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EXPERT TESTIMONY REGARDING THE SPEED OF A VEHICLE: THE STATUS OF NORTH CAROLINA LAW AND THE STATE OF THE ART

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I. INTRODUCTION AND BACKGROUND

Rule 702 of the North Carolina Rules of Evidence states that a witness, qualified as an expert, may testify, in the form of an opinion, if scientific, technical, or specialized knowledge will assist the trier of fact.[1] This "helpfulness" standard has opened the door to opinion testimony on such subjects as a decedent's state of mind at the time of his death by an expert who never saw the decedent,[2] credibility of children who report sexual abuse,[3] and the general packaging of marijuana.[4] North Carolina law is unsettled as to whether this "helpfulness" standard extends to an expert's opinion testimony regarding the speed of a vehicle.

The speed of a vehicle is a critical fact to be proved in a variety of cases. The fact is contested in civil negligence cases[5] and criminal cases.[6] Eyewitness testimony regarding the speed of a vehicle can vary widely. In *State v. McQueen*, three witnesses placed the speed of a vehicle at between 95 to 100 miles per hour, at 75 miles per hour, and at between 60 to 70 miles per hour respectively.[7] Two of the witnesses observed the vehicle for

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1. N.C. GEN. STAT. § 8C-1, Rule 702 (1992).

2. Harvey v. Raleigh Police Department, 85 N.C. App. 540, 355 S.E.2d 147, *cert. denied,* 320 N.C. 631, 360 S.E.2d 86 (1987).

3. State v. Oliver, 85 N.C. App. 1, 354 S.E.2d 527, *cert. denied*, 320 N.C. 174, 358 S.E.2d 64 (1987).

4. State v. Chisholm, 90 N.C. App. 526, 369 S.E.2d 375 (1988).

5. Hicks v. Love, 201 N.C. 773, 161 S.E. 394 (1931).

6. State v. Purdie, 93 N.C. App. 269, 377 S.E.2d 789 (1989).

7. State v. McQueen, 9 N.C. App. 248, 250, 175 S.E.2d 789, 790 (1970).

approximately one minute and the third for approximately 245 yards.[8] Wide disparity in observations is not uncommon.

Studies have documented the degree of accuracy and reliability of eyewitness testimony.[9] An observer's capacity to interpret audio or visual stimuli, as well as an individual's ability to recall the stored information without changes in recollection depend on numerous variables. These variables include external or environmental factors and the personal background and experience of the witness.

A witness to a motor vehicle accident could be an involved driver, an uninvolved motorist, or a bystander. Each of these individuals may be stationary or moving, and each person may also see the accident from a different physical position. As a consequence, multiple witnesses to a single accident, as evidenced in *McQueen*, often have differing if not contradictory descriptions of the same event.[10]

II. THE RELIABILITY OF EYEWITNESSES

Most automobile collisions, specifically the moment of impact, occur in a time period of approximately one tenth of a second. The precise time of impact can be scientifically verified by dividing the typical crush depths or changes of overall body length observed after an accident by the vehicular closing speeds. In addition, the events leading up to a collision may take place within a few seconds. The heightened alertness expected of an individual aware of an impending collision may not be experienced by any party until the actual impact takes place. As a result, an observer may not attach significance to the actions of a motor vehicle unless the vehicle attracts the observer's attention.[11]

Once the collision takes place, and before the individual is questioned, a witness will have time to contemplate the sensory information remembered before, during, and after the accident. Furthermore, the witness may walk around the accident scene in an attempt to piece together the sequence of events which defined

8. *Id.*

9. Gary L. Wells and D.M. Murray, *Eyewitness Confidence*, *in* EYEWITNESS TESTIMONY: PSYCHOLOGICAL PERSPECTIVES 161 (Gary L. Wells & Elizabeth F. Loftus eds., 1984).

10. *McQueen*, 9 N.C. App. at 250, 175 S.E.2d at 790.

11. Luther O. Cox, Jr. et al., *Improving Witness Contributions to Reconstruction and Animation, in* ACCIDENT RECONSTRUCTION: TECHNOLOGY AND ANIMATION II SP-907 62 (Terry D. Day and Wesley D. Grimes eds., 1992).

the accident. During this time the witness' recollection may be clouded or distorted by interaction with other witnesses. The viewing and possible misinterpretation of physical evidence can also influence the witness's account. [12]

Automobile collisions are unexpected traumatic events, which place witnesses in a stressful environment during and after an accident. The bias of an interviewer, if any, as well as the form of the questions (i.e., leading or suggestive) can influence the recollection.[13] In one study developed to monitor changes in eyewitness recollections of complex events, witnesses viewed a film of an automobile accident, and then answered questions concerning what they saw.[14] Some of the subjects were asked questions which introduced misleading or false information.[15] Witnesses were six times more likely to recall seeing a nonexistent event or object when presented with misleading or false information.[16] In another study using a similar methodology eighty percent of the witnesses indicated that their recollections of the accident were influenced by the misinformation.[17]

People generally judge time and distance based on some memorized or familiar measurement standard. For example, the comparison of a distance to the length of a football field or length of a courtroom is often used in the examination of witnesses at trial. Recollections based on these familiar cues can result in erroneous descriptions. Similarly, most people have a concept of the length of a second from the use of clocks or stopwatches. However, as a whole, witness estimates of time are even less reliable than the judgment of distance. Frequently, a witness will state that the accident seemed to occur in slow motion, showing that an individual's concept of time is easily distorted. To judge the speed of an automobile, a witness must be able to estimate time and distance with reasonable accuracy. Therefore, an observer must have adequate opportunity to see a vehicle in relation to a known visual cue or cues over a finite period of time.[18]

12. *Id.*

13. David F. Hall et al., *Postevent Information and Changes in Recollection for a Natural Event, in* EYEWITNESS TESTIMONY: PSYCHOLOGICAL PERSPECTIVES 131 (Gary L. Wells & Elizabeth F. Loftus eds., 1984).

14. *See generally*, ELIZABETH F. LOFTUS, EYEWITNESS TESTIMONY (1979).

15. *Id.*

16. *Id.*

17. *Id.*

18. Cox et al., *supra* note 11, at 63.

The perception of the speed of a vehicle can be influenced by its surroundings, its relationship to moving or stationary objects, and its distance and direction of travel with respect to the observer. All of these factors can be further complicated by the speed and direction of travel of the observer in relation to the observed vehicle.[19]

The authors of this article have been conducting a study of witness observations of vehicle speed. The methodology of these studies involve comparing the best guesses of subjects against the radar gun measured speeds of oncoming, departing, and passing vehicles. In the test, subjects observed the vehicles from a standing position in daylight, and they could both see and hear the vehicle. The subjects were also not significantly restricted with respect to the amount of time available to judge speed. The subjects were under extremely advantageous circumstances since they were not distracted by maintaining control over their own vehicle or avoiding a collision. These ongoing perceptional studies have already demonstrated that the vehicle's direction of travel significantly affects the accuracy of the subjects' estimation of speed. The studies show that individuals could judge speed more accurately for vehicles traveling away from their position as opposed to vehicles traveling towards or perpendicular to their position.

A possible explanation for the accuracy of observation of vehicles traveling away from the witness could be the addition of sound stimuli from the passing vehicle in combination with an extended viewing time as the vehicle traveled away from the observer's position. The observers did not have the benefit of this combination of stimuli or duration in the other two test scenarios. The results of the tests raise an important factor in witness perception — sound and sound variations. That is, sound perception is a essential factor in determining vehicular speed.

Observed witnesses would change an estimation of speed solely based on the magnitude of sound from a vehicle. For example, observers can associate loud engine noise with high speed, which may or may not be the case. It is also not unusual for a witness to give an opinion of speed based only on a loud engine without any visual observations. The wide range of variables which affect auditory information would make sound aided speed

19. *Id.*

estimation suspect at best.[20] Such variables include frequency, amplitude, acoustic attenuation, echo effects, chamber resonance, refraction, and reflection of sounds by physical surfaces.[21]

The test results also suggested that longer viewing times tended to increase the accuracy of the speed estimation. However, in real accident situations, the amount of time surrounding the entire accident sequence could be minimal. As mentioned previously, actual collisions take place in the order of a tenth of a second. If a vehicle is traveling 55 mph prior to a collision, it would be covering 81 feet per second. If a witness has the opportunity to observe the vehicle for three seconds before the collision, the car would travel 243 feet. If the speed is increased by 10 mph (15 feet per second), the car would travel 288 feet. Therefore, a witness would have to differentiate between 243 feet and 288 feet by eye *and* discern the elapsed time to begin to have an accurate foundation for speed estimation. The difficulty is understandably magnified if the observation period is decreased. For example, if a witness views the vehicle for one-half of a second, then the variance in distance is reduced by only seven feet in 288 (2.43%), which is most likely outside the perceptional accuracy of most observers even in the most ideal situations.[22] Given the possible fallibility of eyewitness observation of vehicle speed, expert testimony would seem to be a logical means of helping the finder of fact reach a decision regarding this critical fact.

III. The Status of North Carolina Law in Regards to Admissibility of Testimony from Expert Witnesses as to Speed of a Vehicle

Two North Carolina Court of Appeals decisions made within seventeen months of one another have created uncertainty in

20. This same conclusion was reached in the court of appeals where the court refused to admit the testimony of a witness who heard but did not see the vehicle. Hicks v. Reavis, 78 N.C. App. 315 , 319, 337 S.E.2d 121, 124 (1985).

21. A review of the variables affecting the measurement of sound can be found in any authoritative text on acoustics written at the college postgraduate level. Many of the principles are discussed adequately in undergraduate physics texts. *See*, e.g., Williams et al., Modern Physics (1959).

22. *But see* Beaman v. Sheppard, 35 N.C. App. 73, 239 S.E.2d 864 (1978). The court of appeals determined that a witness had a reasonable opportunity to observe and thus testify regarding the speed of an oncoming vehicle observed for approximately four car lengths or 80 feet. The witness testified the vehicle was traveling 65 to 70 mph. The witness's observation time could not have exceeded two-thirds of one second.

North Carolina law as it regards the admissablity of expert testimony to prove speed of a vehicle. The traditional North Carolina view was espoused in *Coley v. Garris*.[23] In *Coley* the trial court admitted opinion evidence of a North Carolina highway patrol officer who had investigated the accident scene, including gouge and scuff marks, and interviewed witnesses.[24] Based on this investigation the officer concluded that the plaintiff's motorcycle was traveling at a speed of approximately seventy-five miles per hour.[25] Plaintiff, on appeal, contended that the testimony of the officer should have been excluded because his opinion was not based on his personal observation.[26]

The court of appeals, citing *Tyndall v. Hines Co.*[27], stated, "It has long been the rule in North Carolina that 'one who did not see a vehicle in motion will not be permitted to give an opinion as to its speed.'"[28] The court acknowledged that the witness could describe the physical evidence at the scene, including the damage to the vehicle involved, but that the jury is "as well qualified as the witness to determine what inferences the facts will permit or require."[29] No doubt the court in *Coley* was guided by the unequivocal statement contained in *Shaw v. Sylvester*,[30] which represents the first North Carolina case to deal with the subject of expert testimony on vehicle speed. The *Shaw* court, citing Arkansas precedent, stated, "This case furnishes a good illustration why 'courts look with disfavor upon attempts to reconstruct traffic accidents by means of expert testimony, owing to the impossibility of establishing with certainty the many factors that must be taken into consideration.'"[31]

The court of appeals expressed a contrary view in *State v. Purdie*.[32] In *Purdie* an accident reconstruction expert testified in an involuntary manslaughter case that the vehicle accident involving the defendant occurred in the victim's lane of travel.[33]

23. 87 N.C. App. 493, 361 S.E.2d 427 (1987).
24. *Id.* at 494, 361 S.E.2d at 428.
25. *Id.*
26. *Id.*
27. Tyndall v. Hines Co., 226 N.C. 620, 39 S.E.2d 828 (1946).
28. *Coley*, 87 N.C. App. at 495, 361 S.E.2d at 428.
29. *Id.*
30. 253 N.C. 176, 116 S.E.2d 351 (1960).
31. *Shaw*, 253 N.C. at 179-80, 116 S.E.2d at 355 (citing Conway v. Hudspeth, 318 S.W.2d 137 (Ark. 1958)).
32. 93 N.C. App. 269, 377 S.E.2d 789 (1989).
33. *Id.* at 273, 377 S.E.2d at 791.

The expert, a civil engineer who had investigated approximately 1,000 accidents, relied upon the police report, interviews, and photographs of the accident scene.[34] The expert testified that the laws of physics, the rotation and final resting point of the vehicles, location of debris and gouge marks, and the contact points on the vehicles contradicted the defendant's assertions that the victim's vehicle had crossed the center line.[35]

Purdie on appeal identified eleven assignments of error concerning the admission of the expert's testimony. In rejecting each error the court of appeals determined that the expert was in a better position than the jury to determine which lane of travel the accident occurred based upon scientific principles.[36] The court also determined that the conclusion of the expert was not hindered by the fact that the expert had no firsthand knowledge, had not visited the scene nor interviewed witnesses.[37] Finally, it appeared that the court was not at all troubled by the fact that five eyewitnesses testified about the same subject matter as the expert.

Despite the fact that the state's expert in *Purdie* only testified regarding the location of the accident, the court went out of its way to address the defendant's reliance on *Hicks v. Reavis*.[38] *Hicks* presented the traditional North Carolina view that an expert cannot testify as to the speed of a vehicle "if that opinion is based upon physical evidence obtained at the scene rather than personal observation."[39] The *Purdie* court noted that the decision in *Hicks* relied on *Shaw* and that *Shaw* had been decided twenty-four years before the North Carolina Rules of Evidence had been adopted.[40] The court further stated, "The view that experts may not rely upon skid marks, vehicle damage, rotation and resting positions of vehicles, and other physical evidence to give an opinion as to speed has been rejected by the majority of jurisdictions deciding this question."[41]

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34. *Id.*
35. *Id.*
36. *Id.* at 275, 377 S.E.2d at 792.
37. State v. Purdie, 93 N.C. App. 269, 275-76, 377 S.E.2d 789, 792-93 (1989).
38. 78 N.C. App. 315, 337 S.E.2d 121 (1985), *cert. denied*, 316 N.C. 553, 344 S.E.2d 7 (1986).
39. *Id.* at 323, 337 S.E.2d at 125.
40. *Purdie*, 93 N.C. App. at 276, 377 S.E.2d at 793.
41. *Id.* The court cited 29 A.L.R. 3d 248 (1970) (Supp. 1988); 93 A.L.R. 2d 287 (1964) (Later Case Serv. 1983) (Supp. 1988) and the disfavor noted by Professors Brandis and Broun. *See* 1 BRANDIS AND BROUN ON NORTH CAROLINA EVIDENCE, Sec. 183, n.165 (4th ed. 1993). Professor Broun in this note states, "The original

North Carolina's minority view, as represented by the decision in *Coley*, and the line of cases which preceded it, including *Shaw, Tyndall,* and *Hicks,* all concerned the admissibility of testimony by state troopers or other law enforcement officers. An analysis of this line of cases could easily conclude that the North Carolina view is based on the court's displeasure over the use of state troopers and other police officers as experts in civil cases as opposed to the view that experts *per se* have nothing to offer the finder of fact.[42]

In rejecting the defendant's argument that the admission of the trooper's expert testimony was not prejudicial, the *Coley* court stated:

> Trooper Booth "was a State employee whose duty it was to make a disinterested and impartial investigation of the accident. In so doing he was a representative of the state. His testimony should, and no doubt did, carry great weight with the jury."[43]

The power of persuasion of a trooper or other police officer, coupled with the skepticism the court has traditionally shown towards this type of analysis, may have led the court to articulate a broad brush position which rejects all experts who are offered for this purpose. The issue that now confronts the judiciary, given the conflicting views articulated in *Coley* and *Purdie*, is whether the science inherent in accident reconstruction analysis, which is used to determine the speed of a vehicle from physical facts found at the scene of an accident, has sufficient reliability to be judicially recognized in North Carolina. If the science falls within the Rule 702 "helpfulness" standard, then the courts are assigned the singular responsibility of determining if the witness has sufficient expertise in accident reconstruction to apply these scientific principles to the case at issue.

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author of this text cogently argued that the rule limiting testimony in this regard should apply only to lay witnesses, and not to experts. Dean Brandis agreed. (BRANDIS ON NORTH CAROLINA EVIDENCE, Sec. 181 (3rd ed. 1988). This author strongly agrees with both of his predecessors, particularly in light of the language of N.C.R. Evid. 702 . . ." *Id.*

42. *But see* Sparks v. Gilley Trucking Co., 992 F.2d 50 (4th Cir. 1993) (providing contrary opinion regarding the competence of a North Carolina highway patrolman to testify regarding the speed of a vehicle based on an accident investigation and reconstruction).

43. *Coley*, 87 N.C. App. at 496, 116 S.E.2d at 428 (citing *Tyndall*, 226 N.C. App. at 623, 39 S.E.2d at 830).

IV. THE SCIENTIFIC RELIABILITY OF SPEED DETERMINATION USING PRINCIPLES OF PHYSICS

Experts in accident reconstruction use essentially two different methods of speed estimation: one method utilizing the conservation of linear and angular momentum and the other utilizing the conservation of energy. The basic principles of the two methods are closely related since both ultimately come from Newtonian physics and the primary relationship of Force = Mass × Acceleration (F=ma). Accident reconstruction experts utilize both basic methods of calculation independently, when possible, to confirm the validity of conclusions. Both methods present "special cases" to the accident reconstruction expert where the accident dynamics are simplified through cancelled momentums or the absence of friction effects (i.e., sliding on ice or flying through the air in a ballistic trajectory). The recognition and utilization of these special cases usually improves the accuracy of the mathematical estimation. Many times, the accuracy of the calculations depends primarily on the expert's ability to measure or estimate the coefficient of friction between the vehicle tires and the travel surface. As a result, the mathematical tire model that is used may become important to the final accuracy of the results.

The laws of physics state that the momentum of a system of colliding particles (or vehicles) will have a constant value during the period of the collision. A primary basic assumption inherent to such an assertion is that the collision is of sufficiently short duration such that no loss of momentum occurs by friction and thermal losses. This is particularly valid since almost all collisions are approximately 1/10 of a second in length. Since system momentum is defined as the sum products of mass and velocity for the total number of vehicles in the system, a zero summation of the momentums before and after a collision will yield a relationship from which the unknowns may be solved. The typical momentum equation will look something like the following:

$$M_1 * V_1 + M_2 * V_2 = M_1 * V_{1f} + M_2 * V_{2f}$$ [44]

where the first half of the equation represents the vehicle's mass/velocity products before the collision and the second half represents the conditions following the collision. An illustrative "special case" of the momentum method is the instance when two vehicles collide head-on and both come to a complete stop at the point of

44. FRANCIS W. SEARS & MARK W. ZEMANSKY, UNIVERSITY PHYSICS 144-150 (1955).

impact. The complete stop immediately illustrates that the two vehicles possessed momentum of precisely equal value differing only by the virtue of their opposed directions. Then the previously stated equation simplifies to the expression;

$M_1*V_1 = M_2*V_2$,[45]

Information that can be determined about either vehicle can thereafter be converted into a velocity relationship for the opposing vehicle.

The momentum method has the most usefulness when reconstructing two vehicle collisions of the "T" intersection variety when the vehicles head off at measurable angles to their previous paths of travel. It is also useful when the momentums along any vector axis cancel as in the head-on collision just discussed. The momentum method is dependent on the use of the vehicles' drag factors and the physical parameters of the accident scene terrain. Drag factors can be determined from empirical data or data obtained experimentally using a similar vehicle under similar conditions. The vehicles need not be identical, but of approximately similar weight and configuration.

The conservation of energy applied to automobile accident reconstruction is based on the observation that energy remains constant during the course of a collision but merely changes form from kinetic energy, a function of velocity, to other forms of energy (i.e., heat energy created by tire friction with the road surface, mechanical work of deforming the vehicular structures during the impact, and in certain circumstances, to the change in the physical elevation of the vehicle's center of gravity). From Sir Isaac Newton's point of view, the terms of energy, work, and heat can all represent the same numerical quantity, so the ability to understand the relationships between the different forms of energy is essential to the expert's use of the energy method. One common relationship used in accident reconstruction has the following form:

$\frac{1}{2}MV^2 = MG(mu)D$,[46]

where M represents the vehicle mass, V represents the vehicle's velocity, G stands for the gravitational constant of acceleration, D is the value of the length of the observed skid marks (physical evidence), and *mu* represents the coefficient of friction between the car tires and the road surface. The vehicle mass cancels out of

45. *Id.*
46. 2 LYNN B. FRICKE, TRAFFIC ACCIDENT RECONSTRUCTION 90-7 (1990).

both sides of the equation making knowledge of the vehicle weight unnecessary for determination of the vehicle speed. The use of the friction relationship in this equation makes it unnecessary to calculate the amount of heat expended during the braking maneuver. The work expended by the friction relationship quite accurately represents the heat lost to braking.

Additional examples include the calculation of energy consumed by a vehicle running up an incline from its post-impact inertia,[47] the flight trajectory of a flung object thrown high and away by impact, the physical failure of a utility pole sheared off at the ground level by a striking vehicle,[48] and the crushed profile of a roadside guardrail.[49] All of these examples are events that leave significant and measurable amounts of physical evidence which may be examined and analyzed in an objective and quantitative manner.

Perhaps the most often used and important use of the energy analysis method is the determination of the energy consumed by the physical crushing of the vehicular structure. The vehicle's horizontal boundaries are modeled as a collection of springs which possess mathematically linear deformation characteristics. That is, the force of deformation is directly proportional to the depth of deformation. Once the depth of deformation is known, only the spring constant remains to be determined for an accurate calculation of the crush energy.[50] This spring constant for the individual vehicle is referred to as the stiffness constant by the National Highway and Traffic Safety Association and the founders of the modern day crush energy method. Raymond McHenry wrote many of the initial investigative papers on the methods involved and extended his work to the creation of a comprehensive set of computer programs which attempt to simplify the repetitive calculations of a complete accident reconstruction.[51] Variants and offshoots of McHenry's work still represent the most widely used reconstruction programs today. Stiffness constants can be determined by a full scale destructive crash test of a vehicle into a

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47. *Id.* at 90-10 to 90-18.

48. STEPHEN. P. TIMOSHENKO AND JAMES N. GOODIER, THEORY OF ELASTICITY 226-228 (1970).

49. ARCHIE HIGDON ET AL., MECHANICS OF MATERIALS 239-483 (1976).

50. RANDALL L. HARGENS AND TERRY D. DAY, VEHICLE CRUSH STIFFNESS COEFFICIENTS FOR MODEL YEARS 1970-1984 I1-I15 (1987).

51. Raymond R. McHenry, *Development of a Computer Program to Aid the Investigation of Highway Accidents, in* CALSPAN REPORT NO. VJ-2979-V-1, DOT HS 800821 (1971).

quantifiable barrier with extensive internal and external instrumentation. The instruments measure accelerations, velocities, and subsequent vehicle trajectory. Documentation of the crush depths allow the expert to calculate a particular vehicle's stiffness constant for use in reconstructing accident speeds. Most vehicles from the mid-70's onward have been crash tested and adequately documented to allow the use of a reliable stiffness constant.[52]

At considerable expense, a private crush test can be performed with the use of high speed video to measure vehicle motion. The change in a vehicle's speed during impact may be used to determine the resulting stiffness constant. If a test of a particular vehicle model is not available, tests of similar vehicles in size and structure can be collected, analyzed, and averaged to provide a reasonable estimate of crush energy expended during a collision. If only a single component of a structure is damaged, the component may be simple enough to analyze by the application of material mechanics concepts or beam theory as utilized by many of this century's most able architects and engineers in the construction of buildings, bridges, and other critical structures.[53] For instance, often only the bumper on a large vehicle will be damaged in a collision with a smaller vehicle. A force calculated from the physical dimensions of the bumper structure can be directly used to calculate the energy expended against it by the smaller impacting vehicle. This type of energy calculation is highly accurate since it depends only on the easily performed measurements of structural dimensions and long established theory. In its simplest implementation of this method of energy determination, the equation is:

Energy of crush = Force × Depth of deformation.[54]

This method demonstrates that it is not essential to have the benefit of an extensive crash test in order to accurately determine the energy losses due to the crush deformation of a vehicle.

The spring model is a good first-order approximation for the ends of a vehicle, but the crush characteristics of the side structures in present day automobiles have not been sufficiently assessed. Side impact tests are more rare than frontal impact tests because of budget constraints in the existing testing programs. Stiffness constants on side impacts can also be determined

52. HARGENS & DAY, *supra* note 50, at I-1 to VII-1.

53. HIGDON ET AL., *supra* note 49, at 239-483.

54. SEARS & ZEMANSKY, *supra* note 44, at 117.

by comparison with similar vehicle results.[55] In addition, the side stiffness constant can also be determined by mathematical means if crush depths and the striking vehicle's stiffness are known. The momentum methods discussed earlier are accurate and useful in the calculation of speeds involved in side impact collisions.[56] Their combined use provides the expert with quantifiable confirmation of results based on measurable physical evidence collected at the scene in the form of photographs and measurements.

The mathematical models set forth in this article have been validated by independent scientific study.[57] In 1977 and 1978 definitive research was conducted at Cornell University's Vehicle Experimental Research Facility under contract with the National Highway Transportation Safety Administration. This RICSAC study (Research Input for Computer Simulation of Automobile Collisions) conducted twelve staged two-car collisions at different speeds and configurations. The vehicles were completely instrumented to record performance parameters, including speed, and each collision was filmed by ten high speed cameras. The physical evidence, including skid marks, pavement gouge marks and the physical crushing of the vehicle, was also gathered and analyzed by accident reconstruction experts. The experts used the two mathematical models presented in this article to develop data on the speed of the vehicles independent of the instrumentation data provided from the vehicles. Speed data from the actual collision was compared with the results obtained from the reconstruction experts. The mathematical models yielded calculated impact speeds which were within –3 to +3 percent of the impact speeds recorded by the instrumentation.[58]

V. CONCLUSION

The importance of reliable evidence on the speed of a vehicle cannot be overstated. In both a civil and criminal context evidence

55. CRASH 3 TECHNICAL MANUAL, NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION, DEPT. OF TRANSPORTATION (1982).

56. FRICKE, *supra* note 46, at 68-4 to 68-5.

57. Raymond R. McHenry & N. J. DeLeys, *Vehicle Dynamics in Single Vehicle Accident-Validation and Extensions of a Computer Simulation, in* CALSPAN REPORT No. VJ-2251-V-3, NTIS-PB 182663 (1968). *See also,* Ian S. Jones & A. S. Baum, *Research Input for Computer Simulation of Automobile Collisions, Volume IV-Staged Collision Reconstructions, in* CALSPAN REPORT No. ZQ-6057-V-6, DOT HS 805040 (1978).

58. Terry D. Day & Randall L. Hargens, *Further Validation of EDCRASH Using the RICSAC Staged Collisions, in* SAE PAPER 890740 (1989).

of speed may literally be the focal point of the entire matter. The rejection of expert testimony may leave a jury with evidence that is subject to all the weaknesses of human recollection combined with the untrained witnesses inability to perceive differing distances within a short time span. The addition of expert testimony provides the trier of fact with technical expertise which can aid in their understanding of the physical evidence. In allowing this expert testimony the court does not relinquish it's responsibility to assure that any witness, lay or expert, has the skills and data necessary to reach an opinion that would meet the "helpfulness" requirements of Rule 702 of the North Carolina Rules of Evidence.