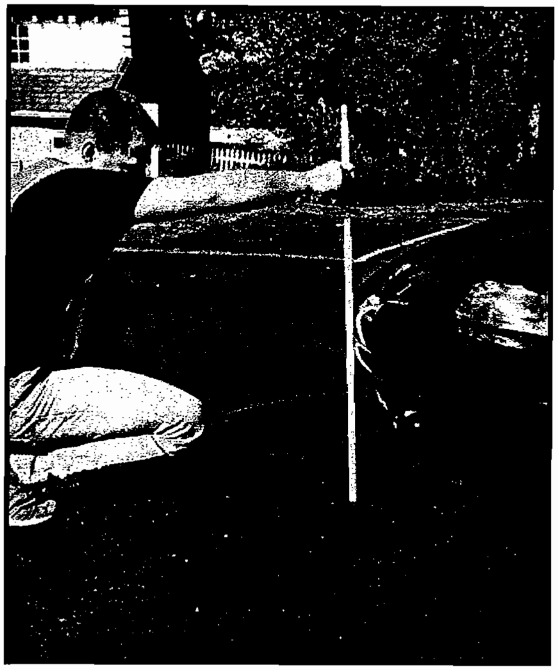
CHECK LIST

A CHECKLIST IS HELPFUL IN IDENTIFYING AND DOCUMENTING DATA FROM A COLLISION

Vehicle data
(See Vehicle Inspection Guide, Appendix A)



1. Obtain specifications for bumper heights, bumper types, model data, VIN number, color, ownership data (See Appendix A, page 1).

2. Complete inspection of vehicle including the identification of the damage: contact vs. induced and old vs. new (See Appendix A, pages 2-4).

3. Inspect an exemplar vehicle for comparative data (See Appendix A, page 4).

4. Document undamaged areas (See Appendix A, pages 5-8).

5. Photograph all damaged and undamaged areas of the vehicle, using color film (See Appendix A, pages 5-8).

6. Obtain occupant restraint data, noting condition of seat belts, and where seat belts were found; do analysis of "webbing", shoulder harnesses and airbags; document location of seat relative to dash board; document headrest type and location.

7. Document window condition, noting which windows were broken or cracked, and opened or closed at the time of impact.

8. Document distinctive marks or substances, such as paint, scrapes, dents or other distinctive marks on exterior of vehicle; hair, blood, scratches or other distinctive marks on interior of vehicle.

9. Obtain data, noting location of cracked or broken lights. Do analysis of bulb/filaments to determine if they were on or off at the time of "impact."

The above checklist is applicable for passenger vehicles, motorcycles and/or trucks.

COLLECTION OF PHYSICAL EVIDENCE

TECHNICAL DATA REQUIREMENTS

COLLECTED DATA CREATED THE FOUNDATION FOR THE ANALYSIS.

While there is no great trick on how to collect data or what data to collect, in order to avoid overlooking items that will be required in an investigation of a collision, it is often helpful to have a list to guide your data collection. Below is a detailed checklist of data to be collected at the time of investigation.

Roadway data

1. Document type of road, number of lanes, geometry of roadway (curve, straight, level, grade), existence of medial strips and guide rails, and location of fixed objects.

2. Document existence, location and type of traffic control devices, and any changes that might occur to these devices, including painted lines on the roadway.

3. Document type of surface (macadam, concrete, etc). Determine if the surface was wet/dry, or in good/poor condition.

4. Document the traffic volume at the time of the incident (number and type of other vehicles on road).

5. Document external lighting, obstructions to view and surrounding features which may distract vehicle operators.

Human factors

1. Research description of driver and occupants (age, driving experience and background data, including previous incidents and claims).

2. Research the "origin and destination" of the occupants (i.e., determine where they were going and where they have been).

3. Research injuries to each occupant (including type, location and source).

4. Report description of incident, including time, place, number of vehicles; direction of vehicles; description of vehicles; lights on/off; incident sequence; points of impact; points of rest; restraint systems on/off .

Incident data (some of this data, if not available, can be derived through expert analysis). Below is a list of such data.

1. Document point of rest of vehicles, tire marks and debris on road (location and direction).

2. Document point of impact. Determine where on the road the collision occurred, and where on the vehicles the impacts are located (location, direction and description).

3. Determine travel direction and speeds of vehicles (pre-impact, at impact and post-impact).

4. Determine locations of each occupant (pre-impact, at impact and post-impact).

5. Obtain description of vehicles and occupants' movements during the incident.

6. Determine point of perception by the vehicle drivers and occupants.

7. Determine evasive action, if any.

DATA COLLECTION TECHNIQUES

BE FAMILIAR WITH DIFFERENT COLLECTION TECHNIQUES.

Data collection techniques: When independently documenting data from the site or vehicles involved in the collision, it is imperative to be familiar with the proper collection techniques. Listed below are some helpful reminders when collecting data.

1. Photograph all sides of vehicle (top, left, right, front, back, inside and undercarriage, if possible).

2. Take photographs from the proper eye height and driver location. Document the photograph with height and location.

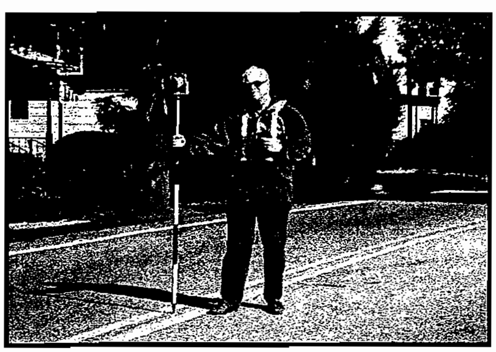
3. Use a measuring devise in photographs for reference purposes (for both vertical and horizontal distances).

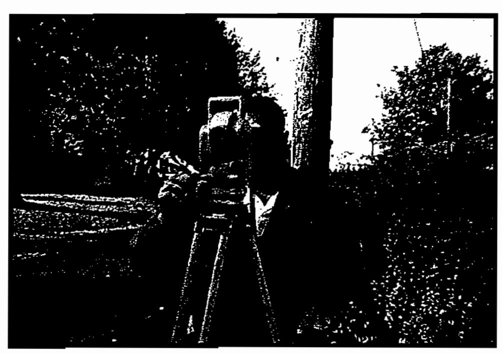
4. Use color film, especially if paint transfer is an issue.

5. Consider testing paint, fiber, or other types of transfers.

6. Document all items photographically prior to removing for further testing, or any other purpose.

7. Use the most accurate measuring techniques available. For measuring sites, use a "total station" surveying system if available. Otherwise, use the coordinate system (grid system) to document field points (see appendix B & C).





INTERVIEWING WITNESSES AND INVOLVED PARTIES

IT IS NOT ENOUGH TO HAVE THE RIGHT INTERROGATION QUESTIONS, YOU MUST ALSO POSSESS AN EFFECTIVE TECHNIQUE.

1. **Interrogation Technique:** How you ask a question often times is critical on what type of response you will obtain, or if you will even get a response.

2. **Mathematical Data:** Develop time/distance/speed relationship between vehicles. These are items which can be cross-checked mathematically.*

3. **Photograph Data:** Use photographs of the area to allow witnesses to point out locations of critical points (points of rest, point of impact, point of perception, etc.).*

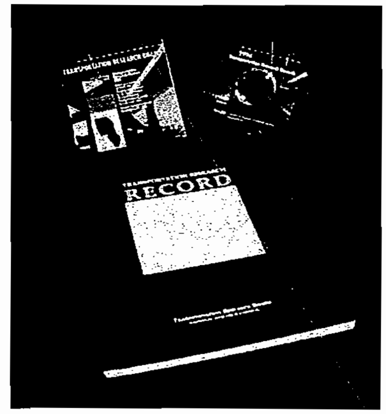
4. **Statements:** Statements should be self-explanatory and detailed as to the who, what, where, when and how of the incident.

5. **Sequence:** Elements of sequence unique to the individual should be included.

6. **Errata Sheet:** A correction or two on each page would indicate that the witness read the statement before signing it.

* Techniques to accomplish this objective are easily explained by a competent expert.

AVAILABLE TECHNICAL RESEARCH



1. Insurance Institute for Highway Safety (IIHS)
   1005 Glebe Road, Arlington, VA 22201
   (703) 247-1500
   Available: Studies, videotapes of crash tests, statistics.

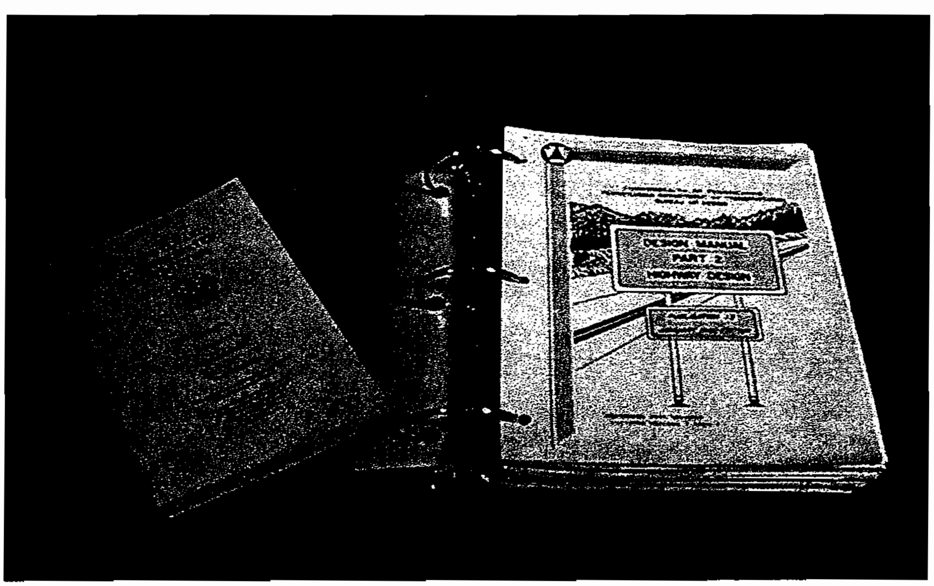
2. National Highway Transportation Safety Administration (NHTSA)
   US Department of Transportation, Washington D.C.
   (202) 366-0123
   Available: Studies, videotapes of crash tests, statistics, regulations, recall data.

3. Society of Automotive Engineers (SAE)
   400 Commonwealth Drive, Warrendale, PA 15096-001 (412) 776-4841
   Available: Studies, research.

4. Transportation Research Board (TRB)
   National Academy of Sciences, 2101 Constitution Avenue, NW, Washington, D.C. 20418 (202) 389-6841.

5. Center for Auto Safety
   2007 S Street, NW, Washington, D.C. 20009
   (202) 328-7700
   Available: Research, studies.

6. National Technical Information Services (NTIS)
   US Department of Commerce, 5285 Port Royal Rd, Springfield, VA 22151
   (703) 487-4780
   Available: Publications.



AVAILABLE PUBLIC DOCUMENTS

VALUABLE INFORMATION CAN BE OBTAINED THROUGH CAREFUL AND PERSISTENT RESEARCH.

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1. **Motor Vehicle Ownership Data:** Items to be alert for include recent ownership, out-of-state purchase, inability to reach previous owner, no title or duplicate title, cash payment for vehicle, previous owner still on title and special conditions noted on title.

2. **Motor Vehicle Model Data:** Items to be alert for include late model vehicles, VIN difficult to match, recovered vehicle was on fire, rebuilt vehicle, and an expensive car with costly "extras".

3. **Employment Data:** Items to be alert for include sketchy or lack of employment history; and salary history (versus car payments or lifestyle). Also, is there a history of driving problems?

4. **Address/Telephone Data:** Research whether place of contact is a residence, or if it is, perhaps, a hotel or bar. A claimant who is difficult to contact or personally visit may be avoiding the investigator for a reason.

5. **Insurance Policy Data:** Determine if the insurance coverage was recently increased, if there was an inquiry as to coverage just prior to the claim, and if this is the first business encounter the person has had with this insurance company. Additionally, check to see if the claimant had limited collision, a high deductible, comprehensive coverage and if there was a lien holder on the policy.

6. **Insurance Loss Reporting Data:** Investigate how the loss was reported. Check the report date to determine if the loss was reported late, if the collision occurred at an unoccupied place and/or late at night, if there was heavy collision damage, and/or low injury damage. Other items of which to be aware include: whether the claimant's recovery was shortly after a fire, whether the claim was not reported to the police, and whether the claim was first reported to an attorney.

7. **Weather Data:** Does description of area and weather match police report data? For example, determine if it was it cold enough to produce icy area, if claimed.

8. **Medical Data:** Determine if treatment occurred on Sundays, holidays, or days offices are usually closed. Research whether provider of care is a great distance from individual. Check for inconsistencies or alterations to medical records, and lack of detail to such records.

ENGINEERING AND SCIENTIFIC ANALYSIS

THE ANALYSIS

EVERY VEHICULAR COLLISION POSSESSES THREE COMPONENTS: THE VEHICLE, THE ROADWAY AND THE HUMAN ELEMENT.

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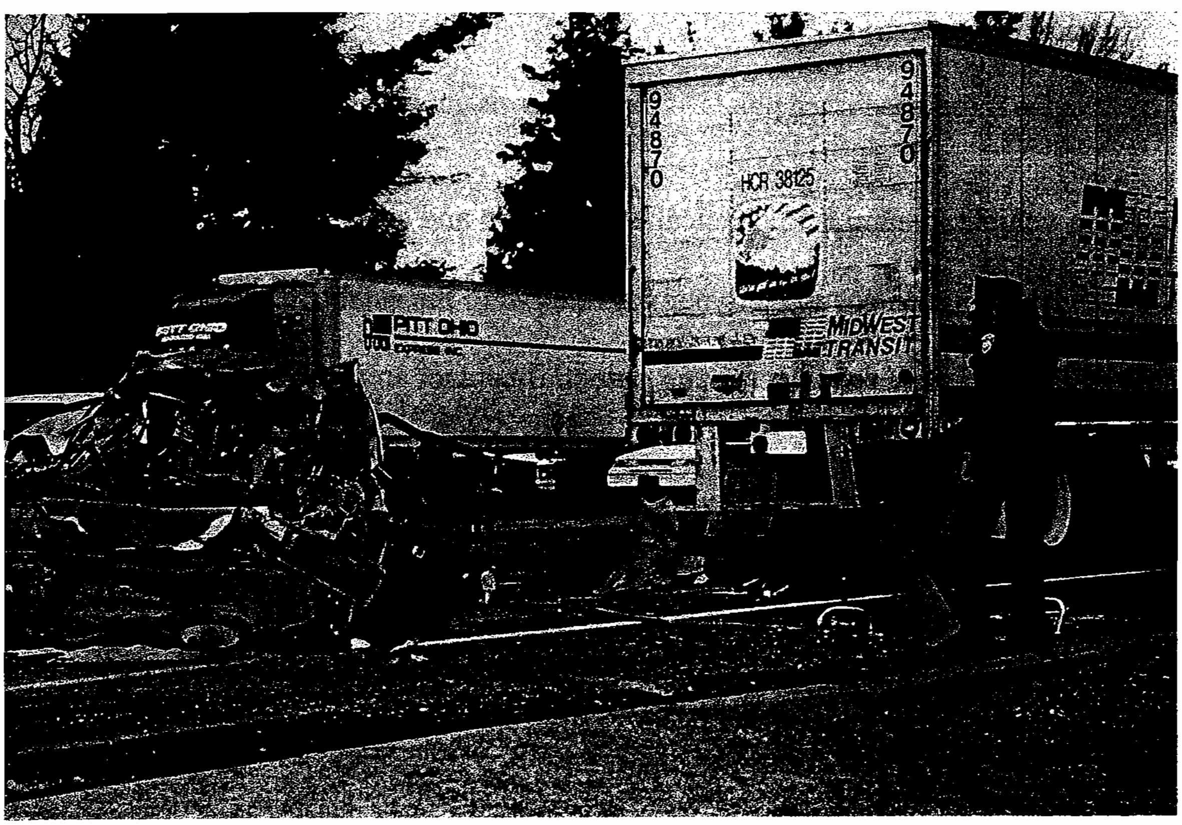
1. Once the proper data has been collected, the next step is to have the appropriate individual(s) review the data to ascertain what, if anything, can be concluded. The key is to have individuals with the proper expertise evaluate the data and coordinate the evaluation.

2. Every vehicular collision possesses three components: the vehicle, the roadway and the human. Without each one of these elements there would be no incident. Based on this concept, it follows that the expertise required would be everything needed to evaluate all factors affecting all three elements and their interaction.

3. The analysis should attempt to evaluate the condition of each element before the incident, the interaction of the elements during the collision (the dynamics), and the damage and injuries as a result of the collision.



GENERAL ANALYSIS PROCESS

THE PHYSICAL EVIDENCE IS EVALUATED SYSTEMATICALLY TO ESTABLISH HOW THE INCIDENT OCCURRED.

After collecting the proper data, the next step is to enlist qualified individual(s) to prepare for an analysis. Listed below is a "general analysis process."

1. Establish damage profile for each vehicle.
2. Determine the points of rest of the vehicles as a result of the collision.
3. Establish Principle Direction Of Force (PDOF) based on damage profile.
4. Establish angle of impact between the vehicle and other vehicle/object.
5. Apply laws of physics to establish relative movements of vehicles based on angle and location of impact.
6. Determine if damage type and location on vehicle(s) is consistent with the expected post-impact movements.
7. Determine if the established points of rest are consistent with the expected post-impact movements.
8. Tie in vehicle dynamics to physical evidence on and around the roadway area.
9. Establish expected occupant dynamics relative to the established vehicle dynamics.
10. Establish occupant movements and potential contact areas. Do analysis for restrained and unrestrained occupants.
11. Correlate occupant movements and impacts with noted injuries.
12. Compare analysis of vehicle and occupant dynamics with testimony of individuals involved in and witnessing the incident.

TWELVE BASIC ENGINEERING CONCEPTS:
UNDERSTANDING VEHICLE COLLISIONS

FOR EVERY ACTION THERE IS AN EQUAL AND OPPOSITE REACTION.

In order to get a feel for how a collision occurred, it is important to have a general understanding of basic engineering concepts as they relate to automotive collisions. Twelve valuable terms and laws of physics are listed below.

1. **FORCE.** An action which produces a pushing or pulling on a body.

2. **APPLIED FORCE.** A force that is produced by direct contact between two bodies. The resistance or slowing force produced by friction when a tire is sliding across a roadway is an APPLIED FORCE.

3. **VECTORS.** FORCES which have both magnitude and direction.

4. **PRINCIPLE DIRECTION OF FORCE (PDOF) or THRUST.**
The direction of the force applied to a vehicle (considered to be concentrated on a particular point) during the collision. The PDOF is determined by observing the direction of damage, abrasions and induced folds on the body and frame of the vehicle.

5. **NEWTON'S FIRST LAW.** A body at rest will remain at rest unless acted on by an unbalanced force. A body in uniform motion (that is, at a constant velocity in a straight line) will remain in motion unless acted on by an unbalanced force.

A VEHICLE AT REST (OR IN UNIFORM MOTION) WILL STAY THAT WAY UNLESS ACTED ON BY ANOTHER FORCE

-Newton's First Law

6. **NEWTON'S SECOND LAW.** If the net forces acting on a body are not zero, the body will be accelerated. The change in the acceleration will be directly proportional to the net force and inversely proportional to the mass of the body. This law is simplified as Force equals Mass times Acceleration.

> **FORCE = MASS x ACCELERATION**
>
> -Newton's Second Law

7. **NEWTON'S THIRD LAW.** When one body exerts a force onto a second body, the second body exerts a force equal in magnitude and opposite in direction upon the first.

> **FOR EVERY ACTION THERE IS AN EQUAL AND OPPOSITE REACTION.**
>
> -Newton's Third Law

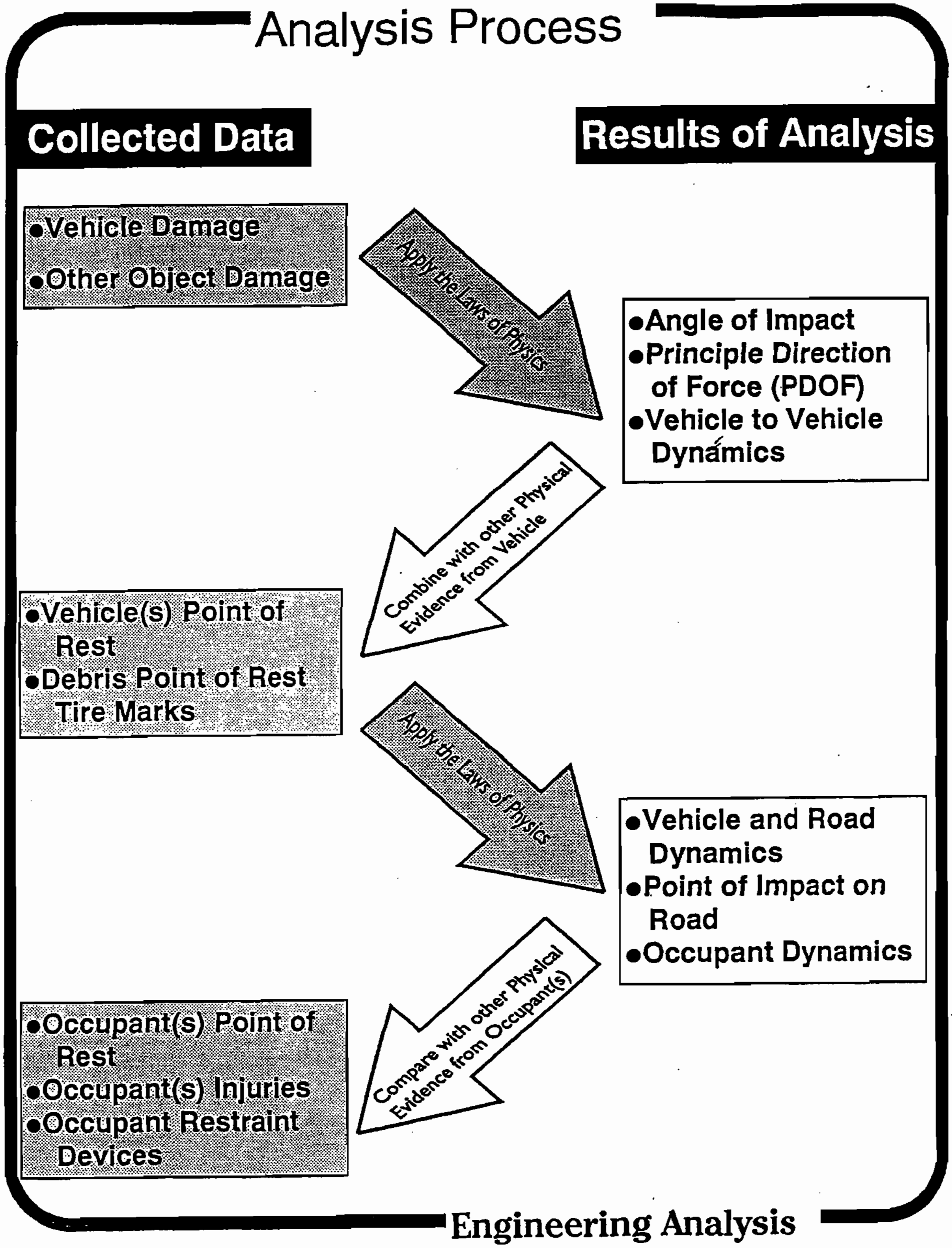
8. **KINEMATICS.** The motion of lines, particles and bodies without consideration of the forces required to produce or maintain motion.

9. There is a relationship between **TIME, DISTANCE and SPEED** (VELOCITY). If two of the three variables are known, the third can be calculated. ACCELERATION is the first derivative of SPEED. VELOCITY is SPEED in a given direction.

10. There are two types of **ENERGY** considered when dealing with vehicular collisions. KINETIC ENERGY, the energy a vehicle possesses as a result of its motion and POTENTIAL ENERGY, the energy the vehicle possesses due to its position.

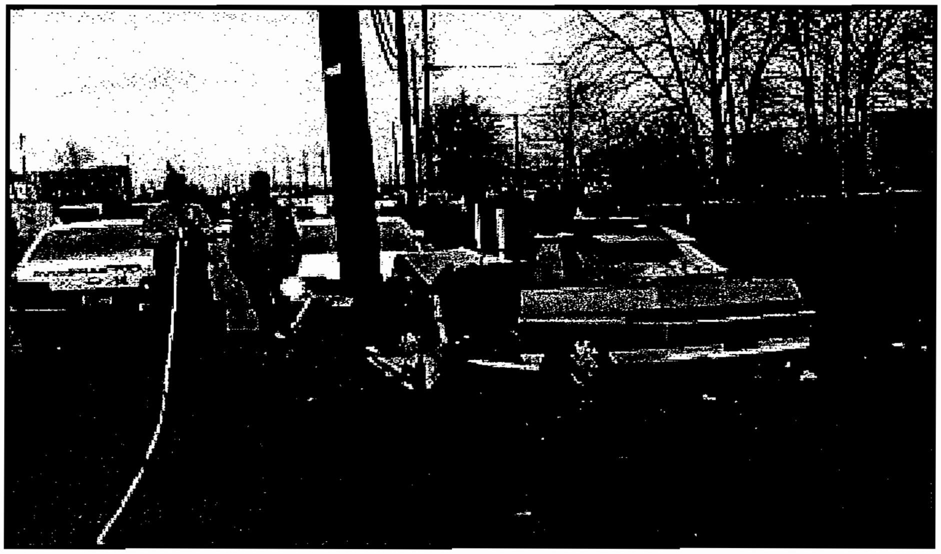
11. **MASS.** The weight divided by the acceleration of gravity (32.2 feet per second squared).

12. **MOMENTUM.** The MASS of an object multiplied by the VELOCITY of an object. MOMENTUM is a vector quantity. It has magnitude and direction.


Analysis Process
Collected Data
Results of Analysis
•Vehicle Damage
•Other Object Damage
Apply the Laws of Physics
•Angle of Impact
•Principle Direction of Force (PDOF)
•Vehicle to Vehicle Dynamics
Combine with other Physical Evidence from Vehicle
•Vehicle(s) Point of Rest
•Debris Point of Rest
Tire Marks
Apply the Laws of Physics
•Vehicle and Road Dynamics
•Point of Impact on Road
•Occupant Dynamics
Compare with other Physical Evidence from Occupant(s)
•Occupant(s) Point of Rest
•Occupant(s) Injuries
•Occupant Restraint Devices
Engineering Analysis

VEHICLE MOVEMENTS AS A RESULT OF IMPACT

HOW VEHICLES ROTATE DEPEND UPON THE POINTS OF IMPACT.



1. The impact between vehicles or other objects involve forces between the vehicle(s) and/or objects. These forces can effect the speed, direction, and/or the rotation of the vehicle.

2. The movement of a vehicle, resulting from impacting an object or being impacted by an object, depends on the direction of the force, the magnitude of the force and where on the vehicle the force is applied.

3. DIRECT CENTRAL FORCE. Forces applied directly through the center of mass of a vehicle. When centered forces are applied to a vehicle, the vehicle moves along the line of the force and there is no rotation. The occurrence of centered forces in vehicle collisions is very rare.

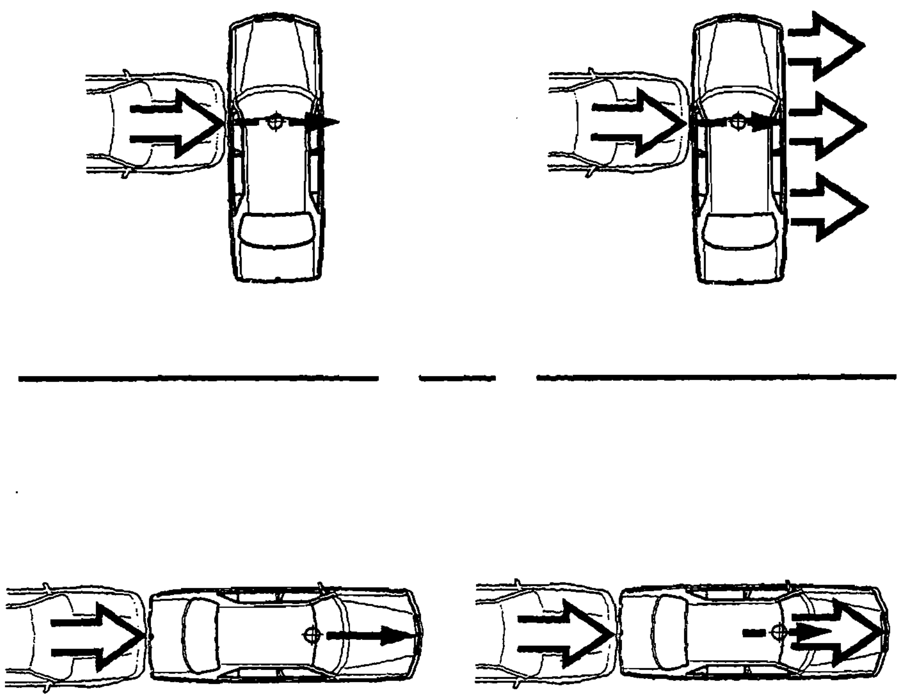
4. ECCENTRIC FORCES. Most vehicle collisions involve forces acting upon a vehicle which do not act directly through the center of mass of the vehicle. These forces produce a rotation, depending upon which side of the center of mass the force is applied.

5. Examples of typical post impact movements are shown in the diagrams noted below. The center of mass is noted by the black circle. The direction of the force applied to the vehicle(s) as a result of the collision is noted by the dotted line. The arrows note the movement of the vehicles.

Vehicle Motion

Centered Impacts

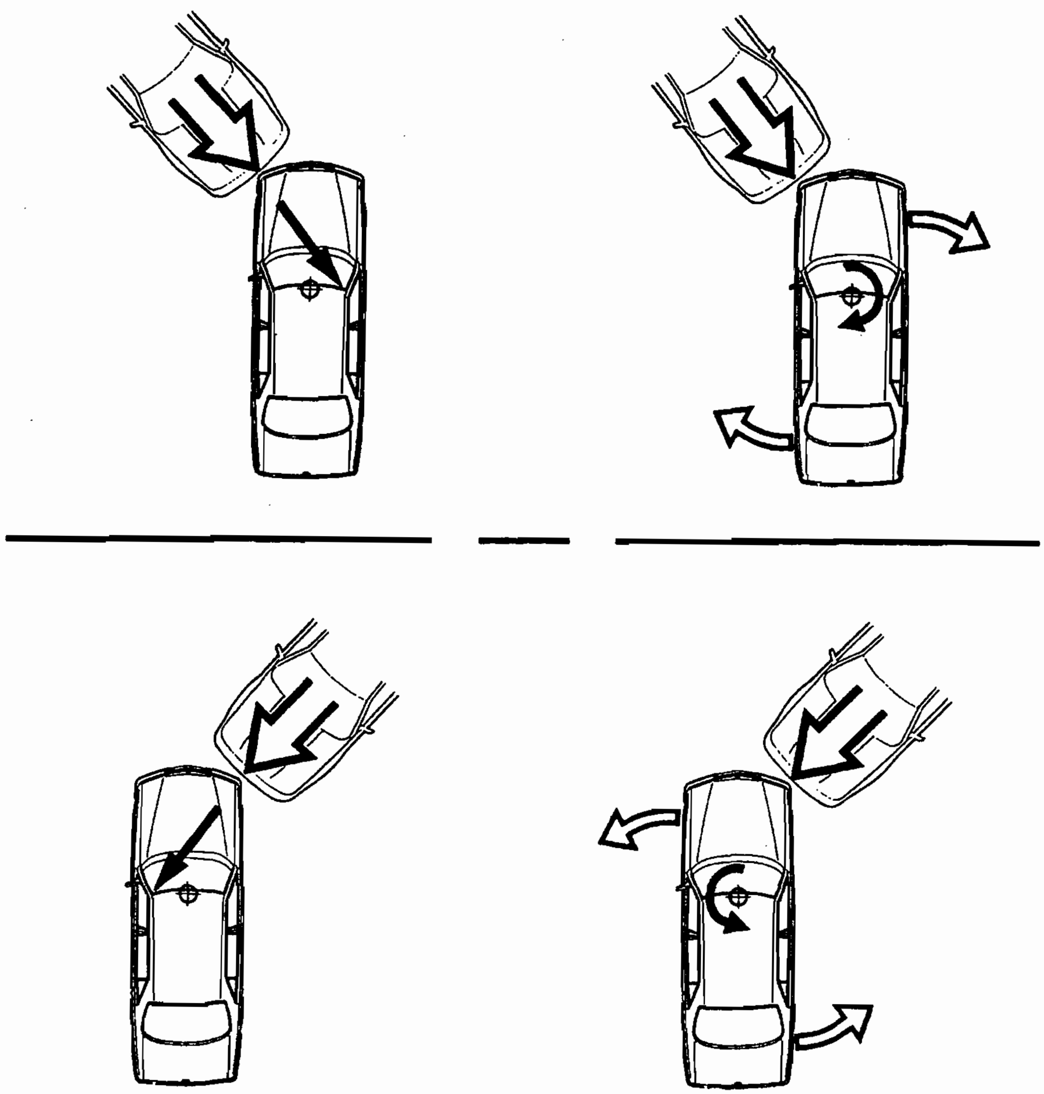
☐ **No Rotation**



Vehicle Motion

Eccentric (Non–Centered) Impacts

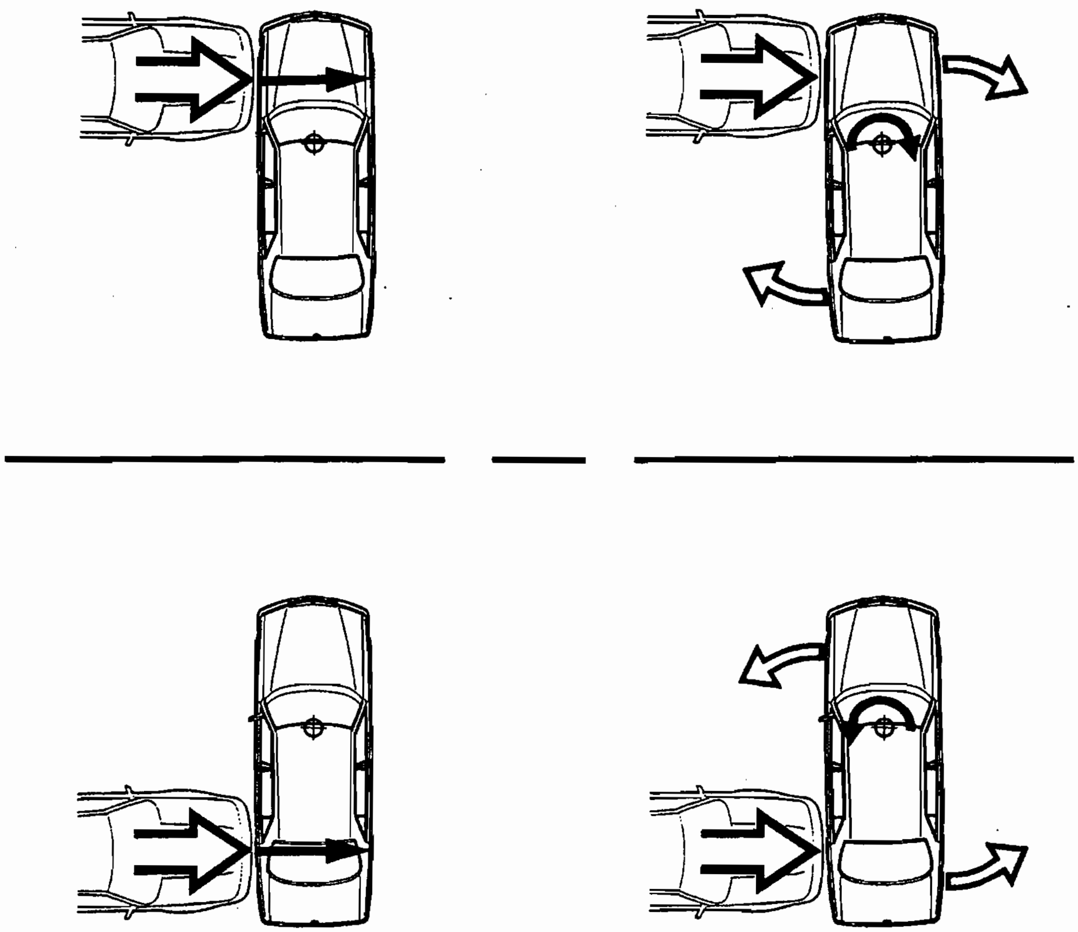
- ❑ **Rotation**



Vehicle Motion

Eccentric (Non-Centered) Impacts

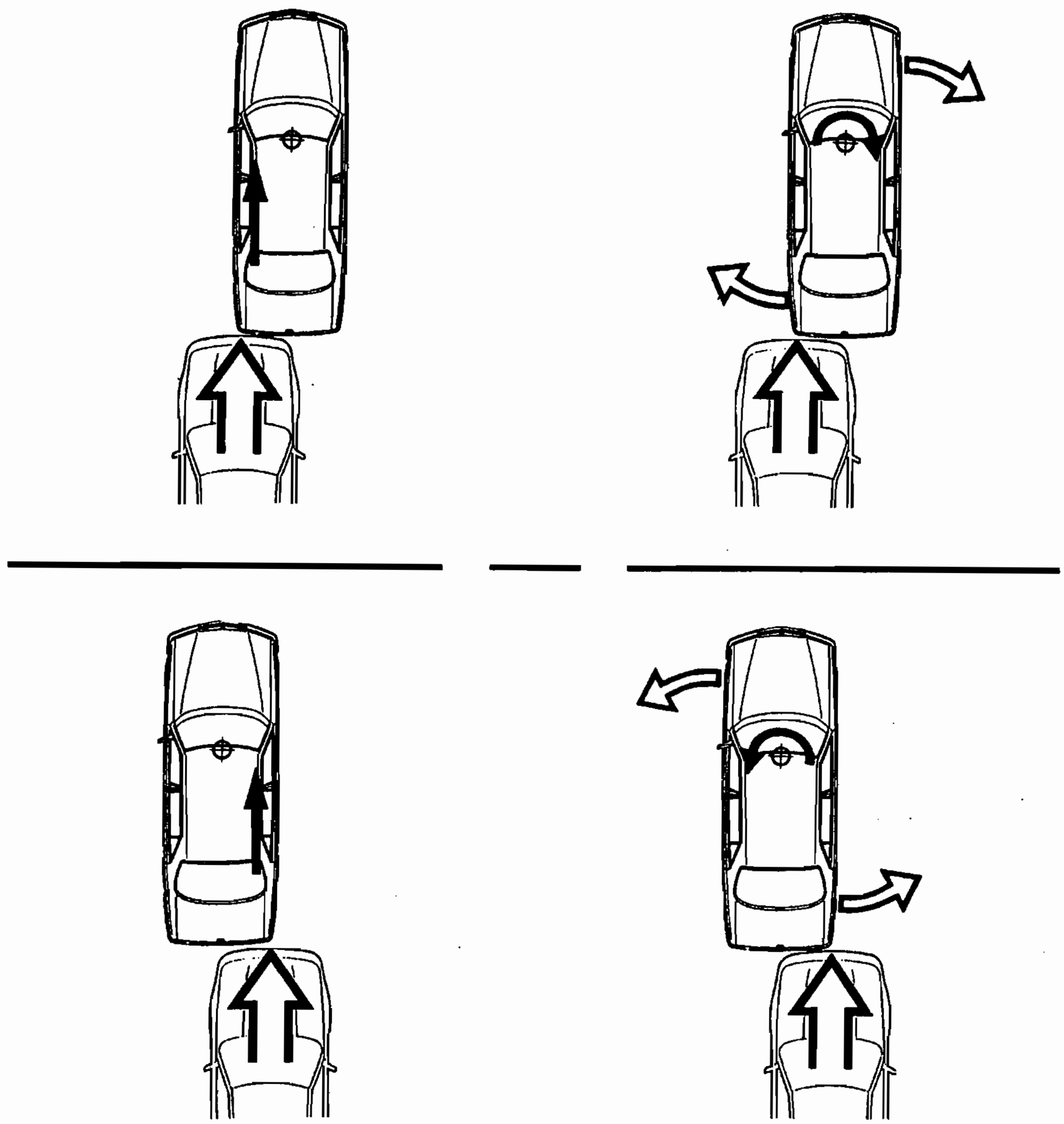
- ❑ **Rotation**



Vehicle Motion

Eccentric (Non-Centered) Impacts

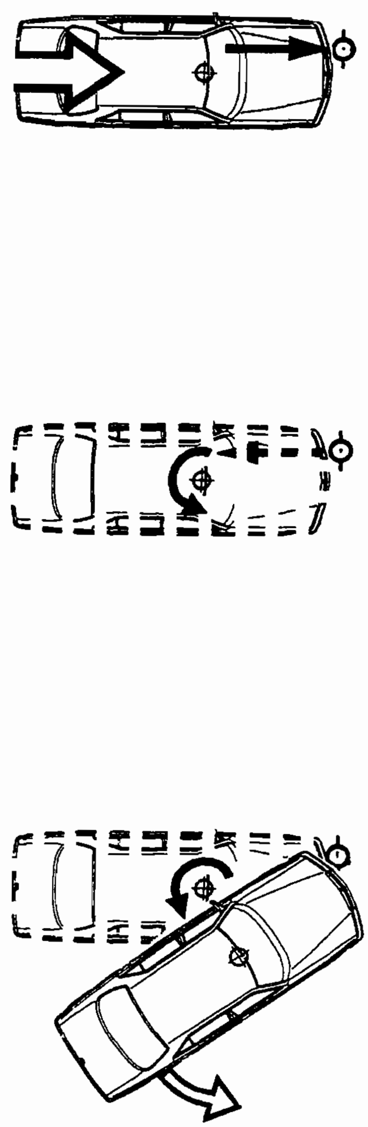
- ❑ **Rotation**



Vehicle Motion

Fixed Object: Eccentric (Non-Centered) Impact

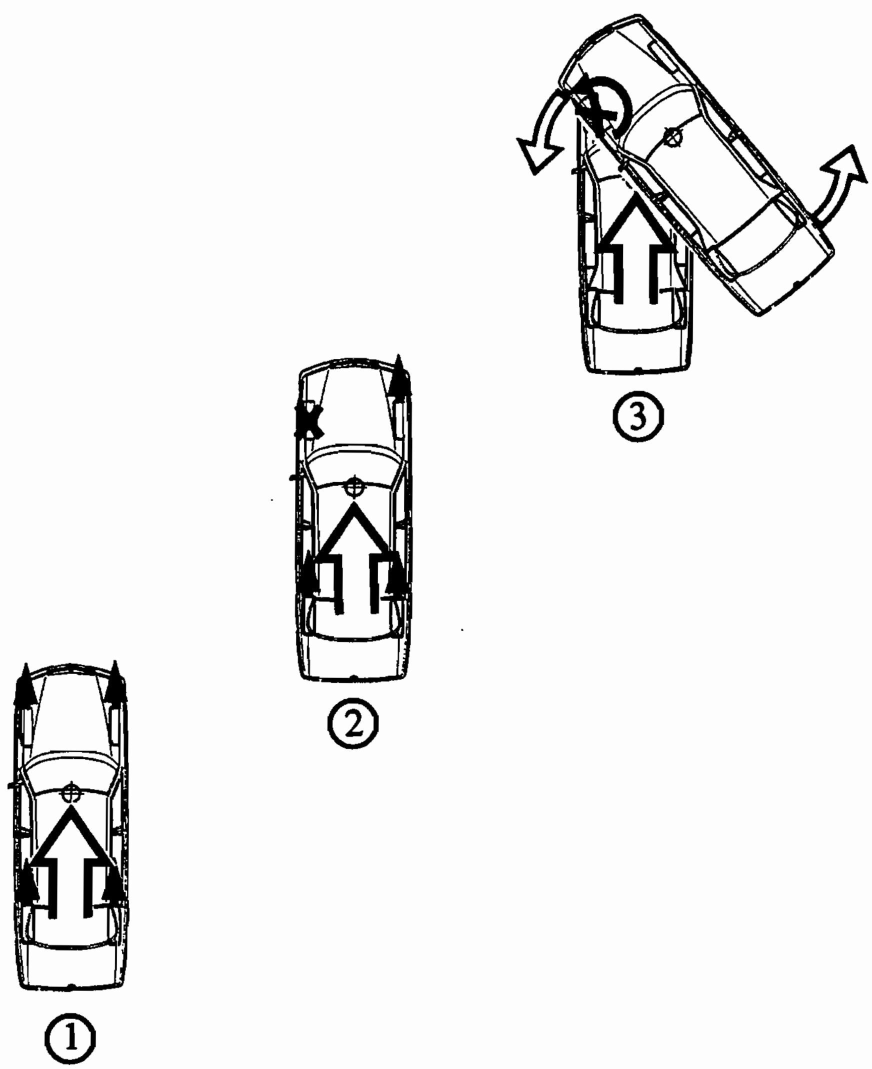
- ❑ **Rotation**



Vehicle Motion

Blowout

❑ **Rotation Due to Blowout on Left Front Tire**



OCCUPANT MOVEMENTS AS A RESULT OF IMPACT

REMEMBER NEWTON'S LAWS?

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1. Remembering Newton's First Law of Motion, an object in motion will remain in motion unless acted upon by an outside force. In a collision, the outside force results from the impact with another vehicle or object.

2. A vehicle will either accelerate or decelerate in response to the force of the collision. As a result, the vehicle may also rotate about its center of mass. Occupants inside the vehicle will respond to the impact forces as well.

3. The relative movements of the occupants depend on the direction, magnitude and location of the force applied to the vehicle. They will also depend on whether the occupant was restrained in the seat at the time of the collision.

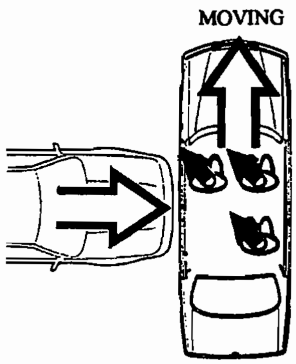
4. Unrestrained occupants, those not secured by lap belts and shoulder harnesses, are free to continue moving in the same direction they were moving before the collision. These bodies continue moving without restriction until they strike the interior of the car, or leave the vehicle. Once they impact the interior of the vehicle, or something outside the vehicle, outside forces become involved.

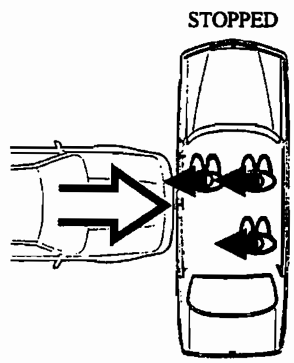
5. Newton's Third Law, which indicates that for every action there is an equal and opposite reaction, helps to evaluate the expected motion of an occupant following a collision.

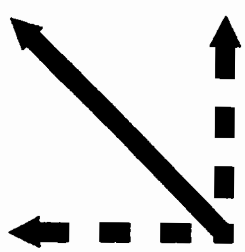
6. Examples of occupant movements in typical collisions are noted below. The pre-impact direction of the vehicle is identified by the thin arrow. The post-impact direction of the vehicle is identified by the thick arrow. The post-impact occupant movement is identified by the black arrow.

Occupant Motion

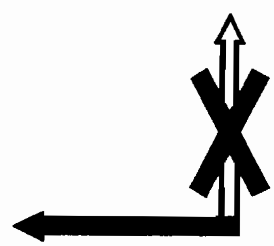
Components of Force







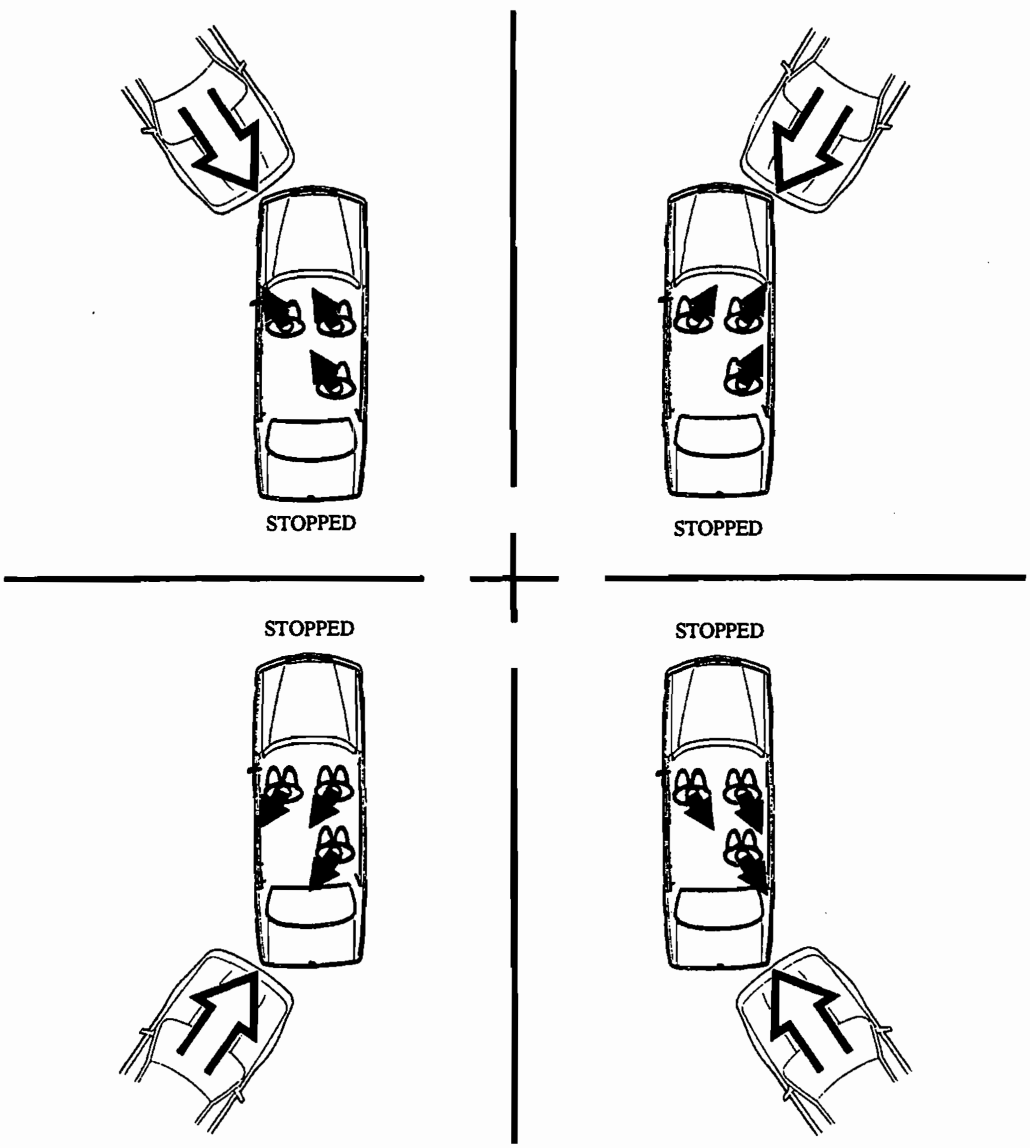
- **Vector Diagram**
  Showing Components of Force Resulting In Occupant Movements



- **Vector Diagram**
  Showing Components of Force Resulting in Occupant Movements

Occupant Motion

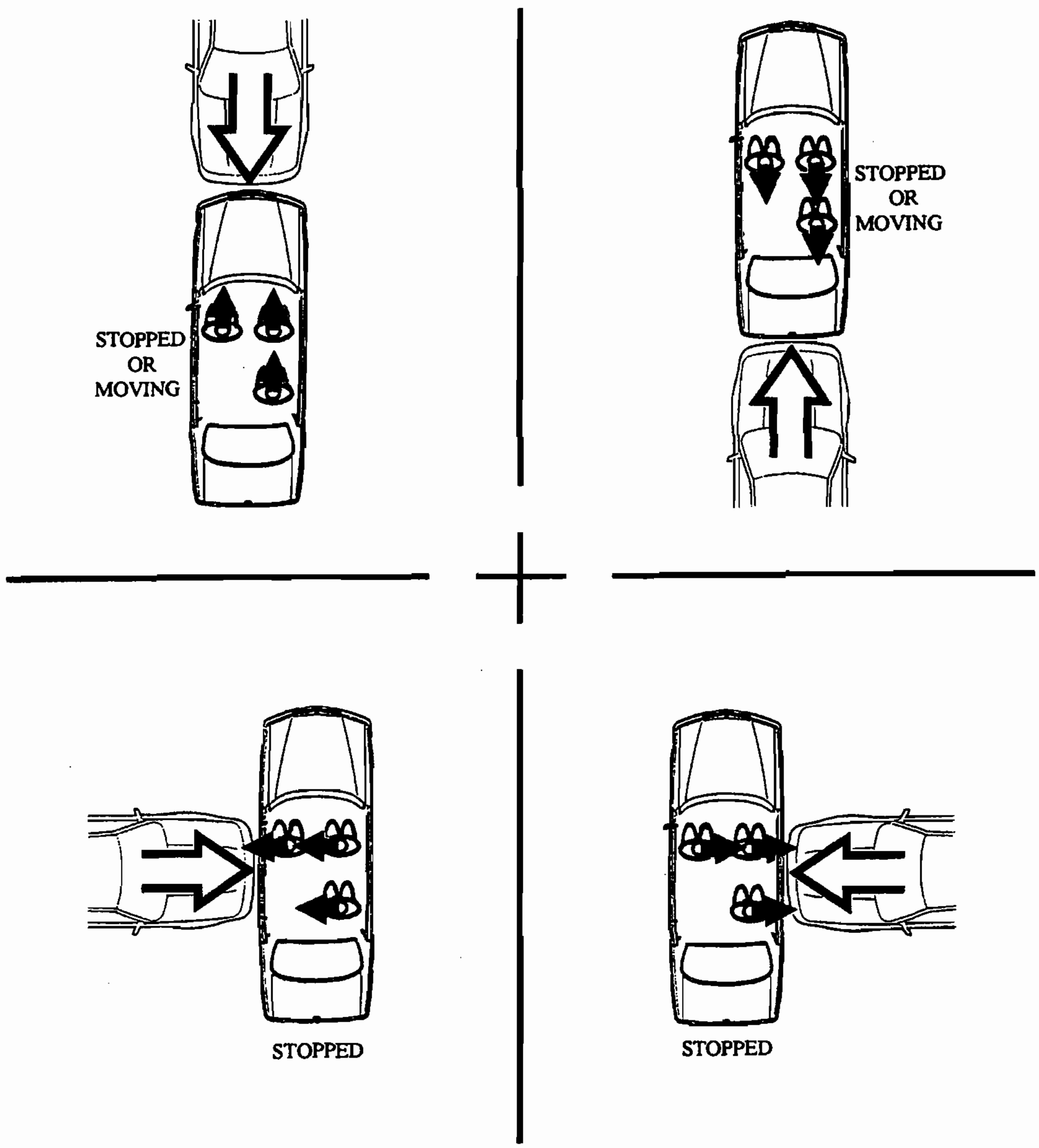
Angle Collisions



Accident Dynamics

Occupant Motion

Typical Impacts



GENERAL NOTES

OTHER CONSIDERATIONS WHEN PERFORMING AN ANALYSIS.

1. Damage patterns (abrasions and scrapes) can indicate direction of force.

2. Match up heights and types of damage. Remember to account for braking and other deviations in height due to the suspension of the vehicles.

3. Tie in all impact areas. Be aware of secondary and tertiary collisions.

4. Seat belts and airbags are most effective in preventing occupants from moving forward into the steering wheel, dash area and windshield as would result from a frontal collision.

5. Seat belts and airbags relieve the occupant from feeling the full effect of the change in velocity due to a collision by slowing the occupant down over a longer period of time than the time increment of the vehicle itself, thereby reducing the rate of deceleration of the occupant.

6. The seat back and headrest are integral parts of the occupant restraint system. Failure of either of these parts undermines the effect of the restraint system.

7. Seat backs are designed to absorb energy. However, seat back failures are common. Some failures are due to the severity of the collision (usually a rear end collision) and some are due to a structural weakness in the seat.

8. The ability for an occupant to be thrown into the dash or windshield as a result of rebounding off of a seat back is a function of the strength of the seat back. If the occupant is thrust with enough force to rebound back into the windshield, it should be questioned as to whether the seat back would have been strong enough to withhold that type of loading without failing.

9. Headrests which are set too low undermine the effectiveness of the occupant restraint system. Most people do not adjust the headrest each time they use a vehicle. It is often left untouched for the time the owner has the car.

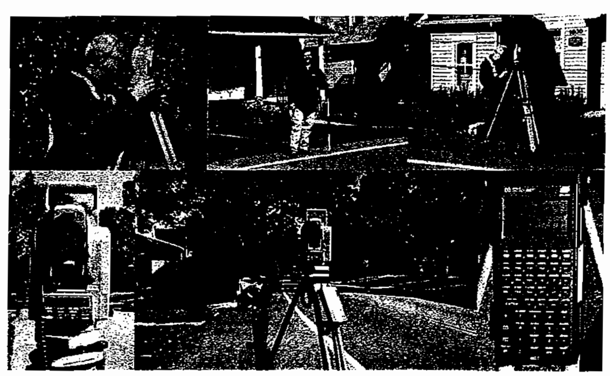
TECHNOLOGICAL ADVANCES IN THE COLLECTION AND ANALYSIS OF DATA RELATING TO COLLISION RECONSTRUCTION

TECHNOLOGICAL ADVANCES IN DATA COLLECTION PROVIDES ADDITIONAL SUPPORT AND DATA TO RECONSTRUCT VEHICULAR COLLISIONS AND TO DEMONSTRATE THE RESULTS

Tools available to engineers reconstructing collisions have changed since the time J. Stannard Baker first wrote about the application of the laws of physics to vehicular collisions. Technological advances have allowed for more complete and accurate data collection as well as more sophisticated and effective data analysis. Noted are technological advances which, when used properly, provide engineers additional support and data to reconstruct vehicular collisions and to demonstrate the results.

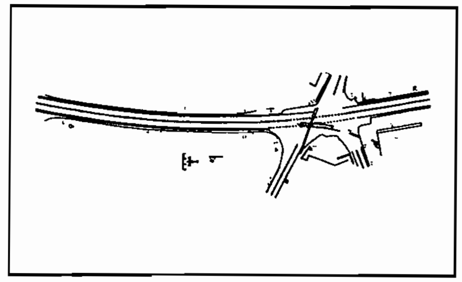
TOTAL STATION:

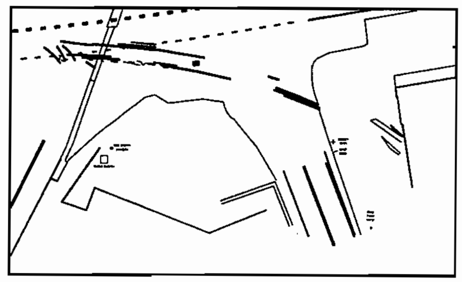
Field measurements were originally "paced off" by investigators. The next generation of field measurements were taken with tape measures and "rolling" wheels. The newest technology is the "Total Station." "Total Station" consists of a capture unit, transit and prism. The transit shoots a laser beam toward a prism. The beam bounces off the prism and is sent back to the transit where it is recorded by a small hand-held computer referred to as the capture unit. The unit records the position of the prism relative to the transit as well as the elevation of the point. "Total Station" is the same technology utilized by surveyors. The accuracy of a properly conducted survey is unparalleled. The survey also provides data that can be rendered in three dimensions, something not possible with measurements using a "rolling" wheel or tape measure. As a result, the "Total Station" data can be inputted into other computer applications allowing for three-dimensional analysis of a collision.



COMPUTER-AIDED DESIGN:

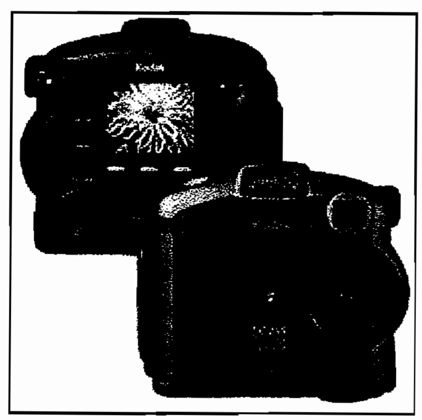
Sketches and diagrams for collision scenes are prepared using recorded data. The accuracy of the drawings is dependent on the accuracy of the field data as well as the competence of the person rendering the drawings. The newest technology utilizes Computer-Aided Design (CAD) techniques to place the recorded field data points into an accurate, functional and aesthetically pleasing diagram that can be used for analysis and demonstrative evidence. The ability of CAD programs to use the "Total Station" data and work in three-dimensions provides a level of analysis and display not available in the past. CAD provides the user with extraordinary means to produce realistic exhibits, models and animations in an accurate and cost-effective manner.





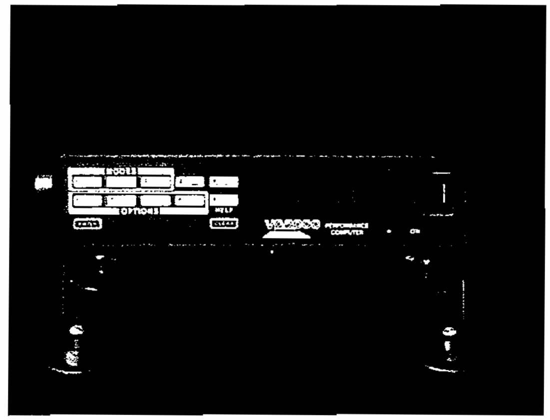
DIGITAL PHOTOGRAPHY:

Technology is changing rapidly, especially in the field of photography. Digital technology is changing the face of how pictures are being recorded, stored and produced. Old-style "copy machines" are being replaced by high-tech digital scanners. At the same time, "film" style cameras are being supplemented and/or replaced by "digital" cameras. This technology allows the user to store, utilize and print collected images in ways that were neither possible or cost-effective in the past. Digital technology allows pictures to be stored on a computer, CD or disk rather than on paper. Images can be e-mailed or printed/plotted to whatever size is required, all in a matter of seconds. The technology also allows the user to view the images before leaving the location where they are taken. Digital images can be manipulated using the computer. For this reason, care must be taken to keep track of the chain of events from when the pictures are taken to when they are produced in the desired format. Testimony as to the authenticity and accuracy of the image produced may be required.



ACCELEROMETER:

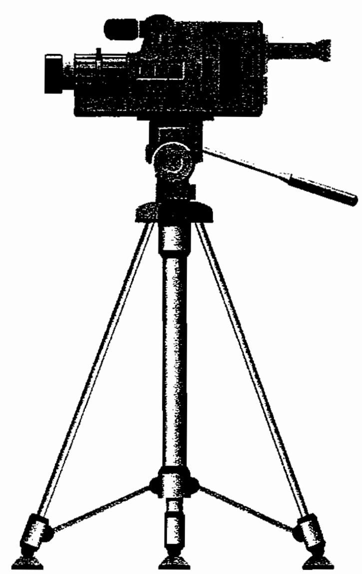
The coefficient of friction between a road surface and a vehicle's tires is required when attempting to calculate the speed(s) of vehicle(s) based on tire marks or post-impact movements. In the past, the value relating to the interaction between the tire and the road surface (the "drag" factor) has been recorded manually by using a weighted tire, rope and scale. The weighted tire was pulled along the road surface at a designated angle and the force required to move the weighted tire was recorded. The "drag" factor was calculated using this data. Unfortunately, this method allowed for many procedural errors.



The use of the weighted tire did not replicate the dynamic actions of a rolling tire attempting to slow on a road surface. These issues ultimately affect the accuracy of the "drag" factor. The opportunities for inaccuracy affected the accuracy of any speed calculations. The accelerometer is a small computer that mounts on/within a vehicle, which measures variables of time, distance and speed as a vehicle slows to a stop or accelerates. Specifically, the computer measures motion as a rate-of-change of speed (i.e. acceleration and deceleration). By applying the appropriate laws of physics with regard to the interrelationship between the recorded variables, the accelerometer accurately computes the "drag" factor. In doing so, the accelerometer eliminates the procedural and technical issues attached to the use of pulling a weighted tire.

VIDEO CAPABILITIES:

Motion...without it there would be no collision. The ability to utilize video cameras to record motion supplements the obvious use of video cameras to record data. Site investigations and specialized testing can be conducted and the entire sequence of events can be recorded using one (or many) cameras. This allows for careful analysis of the testing that can be done at a later time. Recorded data can be evaluated and utilized in its entirety, in part, or using individually recorded frames. Computer technology allows for many effective multi-media uses of video data.

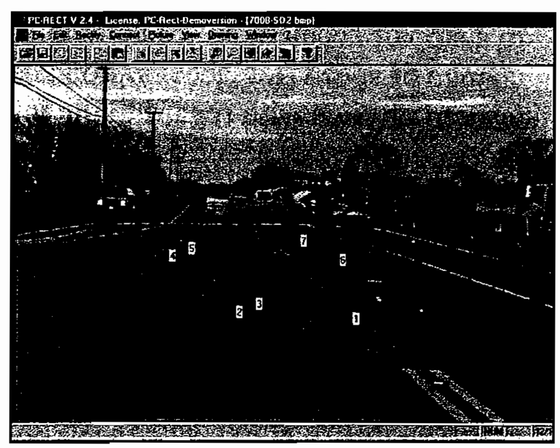


LIGHT METER/CONTRAST METER:

Recording night observations consisted of visual observations as to whether it was dark or not. While visual observations are still a primary aspect of nighttime visibility work, technology can be used to quantify how and what we see. Light meters record the ambient light shining on a particular area. The use of light meters to record the ambient light allows for the production of an illumination grid, a diagram showing the illumination levels of an area. The ability to discern an object at night is, in part, a function of whether the object contrasts from its background. Contrast meters record luminance. By comparing the luminance of an object to its background, a quantitative analysis of its discernibility can be completed to supplement any visual observations recorded.

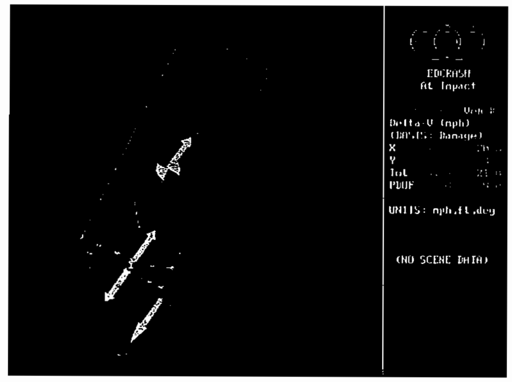
PHOTOGRAMMETRY:

A photograph is a two-dimensional image capable of showing images that are actually three-dimensional. Direct linear measurements applied to a photograph usually will not be accurate because of the "depth" portrayed in the photograph. Accurate measurements of items in a photograph can be completed if the photograph is transformed into a planar surface, much like a map. Photogrammetry is a method of rectifying photographs into accurate map-like image, viewed from above, that can be used to take simple measurements. The data needed to complete this process includes accurate measurements of several items in the photograph. The spacing between physical objects/roadway markings shown in a photograph can be used to rectify the photograph into a plan view. Such physical objects/roadway markings include street signs, vehicle widths and roadway striping which can be measured in the field, or their specifications can be obtained through other sources.



DAMAGED BASED COMPUTER APPLICATIONS:

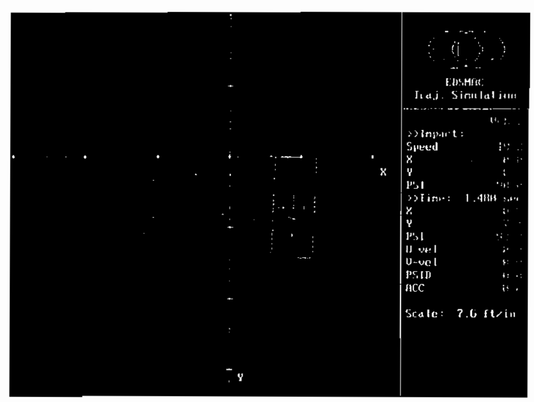
For years, engineers have been refining the procedure for calculating collision energy through vehicle damage. Beginning with the Calspan Reconstruction of Accident Speeds on the Highway (CRASH), and continuing with the refinements and enhancements provided by the National Highway Traffic Safety Administration (NHTSA) and private firms like Engineering Dynamics Corporation, programs have been developed which determine impact speeds and delta-V (change in velocity) using vehicle and site data. The amount



of energy required to create the damage to the vehicle as a result of impact can be calculated using specific input paramaters. These parameters include proper measurements of the damage to vehicle(s), the assignment of the principle direction of force (PDOF) that went into damaging the vehicle, and stiffness characteristics and empirical data selected by the engineer as representative for a subject vehicle.

SIMULATION-BASED COMPUTER APPLICATIONS:

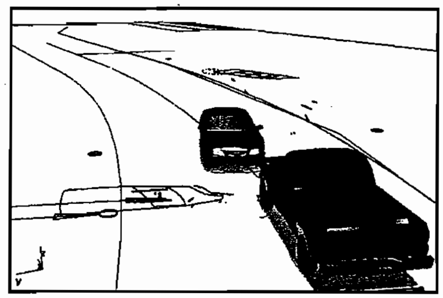
Simulation analysis of collisions uses a set of assumed or estimated initial conditions including the position and velocity of the vehicles and applies the laws of physics to show (simulate) the relative movement of the vehicles based on the initial input parameters. An accurate simulation must take into consideration the location and type of physical evidence resulting from the collision, including the position of the vehicles at impact and rest, the principle direction of force (PDOF) as set forth by the vehicle damage, and the location of tire marks and debris as a result of the collision. By

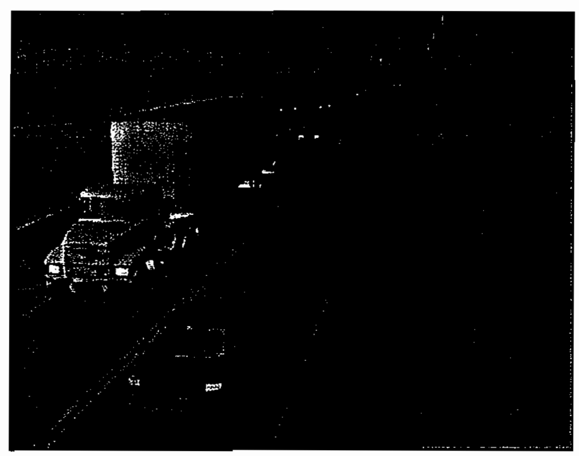


repeated adjustments of the initial conditions and driver input (braking/acceleration), the program will converge on the simulation that best matches the physical evidence, including vehicle damage, while moving the vehicles from impact to their known points of rest.

ANIMATIONS:

Animation is a three-dimensional computer representation that shows moving pictures over time. Much like two-dimensional storyboards that show a sequence of events in the form of still frames at various increments of time, an animation shows this same sequence (and more) in three dimensions over a given ***period*** of time. Animation closes the gap in time inherent in a two-dimensional story board, while at the same time, illustrates a sequence of events dynamically. Collision reconstruction engineers can utilize animations to demonstratively show the results of their analysis. It is important to remember that the animation itself is not the analysis. Technology available today allows engineers to check their manual analysis of a collision using the computer, and to quickly animate their analysis in three dimensions consistent with the physical evidence and the laws of physics. Such three-dimensional representation of a collision analysis can be extremely useful as a demonstrative exhibit, which, for example, will aid a jury in understanding. It should be noted that there are available animation programs that **are not** based on the laws of physics. These programs **will** allow vehicle movements to be shown which are **inconsistent** with the laws of physics. Consequently, if the animation is completed by someone other than the engineer who completed the reconstruction, it is imperative that the engineer authenticate the animation. If the simulation program utilized by the reconstruction engineer has the capabilities of animation, there will be no question that it agrees with the laws of physics for the input provided.





- **What is PC-Crash?**

PC-Crash is a computer program that is specific to the field of collision reconstruction engineering. It is a simulation program, from which 3-dimensional views of vehicular movements and collisions can be rendered to create an accurate 3-D animation of a given occurrence in full-color and true to scale.

- **PC-Crash: The Engineering Perspective**

PC-Crash is an analysis tool that is based upon the laws of physics. It enables the engineer a means for "quickly" checking the results of his manual analysis. It does not do the analysis for you. Instead, you tell it what input to use and what, if any assumptions to make, and it performs the calculations based on these input parameters. Quick and easy variation of input parameters can be made to confirm the accuracy thereof. Variation of the input parameters enables the engineer to quickly hone in on the "right set" of parameters that result in vehicle dynamics, etc. consistent with the physical evidence. Some values for the input parameters can be deemed unreasonable for a given occurrence because the resultant simulation of the vehicle dynamics will not agree with the physical evidence (although it will ALWAYS agree with the laws of physics for the input parameters selected since that is what the computer program is based upon).

- **PC-Crash: Some Potential Uses**

Simulation of vehicular collisions involving any number of vehicles (even single vehicle accidents) and any type of vehicle (i.e. passenger cars, SUVs, pickup trucks, motorcycles, bicycles, trains, trucks, tractor-trailers, including multiple trailers)

Simulation of vehicular turning capabilities. For example, a tractor-trailer made a right turn onto a through roadway from a parking lot or side street at night. The tractor-trailer swung out across its lane and into the opposite lane in making its turn. The tractor was in the process of returning to its own lane when an oncoming vehicle impacted the rear portion of the left (i.e. driver's) side of the tractor or the left front corner of the trailer that was still in the wrong lane. Could this accident have been avoided? Could this particular tractor-trailer have made the right turn without violating the opposite lane, or at least violated it to a lesser extent and completely returned to its own lane before the oncoming vehicle arrived at the eventual point of impact? The tractor-trailer operator says "No," but analysis of the turning capabilities of the tractor-trailer using traditional methods and PC-Crash may say otherwise.

Simulation of vehicle operator visibility given sight lines at the time of the occurrence (i.e. visibility relative to fixed objects such as trees, signs, parked/stopped vehicles, as well as relative to moving vehicles)

Simulation of vehicle handling given vehicle and/or roadway geometry, features and conditions.

Simulation and animation of another expert's analysis (i.e. an expert you may have already retained to do the reconstruction).

Simulation of opposing expert's analysis using his input parameters to show how/why his analysis is inconsistent with the physical evidence and the laws of physics (if that is indeed the case).

Simulation to evaluate the testimony of vehicle operators and occupants, as well as witnesses.

- **What data is needed for PC-Crash analysis?**

Data required to perform an engineering analysis using PC-Crash is the same data required to perform that analysis manually. In fact, all analyses should first be performed manually. Only after such manual analysis is completed, should the computer be used to check the analysis and to "quickly" iterate the input parameters to see what effect such variations have on the outcome of the analysis.

- **What do you get out of your engineer using PC-Crash as part of his analysis?**

Confirmation of an accurate analysis.

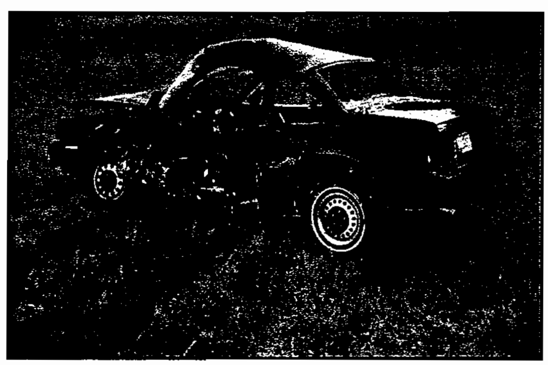
More bang for your buck. Once the simulation is set up, iterations can be done "quickly and easily."

3-dimensional animation clips or a full-blown animation including any view imaginable of a collision (even vehicle operator/passenger views). Animation clips can be provided on CD for viewing on your computer, and full animations can be provided on VHS videotape for use at arbitration or in court as a demonstrative exhibit.

FORENSIC VEHICLE INVESTIGATIONS AND THE BLACK BOX

THE METHODOLOGY HASN'T CHANGED; HOWEVER, TECHNOLOGY HAS HAD A SIGNIFICANT EFFECT ON THE PROCEDURES USED DURING A VEHICLE INVESTIGATION.

A forensic vehicle investigation can be a very important part of a collision investigation and reconstruction. Whether to rule out mechanical issues as a contributing factor or to investigate an actual mechanical failure, the inspection should adhere to a logical, systematic procedure. A well-designed and systematic approach is essential to an efficient and effective evaluation. A thorough evaluation may include research, visual inspection, testing, and documentation. This can be a complicated task, particularly on today's modern vehicles. Many times however, a complete vehicle evaluation is not required or justified. The first step in determining the scope of a forensic inspection should be a review of the available data including such items as police reports, vehicle service and repair records, recall notices, technical service bulletins, and owner complaints databases. This information can be used to help guide the investigator in identifying possible failure trends and other vehicle problems.

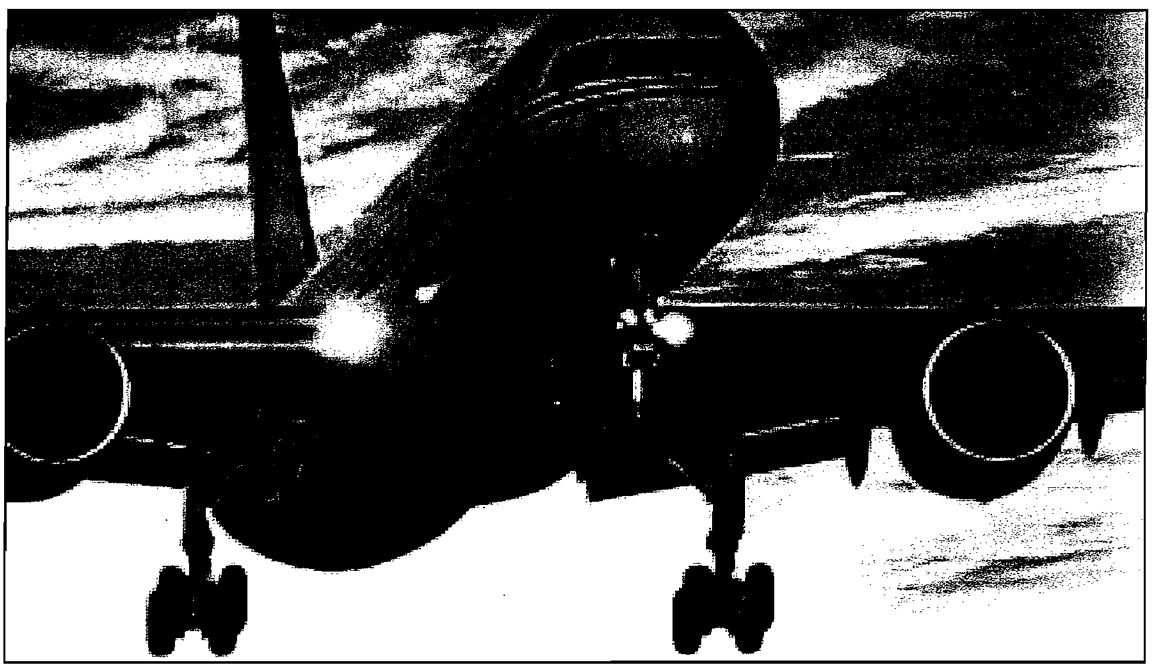


Over the years, the methodology of a forensic vehicle examination hasn't changed much, though some of the procedures have. Perhaps the strongest force behind these changes has been the advances in available technology. From collecting and analyzing data and physical evidence, to interpreting and demonstrating the results, technology has had a significant effect on vehicle investigations. For example, collision scenes (and sometimes vehicular damage) can be documented using high-tech digital surveying equipment. Accelerometers can easily be used to determine a vehicle's braking effectiveness. Computer programs have lowered the cost of data analysis and reconstruction animations.

One of the most significant technological advances to come along in recent years, however, has been the so-called "Black Box". Recently, vehicle and collision investigators, as well as insurance and litigation groups, have been hearing about this latest technology. So what is the Black Box? If you think it sounds like something you've heard of before, you may be right.

THE *AUTOMOTIVE* BLACK BOX - IT'S WHAT YOU THINK IT IS

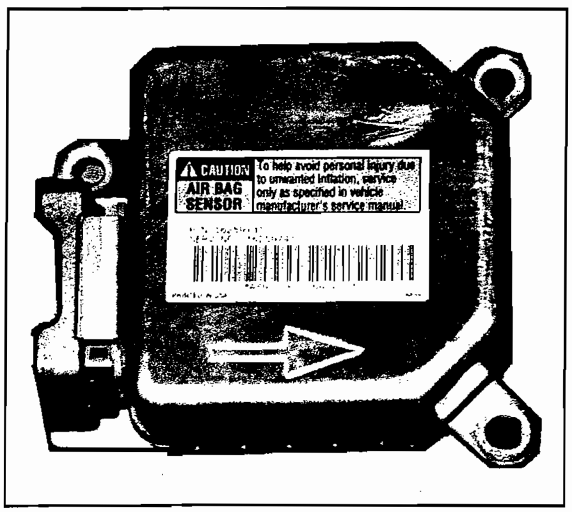
THE BLACK BOX, FOUND IN MILLIONS OF VEHICLES ON THE ROAD TODAY, IS IDENTICAL IN PURPOSE AND SIMILAR IN FUNCTION TO THOSE FOUND IN COMMERCIAL AIRCRAFT.

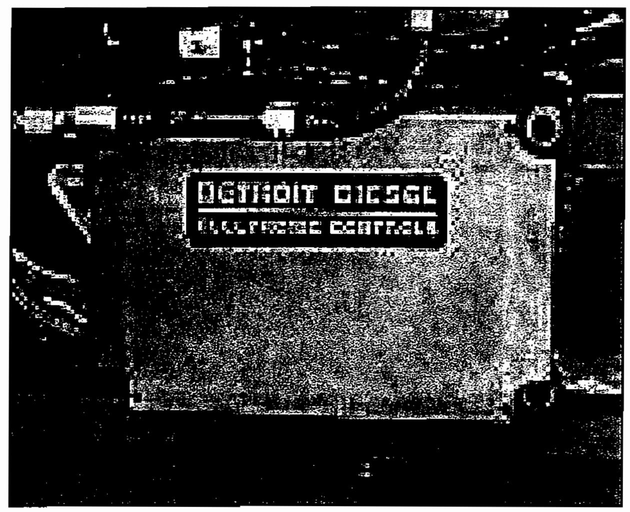


The aviation community has long recognized the need for more data in investigating aircraft crashes. In fact, commercial aircrafts have been equipped with crash data recorders for many years. Crash investigators use the data in the recorders to determine the sequence of events leading up to the crash, as well as to identify any mechanical failures that may have caused, or contributed to, the crash. Engineers have designed the data recorders to continually monitor relevant data from control surface position to engine oil pressure, and to survive even the most severe crashes. Despite aviation's excellent safety record, crashes do occur.

When they do, one of the most important tasks for investigators is locating the data recorder. The media refers to it as "The Black Box".

The automotive industry has known about the Black Box technology for many years, and in fact was a partner in its development. Automotive engineers know that designing a safer vehicle requires an understanding of how a current design performs during a crash. Some manufacturers have used Black Box technology on a limited basis in various test and prototype programs; however, excessive weight and cost, as well as limited functionality, precluded its use in production vehicles.



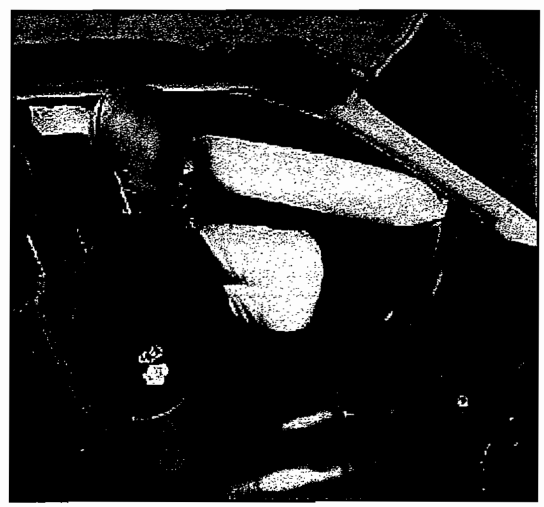


Advances in microprocessor technology have changed all that. The Black Box, found in millions of vehicles on the road today, is identical in purpose and similar in function to those found in commercial aircraft. Just as additional data aids aircraft crash investigators, collision and vehicle investigators benefit from the additional data provided by the automotive and heavy truck Black Box.

A LITTLE "BLACK BOX" HISTORY

...THE SOLE PURPOSE OF THE AUTOMOTIVE BLACK BOX WAS TO DETERMINE IF THE AIRBAG SYSTEM WAS OPERATING AS DESIGNED.

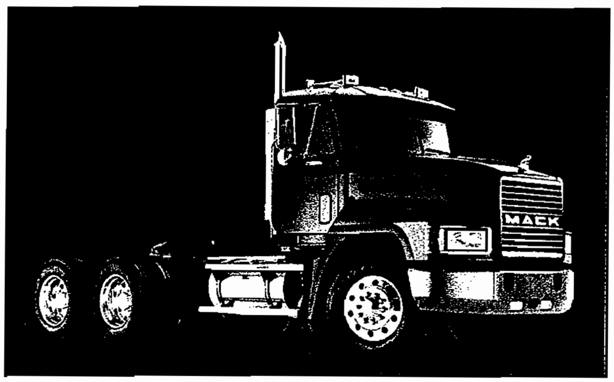
Since as early as 1990, General Motors has been using the Black Box in select production vehicles. The data provided by the earliest GM Black Box was limited and, in fact, had less to do with providing crash data than it did with monitoring the performance of a new and significant vehicle feature – the airbag. At that time, the sole purpose of the Black Box was to determine if the airbag system was operating as designed. The term was also a misnomer, since it was neither black nor a separate component. In fact, the "Black Box" was actually just a small chip within the microprocessor that controlled the airbag system.

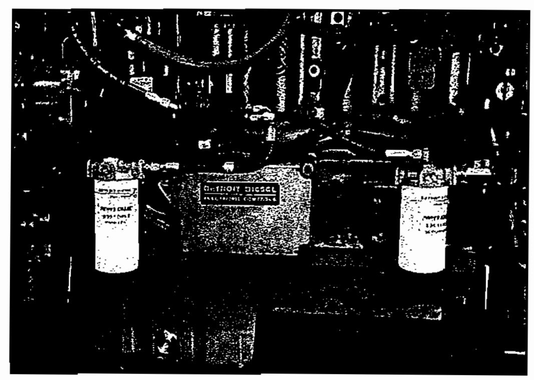


Through the years, the Black Box has evolved into a sophisticated monitoring and recording system, much like those on commercial aircraft. Although still not black, or a separate component, GM's latest Black Box records important pre-crash data such as vehicle speed and braking, engine speed, throttle position, seat belt usage, and more. To date, General Motors has led the automobile industry in incorporating the Black Box into production vehicles. Their systems are reported to be more sophisticated than any other system currently installed, and they are the first manufacturer to publicly announce that their vehicles are indeed equipped with a Black Box. Other manufacturers reported to be utilizing some type of Black Box recording devices include Ford, DaimlerChrysler, and Honda.

The automotive industry is not the only group to utilize this important technology. Heavy truck manufacturers are also using the Black Box and have been doing so for several years. For example, Detroit Diesel Inc., manufacturer of the engines found in many large trucks, utilizes a data recording system that in many aspects is more sophisticated than the GM system.

THE BLACK BOXES ON HEAVY TRUCKS ARE PART OF THE ENGINE'S ELECTRONIC CONTROL MODULE.



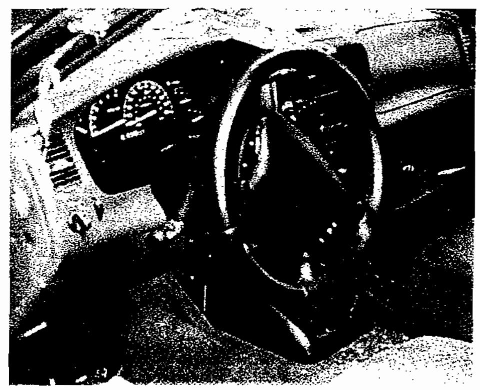


The Black Boxes found on many newer heavy trucks are often part of the engine's electronic control module (ECM). This module is responsible for monitoring and controlling important engine and exhaust parameters. As a result, the Black Box within the ECM can record many of the parameters related to engine operation, including vehicle speed and throttle position. In fact, the heavy truck Black Box can record much the same information as the GM Black Box, although the two systems operate under different conditions. For example, the GM Black Box records data when the airbag deploys. Most heavy trucks, however, are not equipped with an airbag system and therefore requires a different recording "trigger". On these vehicles, data is recorded during a hard braking event as determined by the anti-lock brake system (ABS).

WHAT TO EXPECT FROM THE BLACK BOX

SOME BLACK BOXES CONTAIN DATA ON VEHICLE SPEED, BRAKE APPLICATION, THROTTLE POSITION, AND SEAT BELT USAGE.

One of the most important bits of information the GM Black Box will provide is what collision reconstruction engineers commonly refer to as Delta-V - the change in vehicle velocity, or in some cases, vehicle deceleration/acceleration. Knowing the vehicle velocity change at impact may help in the determination of collision forces acting upon the occupants of the vehicle.



However, the Black Box will record more than just Delta-V. It will provide investigators with important information that previously was not available, or was subject to witness memory and integrity. For example, the Black Box may provide an indication if the vehicle brakes were applied prior to the collision and if so, whether they worked or not. It will indicate if the seat belts were fastened, and can even be used in cases involving alleged sudden acceleration. In fact, the complete value of the Black Box is not yet fully understood.

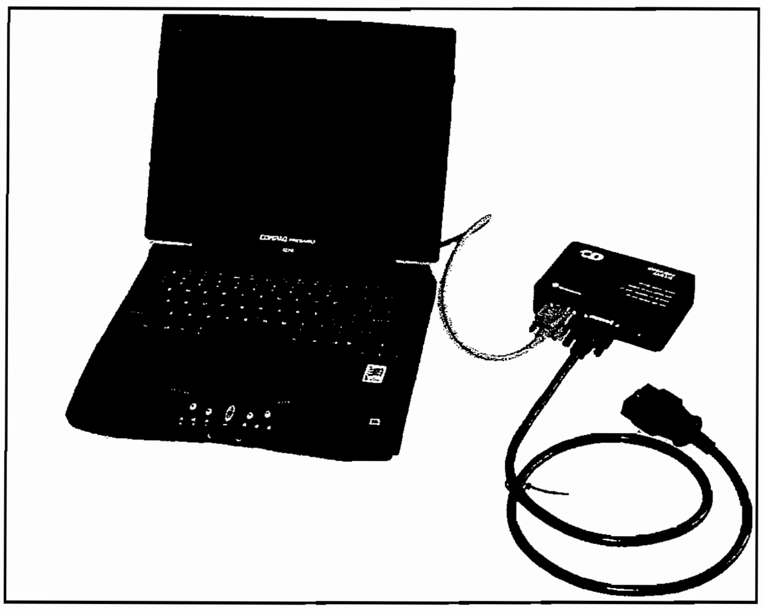
Though the Black Box installed in many newer trucks will provide data very similar to the GM device, there are some important differences. For example, the truck Black Box will not provide information about Delta-V in the same detail as the GM device. However, they do provide important information over a much longer period of time. Some truck Black Boxes record vehicle speed, engine speed, braking status, and more, for up to one minute prior to the recording event. Additionally, some truck Black Boxes actually record the date, time, and vehicle mileage of the recording event.

Just as important as the specific data is the fact that collision reconstruction engineers now have access to this data.

ACCESSING THE DATA

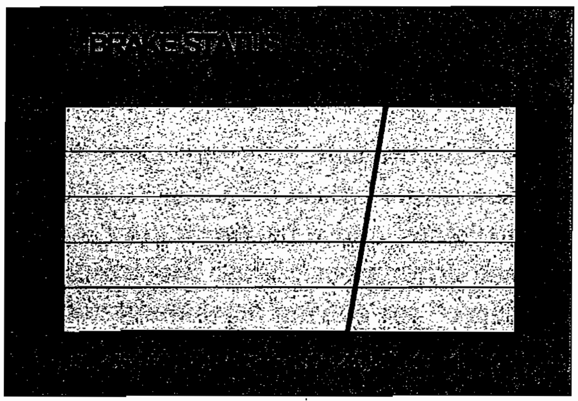
THE EQUIPMENT REQUIRED TO DOWNLOAD THE DATA DEPENDS ON THE TYPE OF BLACK BOX USED.

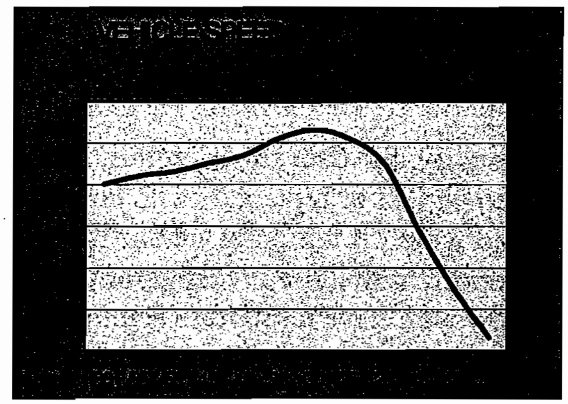
Usually, the data stored within the Black Box is permanent, although some data can be lost or replaced. The conditions that determine which data is permanent and which is temporary are different for each system, and it becomes very important that the investigator understand these differences. Most Black Boxes, however, have a separate electronic "file" reserved for storing permanent data. Data stored in this file can be accessed days, months, or even years after the data was recorded.



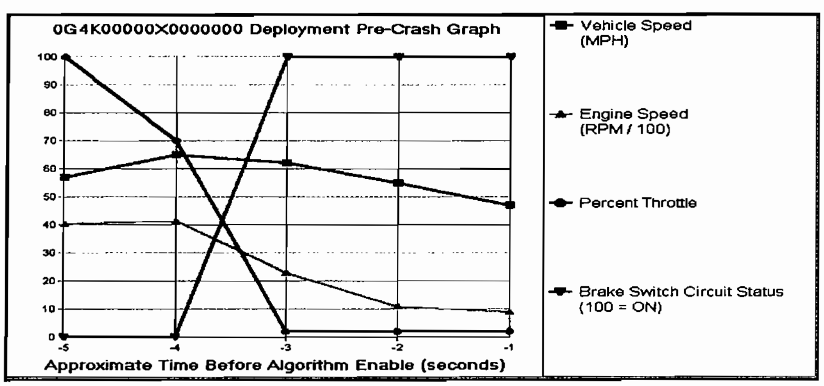
The equipment required to download the data depends on the type of Black Box used. For example, the equipment used to access the data from a GM Black Box cannot be used to access the data from a Detroit Diesel Black Box.

On most of these devices, the recorded data can be accessed in a number of different ways. Most Black Boxes are connected to the vehicle's central computer network. The download equipment connects directly to the nework connector, facilitating quick and easy downloading. Using this connector, however, requires that the vehicle's electrical system is intact. This is often not the case with a vehicle that has been involved in a serious collision. Alternatively, the download equipment can be connected directly to the Black Box. On some vehicles, this is not a difficult process. On others, however, the Black Box is buried deep within the vehicle's interior, such as under one of the front seats, and could be difficult to access.



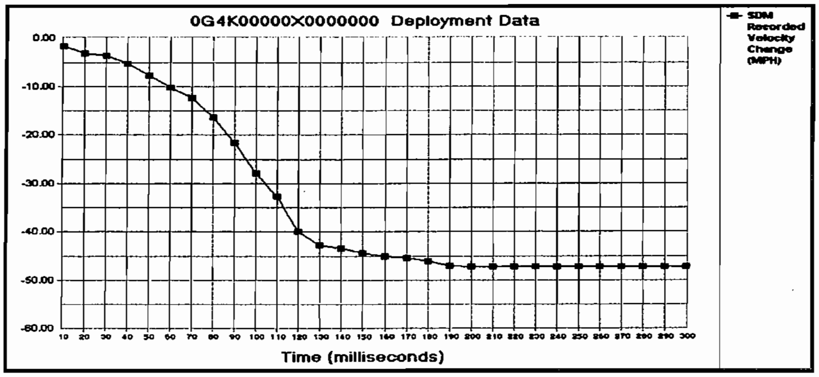


Once the data is downloaded, the engineer can review the data and begin the analysis and interpretation. For example, most data can be illustrated on a time-graph, showing the various parameters as they change in the moments leading up to the recording event.



The engineer can use this information along with speed, time, and distance relationships, as well as human perception and reaction capabilities to begin to reconstruct the incident.

This information can even help the engineer assess vehicle performance, such as braking effectiveness.



BLACK BOX LIMITATIONS

FOR ALL ITS POTENTIAL WORTH, HOWEVER, THE BLACK BOX WILL NOT ELIMINATE THE NEED FOR THE RECONSTRUCTION ENGINEER.

The Black Box has the potential to become one of the most important elements in a collision reconstruction. For all its potential worth, however, the Black Box will not eliminate the need for the reconstruction engineer. For example, it does not record the direction of pre- or post-impact vehicle movement – a major component of many collision reconstructions. Reconstructing the entire collision sequence (i.e., one that includes events after the Black Box recording ends) will require the same kind of analysis that engineers used before the Black Box. Another important consideration is that the Black Box records only Delta-V in the longitudinal, or front-to-rear, direction. If the principle direction of collision force is something other than this, the direction will have to be determined employing the same methods that investigators have used for years. Furthermore, because the Black Box is part of the airbag system, its recording mode is triggered, not surprisingly, when the airbag deploys. Therefore, if the collision dynamics do not cause the airbag to deploy, data will most likely not be recorded.

The data that the Black Box provides will be very valuable; however, there will continue to be other important data available to the collision reconstruction engineer. Whenever possible, an effort should be made to establish consistency between all the available data and avoid the temptation to reach conclusions based solely on the Black Box.

USING THE BLACK BOX IN A FORENSIC EXAMINATION

...THE RECORDED DATA FROM THE BLACK BOX CAN HELP GUIDE THE INVESTIGATOR DURING THE EXAMINATION.

One of the most important components to many forensic automotive examinations is a brake system evaluation. A complete forensic brake system evaluation may include inspection and evaluation of the following items:

Brake Master Cylinder, Calipers and Wheel Cylinders
Hydraulic Valves, Lines, and Hoses
Brake Fluid Quantity and Condition
Power Assist Vacuum Chamber, Check Valve, and Engine Vacuum
Anti-lock Brake Control Valves
Brake Shoes and Pads
Tires and Wheels
Brake Rotors and Drums
Electrical Switches, Sensors, Wiring, and Connectors
Fail-safe and Warning Systems
Electronic Control Modules and Computers

In a case where little is known about the condition of the vehicle's brake system, a comprehensive brake examination may require that all the preceding items, and possibly more, be inspected and or tested.

If the vehicle is equipped with a Black Box, however, the above list could be significantly shortened because the recorded data from the Black Box can help guide the investigator during the examination. For example, if the Black Box shows that the brakes were applied prior to the collision, and vehicle deceleration coincided with that brake application, there is a strong indication that, at least to some degree, the brake system was functioning. The investigator can analyze the Black Box data and make preliminary determinations regarding the operational status and performance of the brake system, and determine the components that may or may not need to be included in the evaluation.

EVALUATING QUESTIONABLE AUTOMOTIVE CLAIMS/THEORIES UTILIZING THE BLACK BOX

ENGINEERS EVALUATE THE VALIDITY OF THEORIES USING SCIENCE AND ENGINEERING PRINCIPLES.

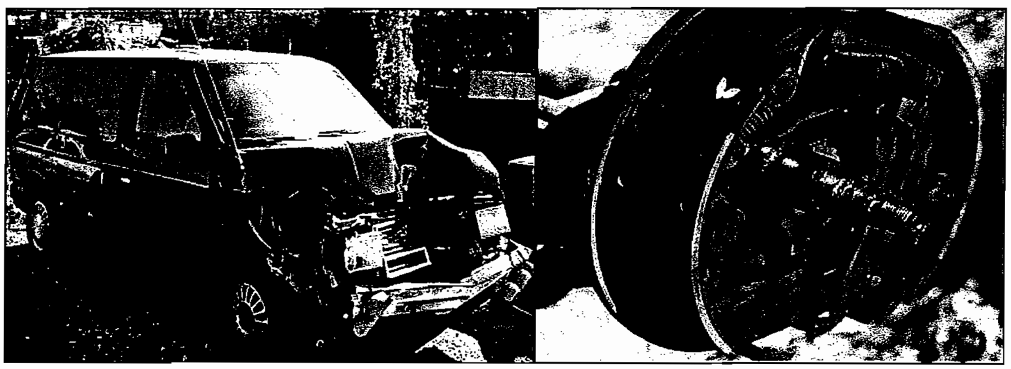
Theft and arson are two of the more common types of "questionable claims" in automotive cases. Investigation of each of these types of potentially "fraudulent" cases requires different areas of knowledge and skill. For example, arson investigations may focus on accelerants, burn patterns, and the extent of fire damage. Theft investigations often focus on signs of forced entry, and ignition lock tampering. Sometimes the physical evidence is indisputable, but other times there is very little physical evidence at all. In many cases, the decision to pay or deny an automotive claim is based on the physical evidence, as well as circumstantial evidence, such as motive.

There are other kinds of "questionable claims" in automotive cases besides theft and arson. By definition, someone who attempts to benefit through misrepresentation, deception, or concealment, is committing "fraud". For example, automotive "fraud" could include someone who knowingly falsely attributes an automotive collision to mechanical failure. In cases like this, it is often difficult to completely exclude the possibility of mechanical failure. Very often, it is the absence of physical evidence that points to the questionable validity of the claim. The Black Box, however, has the potential to become an important tool in the evaluation of questionable automotive claims/theories. It must be clear however that the engineers role is to apply the laws of science/engineering to physical evidence in an effort to independently analyze the data without bias. This means, no pre-determined opinions should be molded. Consider the following case examples.

CASE EXAMPLE 1 – **BRAKE FAILURE**

This is a common claim scenario: the driver of a vehicle has just rear-ended the vehicle in front of him, claiming that his brakes failed. Automotive engineers know that brake failures can occur, and that sometimes they occur intermittently, leaving no physical evidence. If the vehicle was equipped with a Black Box, and if the collision dynamics resulted in data being recorded, there may be a way to determine if the brakes were applied. This is because the Black Box can record the status of the brake switch, which is activated when the brakes are applied. In other words, investigators would know if the driver was applying the brakes during, or shortly before the collision.

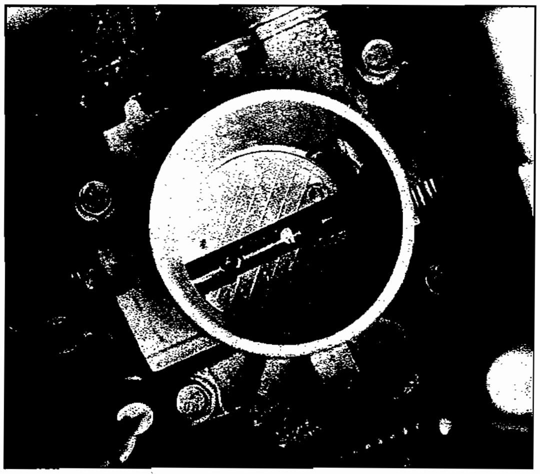
If, however, the Black Box indicated that the brakes were applied, there is still the issue of how well the brakes worked. The Black Box can help determine braking effectiveness because it can record vehicle speed for up to five seconds prior to the collision. The automotive engineer can analyze this data to determine if there was a change in vehicle speed corresponding to the brake application. If the Black Box showed that the brakes were applied, and the vehicle slowed as a result of this brake application, then it is likely that the brakes did not fail as the driver claimed.

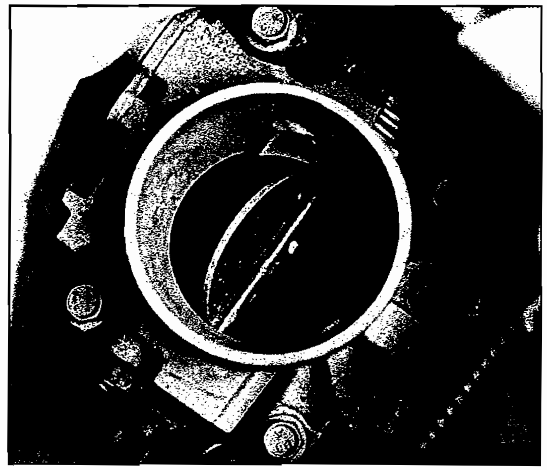


CASE EXAMPLE 2 – **SUDDEN ACCELERATION**

WITH THE BLACK BOX INFORMATION, INVESTIGATORS CAN KNOW HOW FAR THE THROTTLE WAS OPEN BEFORE AND DURING THE COLLISION.

Through the years, sudden acceleration has been the subject of many heated debates between auto manufacturers and consumer groups. It is a phenomenon that usually occurs while the vehicle is idling in gear, or being accelerated from rest. Auto manufacturers have long contended that the vast majority of these cases are the result of operator error; however, consumers have argued that the sudden acceleration is the result of a design defect or mechanical failure. The term usually implies that the acceleration is the result of an uncommanded or unintentional throttle application. Automotive investigators, with experience in sudden acceleration cases, know the difficulty in determining with certainty the exact cause of the acceleration.





When conducting a forensic examination in a case of sudden acceleration, the well-planned inspection should include a visual examination, as well as consideration of the components, systems and controls that have mechanical authority over the engine throttle. Such items may include the following:

Cruise Control
Acceleration and Traction Control
Cold Engine Idle Advance
Accelerator Pedal, Cable and Linkage
Throttle Valve
Idle Air Control Valve

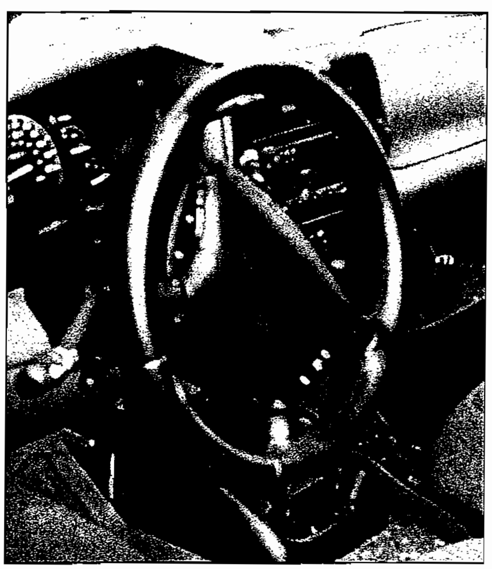
An examination that incorporates all these items can be a difficult task and may yield inconclusive results. On vehicles equipped with a Black Box, however, the investigation may be greatly simplified. This is because one of the parameters that the Black Box records is throttle position. With this Black Box information, investigators can know how far open the throttle was open before and during the collision. This data can be correlated to additional data contained within the Black Box, for example, brake status, engine speed and vehicle speed, as well as the available physical evidence.

CASE EXAMPLE 3 – **STAGED "ACCIDENTS"**

...MANY DRIVERS IN STAGED COLLISIONS ARE NOT WILLING TO SIT BEHIND AN EXPLODING AIRBAG.

Staged "accidents" are a fairly common example of automotive "fraud". A typical scenario involves a collision between the insured vehicle and another object, such as an abandoned car. In this scenario, the individual will drive the insured vehicle into the abandoned car, then leave the scene and fabricate a story of hit-and-run. Often, these staged collisions are the kind that would normally result in airbag deployment.

Sometimes the individuals involved often know not only that the airbag will deploy, but also that the airbag should be deployed after the collision to minimize the appearance of a staged "accident". Not surprisingly, many drivers in staged collisions are not willing to sit behind an exploding airbag. As a result, some have learned how to manually deploy the airbag using two long wire leads and a small battery. Often this is done after the collision with the vehicle stopped.



If the vehicle involved in this scenario was equipped with a Black Box, it could provide the engineer with several clues. For example, if the vehicle ignition was turned off while the airbag was manually deployed, the Black Box would not be activated and would not record the manual deployment event. In this situation, the lack of deployment data from the Black Box would be inconsistent with normal airbag system operation and would suggest that the airbag was deployed by some other means. Alternatively, if the ignition was turned on when the airbag was manually deployed, the Black Box would be activated and would record the manual deployment event. In this case, Delta-V would be the most compelling data that the Black Box would provide. Because the deployment was not the result of an impact, the recorded Delta-V would be zero mph. Again, this would be inconsistent with normal airbag operation and would suggest that the airbag deployment was not the result of the collision.

VEHICULAR TIRES

TIRE EXAMINATIONS

USUALLY THE MAIN OBJECTIVE OF A CURSORY EXAMINATION IS TO FIRST DETERMINE IF A TIRE IS DAMAGED.

Most forensic vehicle investigations typically include a tire inspection. Many times, only a cursory examination is required to determine if a tire may have contributed to a particular incident. It may be a statement of the obvious, but if a tire is inflated after an incident, and is absent of obvious signs of failure, it was most likely not a contributing factor, particularly if the incident occurred on a dry road.

Discovering a tire with gross indications of failure, or one that is not inflated, may be a different story. Usually, the main objective of a cursory examination is to first determine if a tire is damaged. Then, if it is, a more in-depth examination may be required to determine if the damage was the result of the incident or a

MANUFACTURING DEFECTS

TIRE MANUFACUTURING IS HIGHLY PROCESS-SENSITIVE AND REQUIRES CAREFUL ATTENTION TO DETAIL.

Regardless of the product, engineers and manufacturers know that changes in variables such as equipment, processes, and personnel, to name a few, can increase the chances of manufacturing defects. Even a mature and stable design can be susceptible to manufacturing defects, given a change in one or more of the links in the manufacturing chain. Tire manufacturing is highly process-sensitive and therefore requires careful attention to detail.

For example, a critical step in the manufacturing process occurs when the tread is bonded to the tire's inner casing. Without careful temperature control, these components might not achieve the required bond strength, which could result in separation between the tread and casing while the tire is in service.

HEAT AND WEAR

Normally when a tire rolls, its sidewall flexes. This flexing action can cause generation of heat within the tire. If the sidewall flexes too much, due to low tire pressure or excessive loading, for example, excess heat build-up can occur. In extreme cases, this could result in premature tire wear and possibly tire failure.

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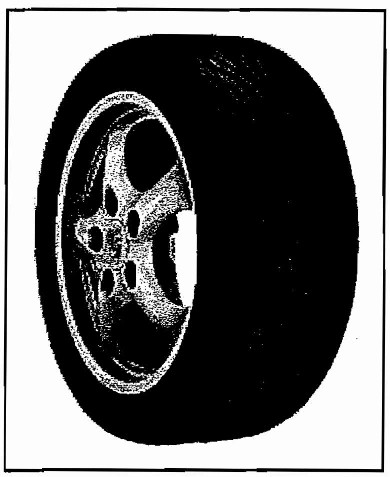
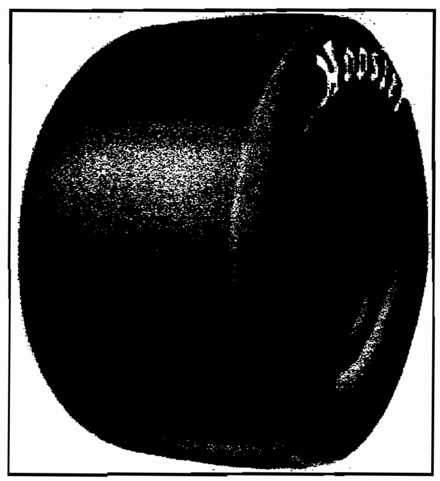
TIRE PERFORMANCE

HYDROPLANING OCCURS WHEN THE VEHICLE IS RIDING ON A THIN LAYER OF WATER BETWEEN THE TIRE AND ROAD SURFACE.

Generally, a tire will perform adequately if it is the appropriate type for the particular application. For example, some race cars perform very well on dry pavement with treadless tires. These tires are sometimes referred to as racing “slicks”. However, because treadless tires do not have grooves that help channel the water away, using these tires on wet pavement will likely result in very poor performance and could lead to hydroplaning.





Hydroplaning occurs when the vehicle is actually riding on a thin layer of water between the tire and road surface. When this occurs on passenger vehicles, it is often the result of worn or thin tread grooves.

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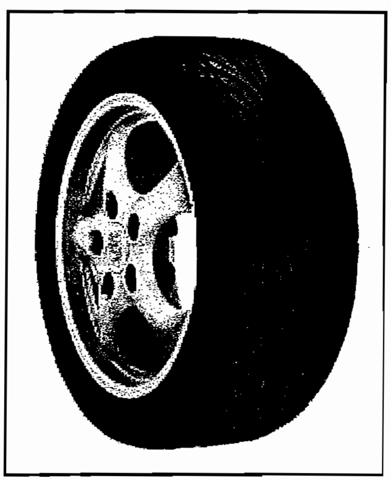

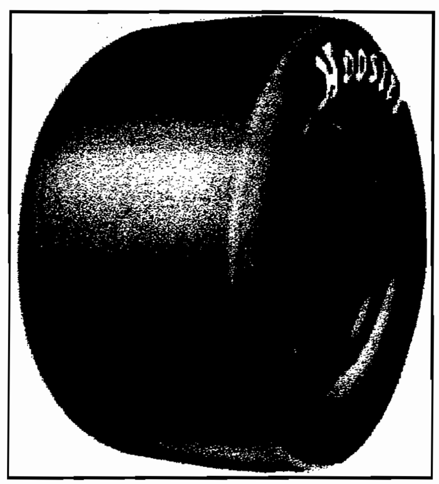

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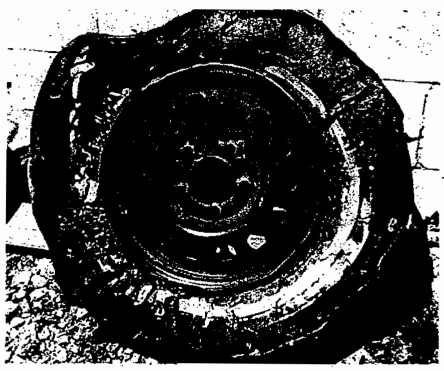

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