FINAL REPORT

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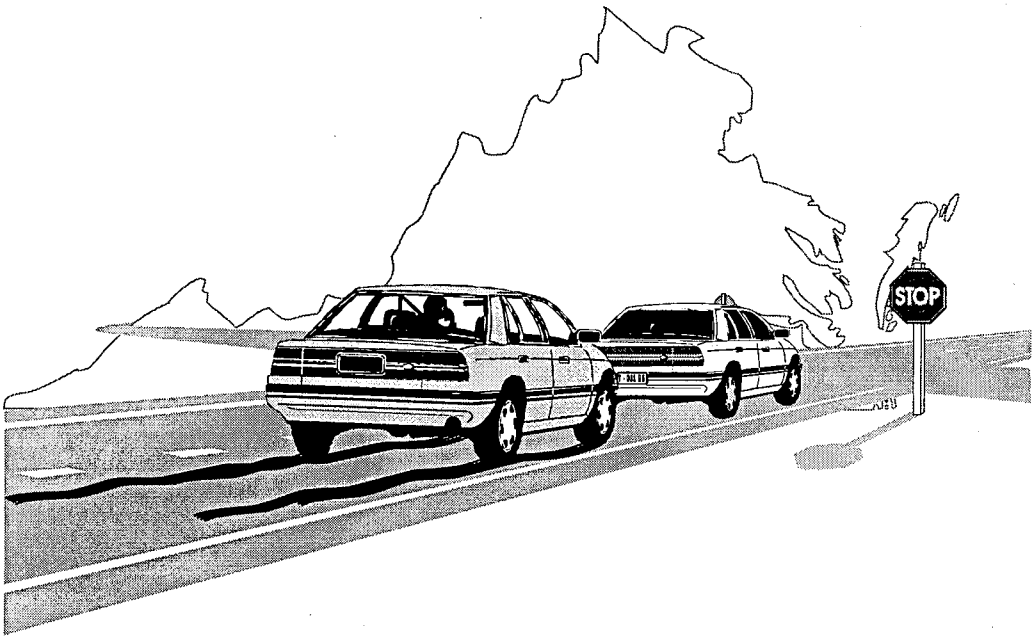
AN INVESTIGATION OF THE UTILITY AND ACCURACY OF THE TABLE OF SPEED AND STOPPING DISTANCES SPECIFIED IN THE *CODE OF VIRGINIA*



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Abstract

This study was conducted pursuant to House Joint Resolution No. 74 introduced by Delegate R. Creigh Deeds during the 2000 Session of the Virginia General Assembly. The resolution requested that the Virginia Transportation Research Council study the table of speed and stopping distances specified in § 46.2-880 of the *Code of Virginia,* especially with regard to the accuracy, completeness, and currency of the data contained in the table; the amendments that might be necessary or desirable; and the usefulness and appropriateness of continuing to include the table in the *Code.*

The authors concluded that information provided in a table of speed and stopping distances can be useful to judges and juries in their deliberations. They also found the data in the table to be inaccurate. Specifically, the reaction time of ¾ second did not incorporate the factor of perception time that is relevant to total stopping distance. Allowing for perception time would double the estimate of the total distance traveled before braking. Further, the braking distances in the table were too great. These distances were calculated without consideration of such factors as improved road surface conditions, improved tires, and increasingly sophisticated braking systems.

The authors recommend that the table of speed and stopping distances in § 46.2-880 of the *Code* be updated as specified in this study. The authors also recommend that the revised table be used within judicially recognized limits, which is to say for illustrative purposes rather than as affirmative proof (or disproof) of a defendant's negligence.

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(The opinions, findings, and conclusions expressed in this report are those of the authors and not necessarily those of the sponsoring agencies.)

Virginia Transportation Research Council
(A Cooperative Organization Sponsored Jointly by the Virginia Department of Transportation and the University of Virginia)

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ABSTRACT

This study was conducted pursuant to House Joint Resolution No. 74 introduced by Delegate R. Creigh Deeds during the 2000 Session of the Virginia General Assembly. The resolution requested that the Virginia Transportation Research Council study the table of speed and stopping distances specified in § 46.2-880 of the *Code of Virginia,* especially with regard to the accuracy, completeness, and currency of the data contained in the table; the amendments that might be necessary or desirable; and the usefulness and appropriateness of continuing to include the table in the *Code.*

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INTRODUCTION

During the 2000 Session of the Virginia General Assembly, Delegate R. Creigh Deeds introduced House Joint Resolution No. 74 (HJR 74—see Appendix A) requesting that the Virginia Transportation Research Council (VTRC) study the table of speed and stopping distances specified in § 46.2-880 of the *Code of Virginia* (the *Code*) (see Appendix B). This table notes the total stopping distances of automobiles and trucks—defined as the sum of the distance the vehicle traveled during the average driver reaction time of ¾ second and the average distance the vehicle traveled during braking—at various speeds between 10 mph and 100 mph. This section of the *Code* also specifies that all courts shall take notice of the table and shall further take notice that the table was the result of experiments subject to particular conditions. This judicial notice requirement gives the table significant weight because when the specified conditions are met, the courts usually apply the table without questioning its accuracy.

HJR 74 directed that the study of the table of speed and stopping distances consider, but not necessarily be limited to, three issues:

1. the accuracy, completeness, and currency of the data specified in the table
2. any amendments to the table that appear to be necessary or desirable
3. the usefulness and appropriateness of continuing to include such a table in the *Code*.

HJR 74 also noted that changes in motor vehicles, motor vehicle equipment (particularly tires and brakes), and highway construction and design since the enactment of the table in 1956 suggest that the table might need to be revised.

PURPOSE AND SCOPE

The purpose of this study was to provide answers for the three areas listed in HJR 74. To achieve this end, the authors reviewed the legal issues and scientific literature pertinent to these areas.

This study was not experimental in that no new tests were conducted to determine average reaction times or braking distances.

RESEARCH DESIGN AND METHODOLOGY

The study was separated into three tasks: (1) an investigation of the legal issues related to the establishment and use of a codified table of speed and stopping distances, (2) an investigation of the scientific issues related to the table specified in the *Code,* and (3) the development of recommendations regarding amendments to Virginia's table.

Legal Issues

The authors sought answers to three legal issues:

1. *The source of the table specified in § 46.2-880 of the Code.* To achieve this end, the authors searched for references to any studies that would support the numbers cited in the table and searched the codes of other states to determine the source of this information.

2. *Whether the statutes or administrative codes of any other states contain similar tables.* The second legal issue involved determining whether other states had similar tables in their codes. This search included a search of the statutes and administrative codes of all 49 other states.

3. *The case law regarding the use of such tables by the courts of Virginia and other states.* Virginia case law relating to the use of the table was reviewed, as was the case law of other states. In addition, an informal sample of attorneys, judges, enforcement officials, and transportation engineers was surveyed to determine how they have used the table.

Scientific Issues

The scientific literature was examined to determine whether the ¾-second reaction time listed in the table was appropriate and whether the braking distances listed for automobiles and trucks were accurate.

Development of Recommendations

The legal and scientific analyses were synthesized to determine whether the table required revision and whether it should remain in the *Code.*

FINDINGS

Legal Issues

Source of Virginia's Table

Section 46.2-880 of the *Code* requires that all courts take notice of the table of speed and stopping distances of automobiles and trucks in actions where it is relevant.[1] The statute's judicial notice requirement gives the table significant weight in the courtroom, since judges usually apply it without questioning its accuracy or insisting upon further evidentiary proof.[2] The table (provided in Appendix B) lists various speeds in miles per hour, from 10 to 100, generally in increments of 5, and provides the corresponding distance traveled in feet per second, the braking distance (in feet), and the distance traveled during "average driver reaction time" (¾ second) for each speed. The sum of the braking distance and the distance traveled during reaction time represents the total stopping distance, listed in the last two columns of the table.[3] The statute also requires courts to notice that the numbers in the table are the result of experiments conducted with motor vehicles that were "unloaded except for the driver, equipped with four-wheel brakes, in good condition, on dry, hard, approximately level stretches of highway free from loose material."[4]

The experiments that yielded the numbers in § 46.2-880 are not cited or referred to anywhere else in the *Code,* and the source of the table is not given. It is safe to assume that the experiments were conducted during or prior to 1956, since the table has not been changed or modified since its enactment that year. During the early 1940s, there was heightened governmental and industrial interest in research regarding the brakes of motor vehicles. Virginia was among the states interested in motor vehicle research and laws during this time. Measuring the skid resistance of Virginia pavements began in 1946,[5] but the results of major studies conducted during that period indicated stopping distances different from those listed in the *Code.*[6] In 1952, the Virginia legislature requested that the Virginia Advisory Legislative Council conduct a study of highway safety issues.[7] The results of this study were reported in 1953, but there was no mention of stopping distances. Two years later, the legislature asked the Virginia

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[1]*See* Va. Code § 46.2-880 (1989).

[2]Black's Law Dictionary 851 (7th ed. 1999) defines judicial notice as "a court's acceptance, for purposes of convenience and without requiring a party's proof, of a well-known and indisputable fact."

[3]*See* Va. Code, *supra* n. 1.

[4]*Id.*

[5]*See* F.P. Nichols et al., *Skid Resistant Pavements in Virginia,* in Highway Research Board, *Road Roughness & Slipperiness,* n. 139, p. 35 (1956).

[6]*See id.; see also* Institute of Traffic Engineers, Traffic Engineering Handbook 72 (Henry K. Evans ed.) (2d ed., 1950); and Highway Research Board, Skid Resistance Measurements of Virginia Pavements 20, Research Report 5-B (1948).

[7]*See* H.J.R. 74, Va. Sess. (1952).

Code Commission to study the state's motor vehicle laws.[8] The commission's report recommended the recodification of Title 46, along with various amendments and additions,[9] but did not raise the issue of stopping distances.

In response to the many requests it received to conduct a comprehensive study on automobile brakes, the U.S. Department of Commerce's Bureau of Public Roads began a research program that was ultimately completed in September 1951.[10] The resulting report, *The Braking Performance of Motor Vehicles*,[11] was published in 1954 and prompted the National Committee on Uniform Traffic Laws and Ordinances to revise the section in the Uniform Vehicle Code (UVC) pertaining to brake performance requirements.[12] The research results were also used by many states with similar performance requirements in their state codes.[13]

Several methods of measuring stopping distances were used between 1940 and 1950. One method involved placing a gun containing a marking material (liquid or powder) on the test vehicle. The material was released in a stream from the gun once the driver touched the brakes, thereby marking the pavement directly underneath the path of the vehicle. Stopping distance was then measured by the length of the marking material on the road once the vehicle came to a complete stop. A calibrated speedometer measured speed. Another method involved mounting a "fifth wheel" containing an odometer-speedometer device at the rear of the car. Both methods were used in the Bureau of Public Roads study.[14] Passenger cars and 25 types of trucks were used in the experiment. Buses were not tested.[15]

The table of speed and stopping distances resulting from the bureau's study was different from the table in the *Code,* except for the braking distance for a vehicle traveling at 20 mph.[16] The stopping distances in the *Code* were more generous for speeds 60 mph and below but were shorter for speeds 60 mph and higher.[17] Evidently, Virginia obtained the numbers in § 46.2-880 from a different research study, but the source of the table and the rationale behind its placement in the *Code* remain unknown.

Existence of Similar Tables in Other States

A small number of states have related tables in their state codes, but the tables pertain more to braking performance requirements than to stopping distances. The tables of Arkansas,[18]

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[8] *See* H.J.R. 49, Va. Sess. (1954).

[9] *See* H.D. 27, Va. Sess. (1955).

[10] *See* F.W. Petring, *Stopping Ability of Motor Vehicles Selected from General Traffic*, SAE Paper, n. 842 for Meeting October 10-12, p. 38 (1956).

[11] C. C. Saal and F.W. Petring, *Braking Performance of Motor Vehicles*, U.S. Department of Commerce Bureau of Public Roads (Government Printing Office, 1954).

[12] *See* National Committee on Uniform Traffic Laws and Ordinances, Uniform Vehicle Code (rev. 1954).

[13] *See* Petring, *supra* n. 10.

[14] *See* Saal, *supra* n. 11, at 16-17.

[15] *Id.*, at 34.

[16] *Id.*, at 106; *Cf.* Va. Code, *supra* n. 1.

[17] *Id.* The Bureau of Public Roads also conducted a similar study of stopping distances of vehicles traveling at high speeds. As with the earlier study, the distances calculated did not match those listed for corresponding high speeds in § 46.2-880. (*See* O.K. Normann, *Braking Distances of Vehicles from High Speeds* HRB, Proc., Vol. 32, 421-36 (1953)).

[18] *See* Ark. Code §27-37-502.

Louisiana,[19] Maryland,[20] Minnesota,[21] and South Carolina[22] regarding braking performance generally match the chart in the UVC.[23] Alabama uses the same chart but provides it in the state's administrative code.[24] The California Vehicle Code has a table for "Emergency Stopping System Requirements" with stopping distances for single motor vehicles, a combination of vehicles, and single motor vehicles with three or more axles manufactured prior to 1964.[25] The table in Michigan's code matches the braking performance requirements listed in older versions of the UVC,[26] indicating numbers from 20 mph for vehicles with brakes on all wheels and for vehicles without such brakes.[27] The numbers in Nebraska's code are not in a table, but they indicate the maximum stopping distance based on the type of brakes on the vehicle (i.e., two-wheel, four-wheel, emergency).[28] New Jersey's code has a table of "Emergency Stopping System Requirements" like California's, but the numbers are different.[29] The New Jersey table is divided into "passenger carrying vehicles" and "property carrying vehicles," with subdivisions of each type.[30]

Case Law on How Tables Have Been Used

Virginia

The table of speed and stopping distances in the *Code* has been and continues to be used in the courtroom, although far less frequently during the past 20 years. The table is usually referenced in actions involving automobile crashes where one party is charged with negligent driving. When the road and vehicle conditions specified in the statute are satisfied,[31] the numbers in the chart help in the determination of whether a party was driving negligently. Experts and law enforcement personnel also use the table in accident reconstruction. In the Virginia courts, an expert or a police officer will often refer to the speed and stopping distance numbers in § 46.2-880 when conducting and testifying about an accident reconstruction.[32] As a

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[19] *See* La. Code § 342.

[20] *See* Md. Code § 22-302.

[21] *See* Minn. Code § 169-67.

[22] *See* S.C. Code § 56-5-4860.

[23] *See* Uniform Vehicle Code, *supra* n. 12.

[24] *See* Ala. Admin. Code § 760-X-1-09 (2)(b).

[25] *See* Cal. Veh. Code § 26508.

[26] *See* National Committee on Uniform Traffic Laws and Ordinances, *Uniform Vehicle Code: Act V—Uniform Act Regulating Traffic on Highways* (rev. 1952).

[27] *See* Mich. Veh. Code § 257.705.

[28] *See* Neb. Code § 60-6, 244.

[29] *See* N.J. Code § 39:3-68.2.

[30] *Id.*

[31] The *Code* specifies that courts shall "take notice that such tables are the result of experiments made with motor vehicles, unloaded except for the driver, equipped with four-wheel brakes, in good condition, on dry, hard, approximately level stretches of highway free from loose material." The courts in Virginia have consistently refused to allow the table of speed and stopping distances into evidence when all of the conditions noted in the statute are not met. *See, e.g., Johnson v. Haas*, 224 Va. 245 (1982); *Bunn v. Norfolk*, 217 Va. 45 (1976); *Terry v. Fagan*, 209 Va. 642 (1969); *White v. Hunt*, 209 Va. 11 (1968); *Cook v. Basnight*, 207 Va. 491 (1966); *Shelton v. Mullins*, 207 Va. 17 (1966); *Beasley v. Bosschermuller*, 206 Va. 360 (1965); and *Stimeling v. Goodman*, 202 Va. 111 (1960).

[32] Telephone interview with Joe Atherton, Accident Reconstruction Expert (June 21, 2000) [*hereinafter* "Atherton Interview"].

result, the table may have a significant impact on an expert's conclusions and his or her subsequent testimony in court.[33]

Virginia case law regarding § 46.2-880 demonstrates that the table is generally accepted and used by judges when the information is pertinent and applicable. Most Virginia case law referencing the table of speed and stopping distances is dated prior to 1970, with approximately five cases implementing it thereafter.[34] However, the table has a limited application since it may be introduced in court only when the specified conditions are met. For example, if two people rather than one were in a vehicle, the table could not be used.[35] More often than not, the narrow application of the table renders it "useless" to attorneys.[36]

Nonetheless, the table has found its way into several Virginia cases, whether to absolve a party from allegations of negligence or, in rare cases, to prove them. In *Minter v. Clements,*[37] the defendant was charged with failure to yield right of way, but the issue was whether the plaintiff was guilty of contributory negligence by not applying her brakes in time to avoid the accident. Using established evidence pertaining to the plaintiff's speed (which was between 20 mph and 25 mph) and the table of speed and stopping distances, the court made the "inescapable inference"[38] that the plaintiff was not negligent:

> The plaintiff had seen the defendant's station wagon, approximately twenty-seven feet or twenty-two feet from the intersection [average distances traveled during the reaction time according to the table], and that she reacted by applying her brakes. Therefore, the physical facts strengthen the conclusion that the plaintiff was keeping a proper lookout. They indicate that the plaintiff was more than twenty-two feet from the intersection, when she saw the defendant ...."[39]

The court, having uncontroverted evidence of the plaintiff's speed, used the table as part of the "physical evidence"[40] to determine when she saw the defendant.

The column in the table in § 46.2-880 indicating distance traveled per second was used in *Wilsher v. Adams*[41] to acquit the defendant driver of gross negligence charges. Based on the accident site in relation to specific landmarks in the area and a consensus as to the defendant's speed at the time of the accident, the judge used the table to deduce that the driver's inattention was "momentary and lasted approximately two seconds."[42] Since a 2-second span of inattention does not constitute gross negligence,[43] the final judgment was entered in favor of the defendant.

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[33]Some of the numbers in the table are also incorporated in the Virginia Driver's Manual to teach new drivers about the relationship between speed and stopping and the importance of keeping a safe distance from other vehicles on the road. *See* Virginia's Motor Vehicle Laws, p. 2:17 (visited June 12, 2000) <www.dmv.state.va.us>.

[34]*See e.g., Thomas v. Settle*, 36 Va. Cir. 42, 44, 1995 Va.Cir. LEXIS 1253 (1995); *Johnson, supra* n. 31; *Bunn, supra* n. 31; *Swiney v. Overby,* 237 Va. 231 (1989); and *McManama v. Wilhelm,* 222 Va. 335 (1981).

[35]*See* Va. Code, *supra* n. 1 ("such tables are the result of experiments made with motor vehicles, unloaded except for the driver . . . .").

[36]Telephone interview with Chris A. Meyer, Esq., Allen, Allen, Allen & Allen (July 20, 2000) [*hereinafter* "Meyer Interview"].

[37]*See Minter v. Clements*, 206 Va. 403 (1965).

[38]*Id.*, at 409.

[39]*Id.*

[40]*Id.*

[41]*See Wilsher v. Adams*, 208 Va. 406 (1967).

[42]*Id.*, at 409.

[43]*See McDaniel v. Wern,* 206 Va. 819 (1966).

Prior case law had also demonstrated that a certain amount of leeway may be given to defendants when the table of speed and stopping distances is applied. In *Laughorn v. Eanes*,[44] the court found that the defendant was not driving negligently, even though she traveled three feet further than the "average driver" according to the table.[45] The opinion did not specify how many extra feet one can travel and still remain within the realm of "average" as indicated in § 46.2-880; however, *Laughorn* suggests that there is judicial hesitation about using the table literally as affirmative proof (or disproof) of negligence.

To a degree, this hesitation is a requirement of the statute: § 46.2-880 indicates that "all courts shall take notice of the following tables of speed and stopping distances of motor vehicles, which shall not raise a presumption, in actions in which inquiry thereon is pertinent to the issues."[46] Although the statutory language is somewhat ambiguous, it can be inferred that the table is not intended to be dispositive proof of negligence but, rather, should be used as a guide for jurors analyzing automobile accident cases. The Virginia Supreme Court seems to take this view. In *Cook v. Basnight,*[47] it held that the court erred in instructing the jury about the table of speed and stopping distances without also instructing them that they could not from the table determine whether the defendant would have been able to stop his car in time to avoid the collision unless there was proof of other factors such as the time at which and the force with which the brakes were applied.[48] In *Bunn v. Dozier*,[49] the Virginia Supreme Court acknowledged that even though the table "create[s] no presumption in law,"[50] it may still have a prejudicial effect upon jurors and, thus, cannot be used unless it is relevant to the case. The Virginia Supreme Court also held, in *Woodson v. Germas*,[51] that the table of speed and stopping distances may not be implemented to prove use of excessive speed when the opposing party's case depends on that sole factor: "Physical facts, when relied on to overcome testimony, must be established by uncontroverted evidence, or by evidence so clearly preponderating as to make existence of such facts unmistakable."[52]

Yet, despite these rulings regarding the table, § 46.2-880 has been used to prove negligence, albeit rarely. In *Richardson v. Lovvorn*,[53] it was held that the defendant was driving "considerably in excess of the speed limit"[54] at the time of the accident. The defendant admitted that he had been driving over the 25 mph speed limit but not faster than 35 mph. A police officer testified that the defendant must have been traveling 39 mph according to the "skid test" for four-wheel brakes[55] that he conducted at the accident scene. The court accepted the police officer's calculations despite the defendant's testimony and the fact that the 52-foot skid marks at the scene would indicate a traveling speed between 30 and 35 mph according to § 46.2-880.[56] Yet,

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[44]*See Laughorn v. Eanes*, 207 Va. 584 (1966).
[45]*See id.*, at 589-90.
[46]*See* Va. Code, *supra* n. 1.
[47]*See Cook, supra* n. 31.
[48]*Id.*, at 496.
[49]*See Bunn, supra* n. 31.
[50]*Id.*, at 379.
[51]*See Woodson v. Germas,* 200 Va. 205 (1958).
[52]*Id.*, at 210.
[53]*See Richardson v. Lovvorn*, 199 Va. 688 (1958).
[54]*See id.*, at 692.
[55]*Id.*, at 691-92.
[56]*See* Va. Code, *supra* n. 1.

the table did not go entirely unnoticed: applying the 39 mph number to the table, the judge concluded that the defendant's total stopping distance at that speed was greater than 101 feet. He, thus, inferred that the accident could have been avoided altogether had the defendant been traveling at a slower speed.[57] In *Richardson,* there appears to be some confusion as to which standard of speed and stopping distances to use: calculations based on independent testing of experts or the numbers indicated in § 46.2-880. The *Richardson* court seemed to resolve the issue by implementing both standards, even though the two sets of numbers conflicted as to the defendant's speed.

In *Thomas v. Settle*,[58] decided in 1995, the primary issue was whether the plaintiff's decedent, who had been driving below the minimum speed limit, was guilty of contributory negligence in a highway collision with a truck. An expert who testified earlier at trial noted that it is impossible for anyone to tell how fast or slow another vehicle is going when the vehicle is 200 or more feet away.[59] Using this testimony, the court then applied the table of speed and stopping distances: if the truck was traveling at the speed limit of 55 mph, the total stopping distance would be 288 feet, which is greater than the 200 feet necessary to perceive the problem. The court concluded that the decedent was negligent in slowing down; there was no way the truck driver could have perceived the problem and subsequently stopped in time to avoid the accident unless he had been driving slower than the speed limit. Although the courts in both *Richardson* and *Thomas* considered other factors surrounding the accident, the table of speed and stopping distances ultimately played a significant role in the final outcome of each case.

With a few recent exceptions such as *Thomas*, the popularity of § 46.2-880 in Virginia's courtrooms appears to be fading. A possible explanation for its infrequent implementation is the significant advancement in accident reconstruction techniques over the past few decades. Experts are increasingly introduced in court to help determine the facts of a case with their own, often more specific, calculations. In this respect, perhaps modern-day accident reconstruction expertise has eclipsed the table of speed and stopping distances, rendering it an overly simplistic tool for crash analysis. Despite the general move toward accepting more accident reconstruction testimony in the courtroom, experts have, nonetheless, encountered significant resistance from Virginia courts when testifying.[60] The case law indicates a compelling judicial interest in preserving the jury's role as the ultimate evaluator of the available evidence and in prohibiting experts from usurping this critical responsibility. Expert testimony is generally admissible if it will help the trier of fact in comprehending the evidence before him or her when such evidence surpasses the average person's realm of intelligence or experience.[61]

In *Kale v. Douthitt,*[62] the 4th Circuit refused to admit the testimony of an expert witness who worked at the National Bureau of Standards for approximately 30 years and had significant

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[57]*See Richardson, supra* n. 53.

[58]*See Thomas, supra* n. 34; *see also Dickerson v. Ball*, 200 Va. 809, 814 (1959).

[59]*Thomas*, at *id.*

[60]*See* Atherton Interview, *supra* n. 32. *See also Brown v. Corbin,* 244 Va. 528, 531-32 (1992) ("this Court repeatedly has held that . . . accident reconstruction expert testimony is rarely admissible in Virginia because it invades the province of the jury. We specifically have excluded expert testimony as to the speed of vehicles in automobile related cases.").

[61]*See* Va. Code §§ 8.01-401.1.

[62]*See Kale v. Douthitt*, 274 F.2d 476 (4th Cir.) (1960). *See also Whittaker v. Van Fossan,* 297 F.2d 245, 246 (1961) (court struck the testimony of an expert who "enlarged" his opinion by implementing some of his own calculations, even though his testimony was primarily based on the statutory stopping distances table).

experience in accident reconstruction on the grounds that his testimony relating to the speed of the defendant's car was "incompetent."[63] Citing *Fishman v. Silva,*[64] the court held that contentions based upon the "so-called immutable laws of physics"[65] are usually not convincing in accident cases since too many material factors are involved in the determination of the defendant's speed, such as the "condition of the highway, judgment or lack thereof in the drivers, a direct blow or a glancing one, and the balance or equilibrium of each car at the time of impact."[66] According to this logic, the table in § 46.2-880 should not be implemented either, since it, too, does not take into account such material factors.

Six years later, the Virginia Supreme Court of Appeals held in *Grasty v. Tanner* that an expert engineer's testimony as to the driver's speed was inadmissible since he had based his opinion on the damaged automobile and the accident scene and had not actually observed the vehicle in motion.[67] The expert, who was a professor in the engineering school at the University of Virginia and also worked for the Virginia Council of Highway Investigation and Research (now known as the Virginia Transportation Research Council),[68] had conducted elaborate tests and calculations to reach his conclusions. Yet, the court rejected his testimony because too many assumptions were made (such as the total weight of the three passengers) and variables unaccounted for, such as whether there was extra weight in the trunk.[69] *Grasty* suggests an underlying suspicion as to the accuracy of accident reconstruction: according to the judge, "reasonable men were capable of drawing their own conclusions as to the speed of the Grasty car" without the testimony of the expert engineer.[70]

In *Thorpe v. Commonwealth,*[71] the court came to a similar conclusion. There is no mention of § 46.2-880 in the *Thorpe* opinion, probably because the conditions of the statute were not satisfied by the facts of the case (e.g., the truck was loaded). The expert who attempted to testify had used skid test and observation data compiled by a police officer to determine the speed of the defendant's vehicle with "a reasonable degree of scientific certainty."[72] The Virginia Supreme Court rejected the testimony because the police officer's tests were conducted 2 months after the accident; consequently, the "essential particulars"[73] were not similar enough to be considered reliable experimental evidence.[74] Citing *Grasty*, the court concluded that there were too many uncertain variables in the expert's calculations, "such as the condition of the

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[63]*See Kale, supra* n. 49, at 480, 483.

[64]*See Fishman v. Silva,* 116 Cal.App. 1 (1931).

[65]*See Kale, supra* n. 49, at 483.

[66]*Id.*

[67]*See Grasty v. Tanner,* 206 Va. 723, 727 (1966).

[68]*Id.,* at 725.

[69]*Id.,* at 727. *Cf.* J. Stannard Baker, *Estimated Stopping Distance and Time for Motor Vehicles,* 2d ed., at 33 (1977) ("Weight on the tires make a great difference in the *force* needed to slide it on a road surface. . . . However, the coefficient of friction does not depend on weight" [emphasis in original]. In addition, a car loaded with only one driver will have about the same stopping distance as a car loaded with two drivers. *Id.*).

[70]*Id.*

[71]*See Thorpe v. Commonwealth,* 223 Va. 609 (1982).

[72]*Id.,* at 612.

[73]*Id.,* at 613.

[74]*Cf. Saunders v. Bulluck,* 208 Va. 551 (1968) (court allows evidence relating to speed and stopping distance tests if the conditions under which they are conducted are substantially similar to those surrounding the accident).

truck, its brakes, its tires, [and] the manner in which the weight of its load was distributed."[75] As a result, the accident reconstruction evidence was held to be "inadmissible speculation."[76]

In *Thorpe*, the Virginia Supreme Court ruled that 2 months is enough time to render the conditions of an accident scene and those of later braking tests substantially disparate. Yet, the *Code* requires that judges take judicial notice of the table of speed and stopping distances, which contains numbers often calculated decades before the accident at issue. Further, the geographic location of the experiments and conditions (other than the few specified) that yielded § 46.2-880 are unknown, creating even more of a potential incongruity between the "essential particulars."

Although the Virginia Supreme Court's stance on preserving the jury's role at trial is understandable, one can also argue that the calculations and methods behind modern-day accident reconstruction are sufficiently complicated to warrant testimony from a qualified expert.[77] Indeed, in *Hubbard v. Commonwealth,*[78] the Virginia Court of Appeals held that the expert testimony that reconstructed the defendant's speed at the time of the accident was properly admitted since the computations involved in the reconstruction process were "dependant upon particular and specialized scientific training and experience."[79] However, even with the *Hubbard* ruling, later cases in the Virginia courts continue to reveal an unsmiling skepticism of experts who attempt to reconstruct accidents before the jury. In *Schooler v. Commonwealth,*[80] for example, the court held that the testimony of a crash reconstruction expert was inadmissible because it invaded the "province of the jury."[81] Although an expert may testify about specific physical observations such as skid marks or dents on vehicles, the jury ultimately must draw inferences (if any) from those observations. The expert witness in *Schooler* offered his understanding of how the accident took place based on his observations and calculations, but the court held that these matters "were susceptible to determination 'on the basis of the ordinary knowledge, common sense, and practical experience' of lay persons."[82] The court supported its holding by citing *Callahan v. Commonwealth,*[83] where the testimony of a fire marshal as to the origins of a fire was excluded because the jurors could have made the assessment themselves.

In *Keesee v. Donigan*, decided in 2000, the Virginia Supreme Court held that expert evidence is not admissible unless it has a sufficient factual basis.[84] Since the accident reconstruction expert lumped the defendant into the "average" category when factoring perception-reaction time into his calculations and had not performed any tests to determine whether the defendant's perception-reaction time was truly average, his testimony had "no

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[75]*See Thorpe, supra n.* 71 at 614.

[76]*Id. Cf. Swiney, supra* n. 34 at 234-35 (Lacy, J., dissenting) ("In my opinion, the Virginia General Assembly . . . has recognized the need for expert evidence on stopping distances . . . . The expert testimony in this case was no more than an extension of the chart contained in [§ 46.2-880]. Certainly the factors assumed by both experts here were substantially similar to those involved in the accident.").

[77]*See Swiney,* at *id.*

[78]*See Hubbard v. Commonwealth,* 12 Va.App. 250 (1991).

[79]*Id.,* at 257.

[80]*See Schooler v. Commonwealth of Virginia,* 14 Va.App. 418 (1992).

[81]*Id.,* at 421.

[82]*Id, (quoting Compton v. Commonwealth,* 219 Va. 716, 726 (1979)).

[83]*See Callahan v. Commonwealth,* 8 Va.App. 135, 138 (1989).

[84]*See Keesee v. Donigan,* 259 Va. 157, 161 (2000).

factual basis in the record."[85] The court's ruling was once again at odds with the table of speed and stopping distances in § 46.2-880, which is based solely on averages.[86] When the court had applied the table in past cases,[87] evidence of the defendant's actual reaction time or of the braking distance of his or her vehicle was not a requirement. Rather, the averages specified in the table were accepted as an accurate representation of "most people" and "most cars" when there was no clear evidence to suggest otherwise.

Other States

States other than Virginia have also used speed and stopping distance tables in the courtroom, although no such table is listed in their statutes. Usually, charts are found in the driver's manual of a state's department of motor vehicles or are otherwise prepared by the department. The courts have mixed reactions to stopping distance charts when they are introduced as evidence. Although several courts have implemented them without objection or question,[88] a seeming majority of jurisdictions has held that there are serious evidentiary problems with such charts and, thus, that they may be used only within "judicially recognized limits,"[89] that is, for illustrative purposes rather than affirmative proof (or disproof) of a defendant's negligence.

In *Hughes v. Vestal*,[90] the North Carolina Supreme Court held that the speed and stopping distance table was so fraught with problems that the table was ultimately excluded as incompetent evidence. According to the court's opinion, the table was not introduced with a proper foundation (i.e., verified and authenticated by a knowledgeable witness) and could not be considered "experimental evidence" since an experiment had to involve substantially similar conditions to the occurrence at issue in the case.[91] The table, which indicated numbers for speed, reaction times, and braking distances, did not detail the characteristics of an "average driver" or the "average tire" and, therefore, did not present any "specific standards by which the facts of a particular case may be evaluated."[92] There was no opportunity for cross-examination of the people who created the table, yet it was used to prove that the defendant was speeding. For these reasons, the court concluded that the table was "pure hearsay."[93] Finally, the numbers in the

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[85]*See id.*, at 162.

[86]*See* Va. Code, *supra* n. 1 (numbers are given for "average stopping distances," and "average driver reaction time").

[87]*See e.g., Thomas, supra* n. 34, at 44. *See also Dickerson, supra* n. 58, at 814; *Minter, supra* n. 37; *Wilsher, supra* n. 41.

[88]*See Steffes v. Farmers Mutual Auto Ins. Co.*, 7 Wis. 2d 321 (1959) (court held that a stopping distance chart in an official publication of a department of motor vehicles is competent evidence to establish the statistics set forth by the numbers); *Blahnik v. Dax*, 22 Wis. 2d 67 (1963) (table of stopping distances used to determine defendant's negligence). *See also Dupre v. Union Producing Co. et al.*, 49 So. 2d 655 (1950) and *Autrey v. Swisher*, 155 F.2d 18 (1946).

[89]*See Hughes v. Vestal*, 264 N.C. 500 (1965).

[90]*Id.*

[91]*Id.*, at 503-04.

[92]*Id.*, at 504.

[93]*See id.*, at 505. *See also Breshears v. Myers*, 266 S.W. 2d 638, 640 (1954) (court held that "the admission in evidence of a statement from a chart in a book prepared by the State Highway Department as to stopping distance at 60 mph (read by the patrolman) was improper as hearsay . . . .").

table were disputable given the many variables involved in the calculation and, therefore, could not be considered common knowledge and judicially noticed.[94]

The *Hughes* court, however, suggested that the table may be used "within judicially recognized limits,"[95] that is, for illustrative purposes rather than affirmative proof (or disproof) of a defendant's negligence. The idea of judicially recognized limits was discussed in an earlier Connecticut case, *Muse v. Page,*[96] where the court held that the table may not be used as dispositive evidence of a defendant's traveling speed but can be implemented to help the jury understand "the limits within which a stop could be effected."[97] Similarly, the court in *Smith v. Hardy* held that the table may be used to recognize the maximum limits for stopping distances relative to traveling speed but not to determine the precise speed of a given vehicle on a particular road.[98]

Difficulties have also arisen in the way such tables are introduced into evidence. In *Schutz v. Breeback*, the court held that the table of speed and stopping distances should not have been admitted into evidence because it was not introduced or explained through a witness connected with the source of the data (in this instance, the department of motor vehicles) or even by an expert on the subject.[99] The table had to be authenticated to be admitted into evidence and offered through a knowledgeable witness so that material factors such as road condition and tire tread would not be overlooked when the numbers were implemented [WHAT DOES THIS MEAN?]. Courts have also ruled that if the experiments that yielded the tables were conducted under specific conditions, such as on a dry pavement free of loose gravel, the conditions of the accident at issue must be substantially similar before such a table can be applied at all.[100]

Scientific Issues

Although the source of the table in § 46.2-880 is not known, it is clear that the experiments from which the numbers came were conducted during 1956 or earlier. The results of those experiments, therefore, did not reflect the significant technological evolution of the automobile, tire, and highway industries over the past 45 years.[101] For instance, advancements in brake pads, disk brakes, anti-lock braking systems, and tire compounds have likely significantly improved the stopping capabilities of vehicles. Further, there is uncertainty as to the reasons and appropriateness for choosing a ¾-second reaction time when stopping distances are calculated.

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[94]*See Hughes, supra* n. 89, at 506. *See also Tuite v. Union Pacific Stages, et al.*, 204 Ore. 565, 583 (1955) (court ruled that the specific conditions and circumstances of an accident are controlling and "it is in the light of those circumstances . . . that an opinion may be expressed by one qualified to express an opinion . . . and not in the light of general averages obtained by experiments conducted at other times and in other places.").

[95]*Id.*, at 507.

[96]*See Muse v. Page,* 125 Conn. 219 (1939).

[97]*Id.*, at 225.

[98]*See Smith v. Hardy*, 228 S.C. 112, 124 (1955); *see also McDonald v. Mulvihill,* 84 N.J. Super. 382 (1964).

[99]*See Schutz v. Breeback,* 228 Md. 179, 183 (1962).

[100]*See Mainz v. Lund,* 18 Wis. 2d 633 (1963). *See also Tuite, supra* n. 94.

[101]Telephone interviews with Alan Wambold, Senior Transportation Research Associate, Department of Legislative Services (June 2, 2000); David McAllister, Virginia Crash Investigation Team Leader at the Transportation Safety Training Center, Virginia Commonwealth University (June 8, 2000) [*hereinafter* "McAllister Interview"]; and Atherton Interview, *supra* n. 32.

Perception and Reaction Time

Although the table in § 46.2-880 considers reaction time, reaction time is but one of several factors that are important in determining the total stopping distance for a vehicle. The series of events that takes place prior to braking can be broken into two phases: perception time and reaction time. *Perception time* is the amount of time it takes a driver to detect a potential problem, identify it as a problem, and decide on the proper course of action. *Reaction time* is the amount of time it takes to execute the decision—in this case, to move the foot onto the brake and begin applying pressure.[102]

Perception Time

Perception time can add up to almost 2 seconds of traveling distance. According to Dewar, an experimental psychologist, there is no such thing as the "average driver" because of the vast individual differences among people.[103] Further, Dewar found that perception-reaction time can increase by 30 to 50 percent in situations that are unexpected and increase even more if a driver is older, inexperienced, unfamiliar with the road, or visually impaired.[104]

The design standards of the American Association of State Highway and Transportation Officials (AASHTO) allow 1.5 seconds for perception time and 1.0 second for reaction time.[105] It is worth noting that design standards are conservative and set to accommodate the large majority of drivers, not just the average driver. A study conducted by the Transportation Research Board in 1998 found that most people can perceive and react to an unexpected roadway condition in 2 seconds or less, concluding that AASHTO's total average perception-reaction time of 2.5 seconds "encompasses most of the driving population and is an appropriate value for highway design."[106]

Reaction Time

The table in § 46.2-880 lists the distance traveled during the reaction time for each speed, which is the distance traveled from the time a driver recognizes a problem to the time he or she applies the brakes.[107] The table indicates that the reaction time of an average driver is ¾ second, and the reaction distance is calculated accordingly for each listed speed.[108] Many accident

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[102]John T. Bates, Perception-Reaction Time, *ITE Journal,* February 1995.

[103]*See* Joseph E. Badger, *Human Factors: Perception and Reaction,* at 1-2 (last visited July 5, 2000) <harristechnical.com/human/htm>.

[104]*Id.*, at 1-2, 4.

[105]*Id.*

[106]D.B. Fambro et al., *Driver Perception-Brake Response in Stopping Sight Distance Situations* (abstract), Transportation Research Board 1628 (1998) (visited June 21, 2000) <http.//nationalacademics.org/trb/bookstore>. *But see* Bates, *supra* n. 102: perception time values allotted for design purposes are often generous, as they are geared not necessarily toward the average driver but, rather, toward *nearly all* drivers.

[107]*See* Virginia's Motor Vehicle Laws, *supra* n. 33.

[108]*See* Va. Code, *supra* n. 1.

reconstructionists have used the ¾-second number for reaction time in their calculations.[109] However, the AASHTO design standards allow for 1 second,[110] and the National Highway Traffic Safety Administration (NHTSA) uses 1.5 seconds for the average reaction time.[111] The methods of calculating reaction time are also questionable: clinical tests of reaction time are not conducted under normal driving conditions but usually in a laboratory where subjects are told to step on a "brake pedal" when they see a signal (often a flashing red light). The study subjects are often expecting something to happen to which they will have to react promptly; simply having this knowledge may be enough to skew the results.[112]

Perception-Reaction Time

Even if there was a national consensus regarding average reaction time, the numbers in § 46.2-880 would still be problematic since they do not reflect perception time. The 4th Circuit Court of Appeals also noted the importance of perception time in 1998 in *Sarbacher v. Widger*.[113] During the trial, the defense objected to the testimony of the plaintiff's expert regarding average reaction times and braking distances since the expert failed to take into account perception time in his calculations. The expert admitted later that his calculations were erroneous because he had "considered reaction distance and perception distance to be the same thing."[114] Although the expert never recalculated his results, his original testimony, which did not factor in perception time, was struck from the record for its inaccuracy. Likewise, the numbers in the table of speed and stopping distances in the *Code* are problematic because perception time is accounted for, nor is it referenced anywhere in the section. This inaccuracy leads to total braking distances that do not sufficiently represent the distances covered in actuality. As a result, juries may be more likely to infer from the table that defendants accused of negligent driving were speeding when they may have been driving at the speed limit.[115]

There is no consensus in the literature on the average combined perception-reaction time. In comparing experimental investigations by Gazis et al.,[116] Sivak et al.,[117] Wortman and Matthias,[118] and Chang et al.,[119] Taoka noted that the mean perception-reaction times found

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[109]*See* Badger, *supra* n. 103, at 4. *See also* Bates, *supra* n. 102, at 35-36: "Courts in some states have taken judicial notice that the minimum PRT [perception-reaction time] *for a simple problem with a simple solution of an expected event* is as low as .75 seconds" (emphasis added). Note that many accidents are unexpected events.

[110]Badger, at *id.*

[111]NHTSA website, *Driving at Night Can Be Deadly* (visited July 13, 2000) <www.nhtsa.dot.gov/people/outreach/safesobr/pub/deadly.pdf>.

[112]*See* Badger, *supra* n. 103. *See also* Bates, *supra* n. 102; G. Johansson and K. Rumar, Drivers' Brake Reaction Times, *Human Factors* 13(1), 23-27 (1971); T. Wilson, *IVHS Countermeasures for Rear-End Collisions, Task 1, Volume VI: Human Factor Studies,* Interim Report, DOT HS 808 565, at 22-23 (Feb. 1994).

[113]*See Sarbacher v. Widger*, 96-1811, slip op. at 1 (4th Cir. Aug 31, 1998).

[114]*Id.*, at 2. In his report entitled "Perception-Reaction Time," John T. Bates writes: "Some apply the term reaction time as if it were synonymous with perception-reaction time; that is why it is crucial for analysts to ensure that all parties involved in a discussion of PRT are defining their terms the same way." *See* Bates, *supra* n. 120.

[115]Atherton Interview, *supra* n. 32.

[116]Gazis, D., R. Herman, and A. Maradudin, The Problem of the Amber Signal in Traffic Flow, *Operations Research* 8 at 112-132 (March-April 1960).

[117]Sivak, M., P. Olsen, and K. Farmer, Radar Measured Reaction Times of Unalerted Drivers to Brake Signals, *Perceptual and Motor Skills* 55 at 594 (1982).

[118]Wortman, R., and J. Matthias, Evaluation of Driver Behavior at Signalized Intersections, *Transportation Research Record* 904 at 10-20 (1983).

ranged from 1.14 to 1.30 seconds.[120] Taoka also noted that a perception-reaction time of 1.5 seconds relates to about the 75th percentile finding in the study by Sivak et al.;[121] that is, 75 percent of the test subjects had measured perception-reaction times of 1.5 seconds or less. In a 1985 study, Olson and Sivak found an average perception-reaction time of 1.6 seconds.[122]

In the field of accident reconstruction, there is also disagreement on the appropriate perception-reaction time to use in calculating total stopping distance. Badger suggests that 1.75 seconds is appropriate for daytime and 2.5 seconds is appropriate for nighttime.[123] McAllister of Virginia Commonwealth University's Crash Investigation Team stated that he typically uses 1.5 seconds to calculate perception-reaction time.[124] Likewise, Michael J. Shepston & Associates, an accident reconstruction firm in Arizona, uses an average perception-reaction time of 1.5 seconds.[125] Thus, it appears that estimates of average perception-reaction time revolve around 1.5 seconds.

Braking Distance

The basic equation used by most accident reconstruction experts to measure speed from braking distance is:[126]

$$s = \sqrt{30df}$$

where s = speed in miles per hour
d = the distance a vehicle will travel in feet
f = the drag factor
30 = a constant to adjust the equation to the units of measurement used.[127]

This formula can also be stated as:

$$d = s^2/30f$$

or

$$f = s^2/30d$$

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[119]Chang, M., C. Messer, and A. Santiago, *Timing Traffic Signal Change Intervals Based on Driver Behavior,* Transportation Research Record TRR 1027 at 20-30 (1985).

[120]Taoka, G., Brake Reaction Times of Unalerted Drivers, *ITE Journal* at 19-21 (March 1989).

[121]*Id.*

[122]Olson, P., and M. Sivak, Perception-Response Time to Unexpected Roadway Hazards, *Human Factors* 28(1) at 91-96 (1986).

[123]*See* Badger, *supra* n. 103.

[124]McAllister Interview, *supra* n. 101.

[125]Michael J. Shepston & Associates website, *Braking/Stopping Distances* (last visited June 6, 2000), <www.scottsdalelaw.com/shepston/braking.html>.

[126]Atherton Interview, *supra* n. 32; McAllister Interview, *supra* n. 101.

[127]Baker, J. *Simple Estimates of Vehicle Stopping Distances and Speed from Skidmarks.* The Traffic Institute, Northwestern University (1981).

In the case of the braking of vehicles, the drag factor includes the force exerted on the wheels by the brakes and the friction between the tires and the roadway. However, once the brakes are locked, no additional amount of force can make the vehicle stop faster.[128] The skidding—the friction between the tires and the roadway— of a vehicle on a flat surface is expressed as the coefficient of friction. The coefficient of friction is the "ratio of the force necessary to move one body horizontally over another at a constant speed to the weight of the body."[129] Thus, for a skidding vehicle, the drag factor may be expressed as the coefficient of friction.

Using the formulae provided previously, the braking distances in § 46.2-880 of the *Code* can be converted into the coefficient of friction value that was used to construct the table. For automobiles, the coefficient of friction ranges from 0.625 to 0.667, with the value at most speeds being around 0.650. The coefficient of friction for trucks in the table is focused around 0.444.

In the accident reconstruction field, there is a consensus that the numbers used in § 46.2-880 are low. According to Atherton, an accident reconstructionist who has been practicing in the field for more than 20 years, the improved road conditions since 1956 have produced an average coefficient of friction of approximately 0.72 for automobiles on Virginia's roadways.[130] In fact, Atherton thinks that to yield accurate results, the numbers in speed and stopping distance tables must be updated regularly to reflect improved road surface technology.[131]

Similar to Atherton, McAllister of Virginia Commonwealth University's Crash Investigation Team stated that he typically uses 0.70 as the coefficient of friction for automobiles on asphalt roads and 0.75 for automobiles on concrete roads.[132] In addition, the numbers published by Michael J. Shepston & Associates use a 0.70 coefficient of friction to calculate a vehicle's braking distance for a given speed.[133]

An accident reconstruction manual published by The Traffic Institute at Northwestern University states that the coefficient of friction for large trucks is approximately 75 percent that for automobiles on dry surfaces.[134] Thus, a coefficient of friction of 0.70 to 0.75 for automobiles would translate into a coefficient of friction of 0.525 to 0.5625 for trucks. Hence, there is evidence that the coefficient of friction for trucks (0.444) in § 46.2-880 is too low.

Although there is a great deal of agreement that the current average coefficient of friction for automobiles ranges from 0.70 to 0.75, there are differences in the average coefficient among automobiles, tires, and roadways. Devices such as an anti-lock braking system (ABS) can reduce braking distance. For example, Atherton indicated that a Corvette with an ABS has a

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[128]Baker, J. *Estimated Stopping Distance and Time for Motor Vehicles*, 2nd ed. The Traffic Institute, Northwestern University (1977).

[129]Encyclopedia.com Electric Library, *Friction* (visited July 11, 2000) <www.encyclopedia.com>.

[130]Atherton Interview, *supra* n. 32. *See also* Baker, *supra* n. 69, at 35: "The road surface character and condition . . . has by far the most effect on skidding distances."

[131]*Id.*

[132]McAllister Interview, *supra* n. 101.

[133]Michael J. Shepston & Associates, *supra* n. 125.

[134]Fricke, L., *Traffic Accident Reconstruction: Volume 2 of the Traffic Accident Investigation Manual,* The Traffic Institute, Northwestern University (1990).

friction coefficient of 0.9 on an average road surface.[135] Thus, as with the numbers used for perception-reaction time, individual cases may vary.

In addition to improved pavement surfaces, tires, and brakes, there is evidence that testing procedures have become more sophisticated since the 1950s. A test conducted in the fall of 1998 by NHTSA[136] examined the feasibility of creating a suitable braking performance test for light vehicles. The goal was to obtain more accurate, up-to-date stopping distances and other related information. Braking tests were conducted on a variety of automobile types, from small passenger cars to full-sized sports utility vehicles, all of which were equipped with new, conditioned tires[137] and a four-wheel ABS.[138] The study used vehicles equipped with an ABS because it is a standard feature on most cars today[139] and testing on cars with an ABS would decrease variability in stopping distance: "If a vehicle does not have [an] ABS, then the test driver must skillfully apply the brakes to attain minimum stopping distance without locking the vehicle wheels."[140] Road friction coefficients were also measured 10 times a day using an instrument called the "skid trailer" to ensure consistent testing conditions.[141] During the testing process, several stops were made per vehicle, and time was allotted for the brakes to cool so that the front rotor temperatures were below 212° F before the next stop was executed.[142] The procedure and calculations involved in this study were complex, and the technology was advanced. Although the testing procedure that yielded the table of speed and stopping distances in the *Code* is not known, researchers at that time did not use the same technological tools or have the same understanding that scientists have today.

CONCLUSIONS

- *The source of the table of speed and stopping distances in § 46.2-880 of the Code remains unknown.* Consequently, doubt is cast on the scientific accuracy of the table since the experimental conditions are unknown. At best, the numbers are grossly out of date.

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[135]Atherton Interview, *supra* n. 32.

[136]National Highway Traffic Safety Administration (NHTSA), *Final Report for the Methodology Study of the Consumer Braking Information Initiative*, Report 99-AIT-17 (1999).

[137]The tires were conditioned by driving the vehicles for 50 miles at 50 mph prior to testing. *Id.*, at 1.

[138]The only vehicle tested that did not have a four-wheel ABS was the pickup truck. The truck, which was acquired "inadvertently," had only a rear-wheel ABS and, therefore, the numbers associated with the truck were not included in the final results. *Id.*, at 2.

[139]Anti-lock brakes were originally developed for airplanes in the 1950s and became standard on luxury cars such as the S-Class Mercedes in the 1980s. The number of vehicles equipped with an ABS has "soared" in the past few years, with about 58 percent of all new cars and 93 percent of light trucks having such systems. (*See* Insurance Institute for Highway Safety [IIHS] website, *Antilock Brakes: Cars, Trucks, Motorcycles* www.hwysafety.org/safety%5Ffacts/qanda/antilock.htm [visited June 7, 2000].) Since the mid-1980s, the number of heavy trucks with ABSs has also increased considerably. (*See NHTSA'S Heavy Duty Vehicle Brake Research Program Report No. 11: Evaluation of Stopping Performance of Trailer Antilock Brake Systems,* Interim Final Report, DOT HS 808 568, at iv [April 1997].)

[140]*See supra* n. 136.

[141]*Id.*, at 2, 8. (The average coefficient of friction for dry pavement was 0.89 to 0.95. Compare this with Virginia's 0.63 to 0.68, used to obtain the data in § 46.2-880.)

[142]*Id.*

- *Information provided in a table of speed and stopping distances can be useful to judges and juries in deciding a case.*

- *The table of speed and stopping distances in the Code is not accurate.* The table should be either updated to reflect current technological trends or deleted from the *Code.* Virginia judges are hesitant to use speed and stopping distance data in court for a number of evidentiary reasons; yet, they are required by statute to take judicial notice of the table. Indeed, the table would likely never be admitted into evidence were it not in the *Code* since it does not meet the "substantially similar conditions test" required of experimental evidence.[143]

- *Updating the table should not present any new problems for the Virginia judicial system;* rather, it will help jurors acquire a realistic understanding of stopping distances.

- *The reaction time of ¾ second specified in the Code does not incorporate the factor of perception time that is relevant to total stopping distance.* Allowing for perception time would double the estimate of total distance traveled before braking.

- *The numbers for the braking distances used in the table are too high.* These numbers were calculated without consideration of such factors as improved road surface conditions, improved tires, and increasingly sophisticated braking systems.

RECOMMENDATIONS

1. *The table of speed and stopping distances in § 46.2-880 of the Code should be updated rather than deleted.* If the table is deleted, juries may rarely have access to information relating to speed and stopping distances in the courtroom.[144] Given the Virginia Supreme Court's stance on accident reconstruction evidence in the courtroom, updating the table and having it remain in the *Code* may be the most prudent option. Such data are often useful when automobile accidents are analyzed, particularly when there is conflicting testimony. Updated information would help make the table even more useful.

2. *The current reaction time of ¾ second should be replaced with a 1.5-second perception-reaction time.* This change would make the table more consistent with what is known about the distance a vehicle will travel from the moment the driver detects a potential problem to the instant of braking. Such a perception-reaction time is consistent with scientific and accident reconstruction information (see Appendix C).

3. *The braking distance should be updated to reflect a coefficient of friction of 0.70 for automobiles and 0.525 for trucks.* Although these numbers would result in shorter braking distances than those in the current table, they are at the conservative end of current estimates (see Appendix C).

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[143]Telephone interview with Judge John E. Wetsel, Jr., Winchester Circuit Court (July 7, 2000).
[144]Wetsel Interview, *supra* n. 143.

Table 1 shows both the current numbers and the recommended changes.

Table 1. Comparison of Current and Recommended Numbers for Virginia's Table

SPEED IN			AVERAGE STOPPING DISTANCES						TOTAL STOPPING DISTANCES: DRIVER AND			
Miles Per Hour	Feet Per Second		Automobile Brakes (In Feet)		Truck Brakes (Brakes on All Wheels) (In Feet)		Average Driver Reaction Time (3/4 Second) (In Feet)	*Average Driver Perception-Reaction Time (1.5 Seconds) (In Feet)*	Automobiles (In Feet)		Trucks (In Feet)	
	Old	*New*	Old	*New*	Old	*New*	Old	*New*	Old	*New*	Old	*New*
10	14.67	*14.7*	5	*5*	7	*6*	11	*22*	16	*27*	18	*28*
15	22.0	*22.0*	12	*11*	17	*14*	16	*33*	28	*44*	33	*47*
20	29.34	*29.3*	21	*19*	30	*25*	22	*44*	43	*63*	52	*69*
25	36.62	*36.7*	32	*30*	47	*40*	27	*55*	59	*85*	74	*95*
30	44.0	*44.0*	47	*43*	67	*57*	33	*66*	80	*109*	100	*123*
35	51.3	*51.3*	63	*58*	92	*78*	38	*77*	101	*135*	130	*155*
40	58.7	*58.7*	82	*76*	120	*102*	44	*88*	126	*164*	164	*190*
45	66.0	*66.0*	104	*96*	152	*129*	50	*99*	154	*195*	202	*228*
50	73.3	*73.3*	128	*119*	187	*159*	55	*110*	183	*229*	242	*269*
55	80.7	*80.7*	155	*144*	227	*192*	61	*121*	216	*265*	288	*313*
60	88.0	*88.0*	185	*171*	270	*229*	66	*132*	251	*303*	336	*361*
65	95.3	*95.3*	217	*201*	316	*268*	71	*143*	288	*344*	387	*411*
70	102.6	*102.7*	252	*233*	367	*311*	77	*154*	329	*387*	444	*465*
75	109.9	*110.0*	289	*268*	422	*357*	82	*165*	371	*433*	504	*522*
80	117.2	*117.3*	328	*305*	480	*406*	88	*176*	416	*481*	568	*582*
*85**	*	*124.7*	*	*344*	*	*459*	*	*187*	*	*531*	*	*646*
90	132.0	*132.0*	425	*386*	607	*514*	99	*198*	524	*584*	706	*712*
*95**	*	*139.3*	*	*430*	*	*573*	*	*209*	*	*639*	*	*782*
100	146.6	*146.7*	514	*476*	750	*635*	109	*220*	623	*696*	859	*855*

*Not included in current version of table.

4. *The revised table should be used solely for illustrative purposes or within "judicially recognized limits."*[145] The judge's instructions to the jury should include an explanation of the relevance of the table to the case and the fact that, inevitably, there will be factors that are not reflected by the numbers in the table such as visibility at the time of the crash and driver fatigue. The jurors should, therefore, not use the table as dispositive evidence for or against a party but only to acquire a general sense of speed and its relation to stopping distance.

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[145] *See Hughes, supra* n. 89; and *Muse, supra* n. 96.

direction and supporting this study. The authors also thank Linda D. Evans, VTRC Editor, for editing and preparing the final version of the study document.

APPENDIX A

HOUSE JOINT RESOLUTION NO. 74

Offered January 18, 2000

Requesting the Virginia Transportation Research Council to study the tables of speed and stopping distances contained in § 46.2-880 of the Code of Virginia.

Patron-- Deeds

Referred to Committee on Rules

WHEREAS, among the most important goals of Virginia's transportation program are the convenience and safety of the motoring public; and

WHEREAS, the vehicle speed is a critical variable in assessing and pursuing both travelers' convenience and highway safety; and

WHEREAS, it is highly desirable that the most accurate, complete, and current data be available to permit not only traffic engineers and other transportation professionals, but also the General Assembly and local transportation officials, to determine the optimum speed limits for Virginia's highways, speed limits that will allow travelers to reach their destinations both quickly and safely; and

WHEREAS, one source of data used by the General Assembly and others (including the courts of Virginia, who are required take judicial notice thereof) is the tables of speed and stopping distances contained in contained in § 46.2-880 of the Code of Virginia; and

WHEREAS, with the exception of changes in the number of the section itself, nothing in these tables has changed in any way since this section was first enacted by the General Assembly in 1956; and

WHEREAS, the number and extent of changes in motor vehicles, motor vehicle equipment (particularly tires and brakes), and highway construction and design that have occurred in the intervening 44 years strongly suggest that the tables of speed and stopping distances contained in contained in § 46.2-880 of the Code of Virginia may be in need of revision; now, therefore, be it

RESOLVED by the House of Delegates, the Senate concurring, That the Virginia Transportation Research Council be requested to study the tables of speed and stopping distances contained in § 46.2-880 of the Code of Virginia. Such study shall consider, but not necessarily be limited to, (i) the accuracy, completeness, and currency of the data contained in such tables, (ii) the amendments to such tables that appear to be necessary or desirable, and (iii) the usefulness and appropriateness of continuing to include such tables in the Code of Virginia.

All agencies of the Commonwealth shall provide assistance to the Council for this study, upon request.

The Council shall complete its work in time to submit its findings and recommendations to the Governor and the 2001 Session of the General Assembly as provided in the procedures of the Division of Legislative Automated Systems for the processing of legislative documents.

APPENDIX B

SECTION 46.2-880 OF THE *CODE OF VIRGINIA*

§ 46.2-880. Tables of speed and stopping distances.

All courts shall take notice of the following tables of speed and stopping distances of motor vehicles, which shall not raise a presumption, in actions in which inquiry thereon is pertinent to the issues:

SPEED IN		AVERAGE STOPPING DISTANCES			TOTAL STOPPING DISTANCES: DRIVER AND	
Miles Per Hour	Feet Per Second	Automobile Brakes (In Feet)	Truck Brakes (Brakes on All Wheels) (In Feet)	Average Driver Reaction Time (3/4 Second) (In Feet)	Automobiles (In Feet)	Trucks (In Feet)
10	14.67	5	7	11	16	18
15	22.0	12	17	16	28	33
20	29.34	21	30	22	43	52
25	36.62	32	47	27	59	74
30	44.0	47	67	33	80	100
35	51.3	63	92	38	101	130
40	58.7	82	120	44	126	164
45	66.0	104	152	50	154	202
50	73.3	128	187	55	183	242
55	80.7	155	227	61	216	288
60	88.0	185	270	66	251	336
65	95.3	217	316	71	288	387
70	102.6	252	367	77	329	444
75	109.9	289	422	82	371	504
80	117.2	328	480	88	416	568
90	132.0	425	607	99	524	706
100	146.6	514	750	109	623	859

The courts shall further take notice that such tables are the result of experiments made with motor vehicles, unloaded except for the driver, equipped with four-wheel brakes, in good condition, on dry, hard, approximately level stretches of highway free from loose material.

APPENDIX C

RECOMMENDED TABLE OF SPEED AND STOPPING DISTANCES FOR § 46.2-880 OF THE *CODE OF VIRGINIA*

SPEED IN		AVERAGE STOPPING DISTANCES			TOTAL STOPPING DISTANCES: DRIVER AND	
Miles Per Hour	Feet Per Second	Automobile Brakes (In Feet)	Truck Brakes (Brakes on All Wheels) (In Feet)	Average Driver Perception-Reaction Time (1.5 Seconds) (In Feet)	Automobiles (In Feet)	Trucks (In Feet)
10	14.7	5	6	22	27	28
15	22.0	11	14	33	44	47
20	29.3	19	25	44	63	69
25	36.7	30	40	55	85	95
30	44.0	43	57	66	109	123
35	51.3	58	78	77	135	155
40	58.7	76	102	88	164	190
45	66.0	96	129	99	195	228
50	73.3	119	159	110	229	269
55	80.7	144	192	121	265	313
60	88.0	171	229	132	303	361
65	95.3	201	268	143	344	411
70	102.7	233	311	154	387	465
75	110.0	268	357	165	433	522
80	117.3	305	406	176	481	582
85	124.7	344	459	187	531	646
90	132.0	386	514	198	584	712
95	139.3	430	573	209	639	782
100	146.7	476	635	220	696	855

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