It does not include paved or otherwise improved shoulders or what is sometimes called a "berm" or "breakdown lane."

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

Run-off. Rivulets of liquid debris from a puddle area flowing downhill toward soak-in at the edge of the pavement; frequently the source of tire prints after a collision.

Rut. A depression in soft or loose material, such as snow or dirt, made by a rolling tire.

S

Same direction collision. A collision between two traffic units moving in the same direction on the same roadway. Sometimes called a rear end collision.

Scar. Any sign that the road, roadside, or fixed object has been damaged or marred by a traffic collision.

Scene. The location of a traffic collision while people and vehicles involved are still there. Compare with **site**.

Scrape. A broad area of a hard surface covered with many scratches or striations made by a sliding metal part without great pressure.

Scratch. A light and usually irregular scar made on a hard surface, such as paving, by a sliding metal part without great pressure.

Scuff mark. A tire friction mark made by a tire that is both rotating and slipping on a road or other surface.

Secondary impact. Second or subsequent impacts between the same two vehicles during the crash.

Semitrailer. Any vehicle with or without motive power, other than a pole trailer, designed for carrying persons or property and for being drawn by a motor vehicle, and so constructed that some part of its weight and that of its load rests upon or is carried by another vehicle. See **truck**.

Separation velocity. The velocity (including the direction of travel) a collision vehicle possesses at the point where the physical contact has ended.

Shoulder. That portion of the road contiguous with the roadway for accommodation of stopped vehicles, for emergency use, and for lateral support of the roadway structure. The line between the roadway and the shoulder may be a painted edge line, a change in surface color or material, or a curb.

Sideslip angle, vehicle. The angle of the vehicle x-axis and the vehicle velocity vector at some specified point in the vehicle. Usually, the angle is designated by β .

Sidewalk. That portion of a street between the curb lines, or the lateral lines of a roadway, and the adjacent property lines, intended for use by pedestrians.

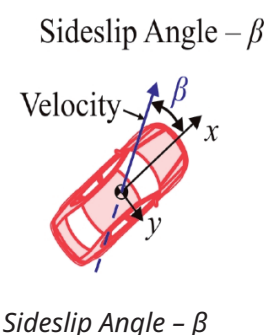
Simple reaction. A preplanned reaction to an expected hazard or other stimulus.

Site. The location of a traffic collision after vehicles and people involved have gone. Compare with **scene**.

Situation hazard. A circumstance that more or less endangers a traffic unit on a trip and which must be avoided to prevent a collision.

Skid mark. A friction mark on a pavement made by a tire that is sliding without rotation. Sliding of wheels may be due to braking, to collision damage, or, rarely, to other circumstances.

Skip skid. A braking skid mark interrupted at frequent intervals; the skid mark made by a bouncing wheel on which brakes keep the wheel from turning. Compare with **gap skid**.



Slave flash. A supplementary photoflash placed at a distance from the master flash to increase the illuminated field in a photograph and fired by a photoelectric device actuated by light from the master flash.

Sliding friction. The value of the force coefficient of a tire obtained on a locked wheel for a given tire, road surface, environment, and operating condition.

Slip angle, tire. The angle between the tire *x*-axis and direction of travel of the center of tire contact. This angle describes the horizontal angle between the direction of wheel travel and the direction of wheel heading.

Soak-in. An area on the shoulder or roadside saturated with liquid debris either at the end of run-off or as a puddle marking the rest position of a vehicle after a collision.

Spatter. The collection of marks on the road made by liquid from the vehicle or its cargo squirted from containers on the vehicle by force of collision. Spatter areas are irregular in shape and often consist of many spots.

Speed. A rate of progress (distance per time), usually without regard to direction; distance divided by time (if speed is constant).

Spread tandem. A two-axle assembly in which the axles are separated by distances substantially greater than that in conventional assemblies.

Spring brake. A device that consists of a conventional brake chamber and an emergency or parking brake mechanism for use on vehicles equipped with air brakes. The service brake chamber portion of the spring brake is identical to, and functions the same as a brake chamber. The rear portion of the spring brake, sometimes called the piggyback, houses a large and powerful spring and diaphragm, which under normal conditions, is held in the released position (spring compressed) by air pressure. If air is exhausted from the spring cavity, the spring expands, forcing the diaphragm, push plate, and rod forward, applying the vehicle brakes. A mechanical release bolt at the rear of the chamber is provided to mechanically cage the spring and release the brakes, if necessary.

Stabilized collision situation. The condition prevailing after motion and other action constituting the events of a collision have ceased and no further harm will ensue unless a new series of events is initiated by some means.

Stiffness (crush) coefficient. Empirical factors used in the calculation of total dissipated energy and ultimately the velocity change (Δv) for vehicular collisions. These factors define the force deflection relationship or crush resistance of the vehicle's exterior.

Strategy. Adjusting speed, position on the road, and direction of motion, giving signals of intent to turn or slow, or any other action in situations involving potential hazards; any maneuvers while on a trip which increase the chance of success in avoiding an actual hazard.

Striations. Narrow, light, parallel stripes or streaks usually made by friction or abrasion on the roadway or on vehicle parts.

Superelevation. The degree to which the outside edge of a roadway is higher than the inside edge at a specified point on a curve; the change in elevation per unit distance across the roadway from inside to outside edge; bank.

T

Tachograph. A recording device in a truck tractor that automatically records the number of miles driven, the speed, the number of stops, and other pertinent statistics.

Tactic. An action taken by a traffic unit to avoid a hazardous situation; steering, braking, accelerating, etc. to avoid a collision. Often called evasive action.

Tandem axle. An assembly to two axles, either, none or both of which may be powered.

Tangent. A line that touches a curve at only one point and is perpendicular to the radius at that point; a term used to describe a straight offset method.

Technical follow-up. A collection of additional facts from any source and organization and preliminary study of all available data relating to a collision.

Time-distance analysis. An analysis that utilizes the mathematical relationship(s) among the variables of a motion—elapsed time, distance traveled, and vehicle speed.

Tire friction mark. A tire mark made when a slipping or sliding tire rubs the road or other surface; skid marks; yaw marks; acceleration scuffs and flat-tire marks.

Tire mark. A mark made on a road or other surface by a tire on a vehicle: tire friction mark, imprint.

Total stopping distance. The total distance it takes for a vehicle to come to a stop—the sum of the braking distance and the reaction distance.

Total work station (TWS). An instrument consisting of a mapping unit, the theodolite, and a retroreflective evidence mirror that uses a pulse of infrared light to measure and document evidence locations at a crash scene. The TWS can be used to map road geometries, curvatures, etc. to produce a to-scale drawing of a crash scene (another version of the TWS uses GPS locations to document the evidence).

Tracking. Marks made when tires roll through puddles, run-off, or spatter and, becoming wet, leaving tire prints on the pavement as they roll on.

Track width. The distance on the ground between the center of the tire tread on one side of the vehicle to the center of the tire tread on the opposite side.

Traffic. Pedestrians, ridden or herded animals, vehicles, street cars, and other conveyances either singly or together while using any highway for purposes of travel.

Traffic unit. An element of traffic; a person using a trafficway for travel or transportation; vehicle; pedal cycle, pedestrian, etc.

Trafficway. The entire width between property lines, or other boundary lines, of every way or place of which any part is open to the public for purposes of vehicular travel as a matter of right or custom. All highways are trafficways, but trafficways include also some areas on private property such as shopping centers.

Trailer. Every vehicle with or without motive power, other than a pole trailer, designed for carrying person or property and for being drawn by a motor vehicle and so constructed that no part of its weight rests upon the towing vehicle.

Trailing edge. That portion of a vehicle component (such as door, window, fender, quarter etc.) which is closest to the rear of the vehicle. The rear most part of a vehicle with respect to the vehicle's motion and attitude.

Tread. That part of a tire designed to come in contact with the ground.

Triangulation. A method of locating a spot in an area by measurements from two or more reference points, the locations of which are identified for future reference. Compare with **coordinates**.

Tri-axis identification. See **vehicle coordinate system**.

Trip point. That point on the ground surface at which the motion of a vehicle component is suddenly halted such that a flip, roll over, or vault begins.

Truck. Every motor vehicle designed, used, or maintained primarily for the transportation of property.

Truck tractor. Every motor vehicle designed and used primarily for drawing other vehicles and not so constructed as to carry a load other than part of the weight of the vehicle and load so drawn.

U

Uncontrolled final position. A final position reached by a traffic unit after a collision without conscious human intervention.

Underbody debris. Debris consisting of mud, dust, rust, paint, snow, or road tar loosened by collision from the underside of the vehicle body, fenders, and other parts.

Understeer. A characteristic of a motor vehicle as loaded that results in a tendency to swerve toward the outside of a curve. Motor vehicles with more weight on front wheels than on rear wheels, or with too little pressure in the front tires, are likely to understeer at high speed.

Uniform Vehicle Code. A specimen set of motor vehicle laws, designed and advanced as a comprehensive guide or standard for state motor vehicle and traffic laws.

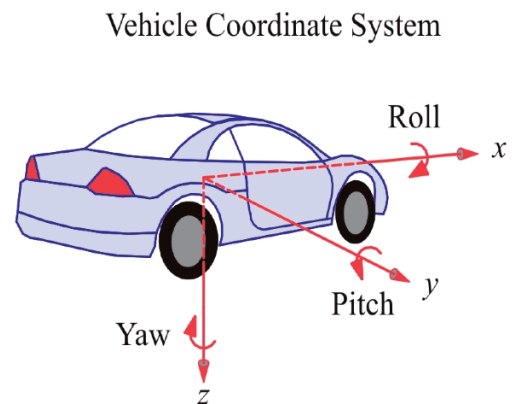
V

Vault. An endwise flip.

Vector. A quantity that has both magnitude and direction, such as force, velocity, acceleration, momentum. It is represented graphically with the angle of the arrow indicating direction, and its length representing magnitude.

Vehicle. Every device in, upon, or by which any person or property is or may be transported or drawn upon a highway, excepting devices moved by human power or used exclusively upon stationary rails or tracks.

Vehicle coordinate system, sometimes called the **tri-axis system.** See diagram for roll, pitch, and yaw rotation definitions plus x -, y -, and z -coordinates.



Vehicle Coordinate System

Vehicle Identification Number (VIN). The number assigned to the vehicle by the manufacturer primarily for identification and registration purposes.

Vehicle length. The maximum dimension measured longitudinally between the foremost point and the rearmost point in the vehicle, including bumper, bumper guards, tow hooks and/or rub strips, if standard equipment. Also known as overall length (OAL).

Vehicle width. The maximum dimension measured between the widest point on the vehicle, excluding exterior mirrors, flexible mud flaps, and marker lamps, but including bumpers, moldings, sheet metal protrusions, or dual wheels if standard equipment. Also known as overall width (OAW).

Velocity. Time rate of change of position in which direction and rapidity are elements; distance divided by time (if velocity is constant); a vector quantity measured in feet per second (ft/s) or meters per second (m/s).

W

Wet tank. The first tank that receives air pressure from the air compressor and is susceptible to water buildup. This tank must be drained at least once per day for water and engine oil. The next air tanks in line are referred to as dry tanks.

Wheelbase. The distance from the center of the front wheels to the center of the rear wheels, or, if there is a tandem axle, the distance to the midpoint between the two tandem axles.

Wheel slip. The ratio of the forward velocity of the tire at the road surface to the forward velocity at the center of the wheel.

Wind resistance. The force of the atmosphere against a moving vehicle; atmospheric drag factor; a combination of forces produced by motion of the vehicle through the air and motion of the air itself. Under certain circumstances wind may assist rather than resist the motion of the vehicle.

Windshield header. The structural body member which connects the upper portions of the A-pillars and is above the top edge of the windshield.

Y

Yaw. A sidewise movement of a vehicle in turning; movement of a vehicle in another direction than that in which it is headed; sidewise motion produced when sidewise force exceeds traction force. Often the result of driver overcorrection or exceeding the critical speed. Sometimes revealed by tire marks on the roadway.

Yaw mark. A scuff mark made while a vehicle is yawing; the mark made on the road by a rotating tire that is slipping in a direction that is parallel to the axle of the wheel.

Yaw moment of inertia. The moment of inertia about the vehicle's z-axis. See **moment of inertia** and **tri-axis identification**.

Yaw velocity. Angular velocity (radians per second and degrees per second) about the z-axis.

