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Methods for Setting Posted Speed Limits

The purpose of this TRS is to serve as a synthesis of pertinent completed research to be used for further study and evaluation by MnDOT. This TRS does not represent the conclusions of either CTC & Associates or MnDOT.

Introduction

Traditionally, Minnesota's posted speed limits are determined using the Institute of Transportation Engineers methodology as well as other considerations. The ITE methodology uses field measurements to evaluate roadway segments for the speed at or below which 85 percent of free flowing vehicles are traveling. MnDOT has observed that the ITE methodology often determines a higher operational speed for two-lane rural highways than MnDOT believes is warranted by other engineering and safety considerations. Further, MnDOT is being asked to justify posted limits of 55 mph when statutory limits for such roadways in Minnesota are 65 mph.

Consequently, MnDOT would like to identify alternative methods used for determining posted speed limits that produce greater compliance by motorists.

CTC & Associates conducted a literature search and contacted three state departments of transportation—Illinois, Texas and Washington—to help identify potential methods, focusing on the following areas:

- Equipment and sampling methods, including the use of 24-hour tube counts
- Methods most effective for improving compliance with posted speed limits
- Factors taken into account when setting speed limits, including land use, access points and other roadway users
- Determining whether differing methods are more effective for urban than for rural roadways

Summary

We identified research related to the following key topic areas:

- National Resources
- Consultation with State Practitioners
- State Practices
- International Practices
- Related Research

National Resources
A recent Federal Highway Administration report, Methods and Practices for Setting Speed Limits, gives a comprehensive overview of methods for setting posted speed limits along with several case studies illustrating their application. There are four primary methods:

- **Engineering approach:** A two-step process where a base speed limit is set according to the 85th percentile speed and then modified according to the design speed for the road and other criteria. While most states do not have quantitative criteria for the 85th percentile speed, Illinois's procedures and the Northwestern Speed Zoning Technique are notable exceptions. Another alternative for determining deviations from the 85th percentile is the road risk method, which uses the functional classification of the road and its setting to determine base speed.
- **Expert systems:** Speed limits are set by a computer program that uses knowledge and inference procedures that simulate the judgment and behavior of speed limit experts.
- **Optimization:** Speed limits are set to minimize the total societal costs of transport.
- **Injury minimization/safe system approach:** Speed limits are set according to the crash types that are likely to occur, the impact forces that result and the human body's tolerance to withstand these forces.

The report includes a table summarizing these methods along with their advantages and disadvantages; a section on speed data collection equipment and processes; a chart of the advantages and disadvantages of speed collection devices; and two case studies demonstrating the application of these methods.

Consultation with State Practitioners/State Practices
We contacted practitioners at the Illinois, Texas and Washington State DOTs to discuss their procedures for setting posted limits and the equipment and sampling methods used for collecting speeds. We also reviewed the documented procedures for these states as well as those from Florida DOT and several other states. Most states use the 85th percentile speed as a base and make modifications based on crash risk, land use, road geometry and other factors. Some states also use the 10 mph pace and average test run as a check; Illinois DOT and Montana DOT use them when establishing the base speed limit.

- Illinois DOT has a comprehensive, quantitative system using several factors to determine posted speed limits; it averages the 85th percentile speed, upper limit of the 10 mph pace and average test run speeds, and then modifies the results based on crash rate, access control, pedestrian activity and other factors. Florida DOT also incorporates the 10 mph pace into its calculation of base speed limits, and Montana DOT uses both the 10 mph pace and average test run.
- Texas DOT sets limits close to the 85th percentile speed, with some modifications for crash rates, traffic volumes, land use and road geometry. The agency considers setting limits more than 5 mph below the 85th percentile speed as risking noncompliance. Guidelines for determining the 85th percentile speed using radar are included on pages 3-4 to 3-9 of Procedures for Establishing Speed Zones.
- Washington State DOT follows directions from the Manual on Uniform Traffic Control Devices for using the 85th percentile as a base and then making changes based on such factors as land use, collision history and road geometry. It often sets speed limits well below the 85th percentile speed, leading to significant problems with noncompliance. There is no systematic procedure for determining variable speed limits, which are modified in some locations for weather or traffic at the discretion of engineers. The agency is considering adopting elements of the Illinois system.
- All states that we contacted use the same procedures for urban and rural roads.
- None of the states we contacted make use of expert systems (including USLIMITS); Washington State DOT noted that these systems are too constraining.

International Practices

- Australia and Abu Dhabi use expert systems to set posted speed limits.
- Greece uses the 85th percentile speed as a base.
- New Zealand and Canada use the road risk methodology, which uses the functional classification of the road and its setting to determine a base speed. Canada also uses the 85th percentile speed as a check.
- Norway and Sweden use injury minimization to set speed limits according to like crash types to minimize injuries. See also Safe System/Harm Minimization in **Related Research** below.

Related Research

- **85th Percentile Evaluations:** Several studies support the use of the 85th percentile speed as a base to maximize compliance and safety. Nevertheless, many states set posted speed limits well below the 85th percentile speed. “Well below” means not within 5 mph as recommended by the MUTCD.
- **Expert Systems and Mathematical Models:** In a number of studies, researchers developed software algorithms for setting speed limits, including the FHWA’s Web-based application USLIMITS, a knowledge-based expert system that can be used by decision-makers to aid in the selection of a safe and operationally efficient speed limit for speed zones.
- **Safe System/Harm Minimization:** This system is currently used in Sweden and The Netherlands, and has been the focus of numerous studies in Australia, which currently uses expert systems. One study notes that in the short and medium term, many of the Safe System road features may not be economically viable and not all speed limits would be immediately acceptable to the public.
- **Optimal Speed Limits:** Not currently used by transportation agencies, we found one study of in Norway and Sweden.
- **Road Risk Method:** One paper examines combining the road risk and 85th percentile methods.
- **Rational Speed Limits:** The National Highway Traffic Safety Administration has conducted demonstration projects in Indiana, Massachusetts, Mississippi and Virginia of higher speed limits with increased enforcement and public education. These speed limits significantly increase compliance.
- **Speed Collection Technologies:** One study reviews the accuracy and precision of five common portable speed measurement systems, including the traffic classifier with pneumatic tubes, traffic classifier with piezoelectric sensors, tape switches, radar and lidar (i.e., police laser), and found lidar and radar to be most accurate and precise for higher speeds. Another study tested eight portable and semiportable traffic detector systems.

National Resources

Methods and Practices for Setting Speed Limits: An Informational Report, Federal Highway Administration, April 2012.
http://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwasa12004/fhwasa12004.pdf
This report describes four primary methods for establishing speed limits. *From page 10 of the report:*

- **Engineering approach:** A two-step process where a base speed limit is set according to the 85th percentile speed, the design speed for the road, or other criterion. This base speed limit is adjusted according to traffic and infrastructure conditions such as pedestrian use, median presence, etc. Within the engineering approach there are two approaches; 1) Operating Speed Method and 2) Road Risk Method.
- **Expert system approach:** Speed limits are set by a computer program that uses knowledge and inference procedures that simulate the judgment and behavior of speed limit experts. Typically, this system contains a knowledge base containing accumulated knowledge and experience (knowledge base), and a set of rules for applying the knowledge to each particular situation (the inference procedure).
- **Optimization:** Setting speed limits to minimize the total societal costs of transport. Travel time, vehicle operating costs, road crashes, traffic noise, and air pollution are considered in the determination of optimal speed limits.
- **Injury minimization or safe system approach:** Speed limits are set according to the crash types that are likely to occur, the impact forces that result, and the human body’s tolerance to withstand these forces.

Table 5 of this report (page 24) summarizes these methods, including their advantages and disadvantages. The following sections provide more information about each method. To demonstrate the application of these methods for determining speed limits, two case studies are presented (beginning on page 53 of the report).

Engineering

According to the report, the 85^{th} percentile speed method was originally based on safety and is attractive because it reflects the collective judgment of the vast majority of drivers about a reasonable speed for given traffic and roadway conditions (page 12). And while the MUTCD recommends speeds within 5 mph of the 85^{th} percentile speed, often they are set much lower; in many cases, even the 50^{th} percentile speed exceeds the posted speed limit, often because of political pressures. Setting speed limits lower than the 85^{th} percentile speed will not encourage compliance. Factors that serve as a basis for making adjustments to the 85^{th} percentile speed include crash data and engineering judgments (page 13).

The engineering method is based on a formal review of traffic flow, roadway design and other factors. However, few jurisdictions have quantitative criteria for these adjustments with two notable exceptions:

- Illinois' Policy on Establishing and Posting Speed Limits on the State Highway System considers access, pedestrian traffic, curbside parking and safety performance in addition to existing speed profile to establish the recommended speed limit. Appendix C of the report describes the procedure, including specific numerical adjustments. For Illinois' complete guidelines, see **State Practices**.
- Northwestern Speed Zoning Technique is used by several municipalities and is similar to the Illinois procedure but considers a wider range of traffic and infrastructure factors, including presence of a median, lane width and vertical alignment. Appendix D of the report describes this procedure.

An alternative engineering approach is the road risk method (page 15), which sets speed limits by the risks associated with the physical design of the road and the expected traffic conditions. Rather than using the 85^{th} percentile speed as a base speed limit, it uses the functional classification of the road and its setting, including land use (road geometry is a secondary factor). This method is good for reconciling the legislated speed of the road with its function, and is used in New Zealand and Canada. Appendix E of the report includes an example.

Expert Systems (USLIMITS2)

This software employs a decision algorithm to advise the user of the speed limit for the specific road section based on inputs from the user and takes into account section length, crash statistics and many other factors. See pages 16 to 21 for an overview of its logic. Appendix F of the report includes a sample case study. (See also Expert Systems and Mathematical Models in **Related Research**.)

Optimal Speeds

The optimum speed limit is the speed limit that yields the minimum total societal cost, which includes vehicle operation costs, crash costs, travel time costs and other social costs. This method of setting speed limits is rarely used due to the difficulty of quantifying key variables.

Injury Minimization

With this method, vehicles cannot legally travel at speeds where, in the event of a crash, the release of kinetic energy can produce a serious or fatal injury. This method is used in Norway and Sweden. It yields low speed limits that do not encourage compliance and is not commonly used in the United States.

Speed Collection and Case Studies

The report also includes a section on speed data collection equipment and processes (pages 42 to 49). Table 10 lists the advantages and disadvantages of speed collection devices (page 43).

ITE Speed Zoning Guidelines, ITE Committee 4M-25 Speed Zone Guidelines Recommended Practice, Institute of Transportation Engineers, undated.
http://www.ibiblio.org/rdu/ite-szg.html
These guidelines offer a rationale for the 85th percentile speed. Several studies have demonstrated that drivers who travel either slower or faster than the 85th percentile speed of the traffic stream have a higher accident involvement rate than those drivers whose speed is close to the 85th percentile speed. Posted speed limits should be the maximum speed considered to be safe and reasonable (i.e., the 85th percentile speed).

Speed Concepts: Informational Guide, Federal Highway Administration, September 2009.
http://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwasa10001/fhwasa10001.pdf
This guide notes that the dominant factor in establishing posted speeds is the 85th percentile speed.

From the abstract: The objectives of this guide [are] to:

- Define common speed-related terminology so that the guide's contents can be clearly conveyed
- Explain the differences between designated design speed, inferred design speed, operating speed, and posted speed limits
- Illustrate perceptions and research conclusions related to the effects of speed
- Document speed-based technical processes
- Summarize State and local government agency roles and actions related to traffic speed
- Highlight speed management and mitigation measures.

The informational guide uses a combination of speed profile plots, tabular summaries, illustrative examples, and narrative discussion to describe each of the objectives noted above.

Manual on Uniform Traffic Control Devices, FHWA, 2009.
http://mutcd.fhwa.dot.gov/
See Section 2B.13 Speed Limit Sign (R2-1):
http://mutcd.fhwa.dot.gov/HTM/2003r1/part2/part2b1.htm#section2B13
From the manual: When a speed limit is to be posted, it should be within 10 km/h or 5 mph of the 85th-percentile speed of free-flowing traffic. Other factors that may be considered when establishing speed limits are the following:

A. Road characteristics, shoulder condition, grade, alignment, and sight distance;
B. The pace speed;
C. Roadside development and environment;
D. Parking practices and pedestrian activity; and
E. Reported crash experience for at least a 12-month period.

Design Speed, Operating Speed, and Posted Speed Practices, *NCHRP Report 504*, 2003.
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_504.pdf
From the report: This report examines the relationship between design speed and operating speed through a survey of the practice and a thorough analysis of geometric, traffic, and speed conditions. The basis for recent changes in speed definitions in AASHTO's A Policy on Geometric Design of Highways and Streets (Green Book) and the Manual on Uniform Traffic Control Devices (MUTCD) are presented.

Managing Speed: Review of Current Practice for Setting and Enforcing Speed Limits, Transportation Research Board Special Report 254, 1998.
http://onlinepubs.trb.org/onlinepubs/sr/sr254.pdf
In addition to reviewing current practice in setting and enforcing speed limits, guidance is provided to state and local governments on appropriate methods of setting speed limits and related enforcement

strategies. Chapter 3 reviews the primary methods for setting speed limits (beginning on page 85), including statutory speed limits, optimum speed limits, the engineering study method, the expert system approach and variable speed limits. It notes that setting the speed limit on the basis of the 85th percentile speed is not always appropriate (page 208), and cites research to the effect that the 85th percentile speed not only represents the upper bound of the preferred driving speed of most drivers, but, according to some studies, for some roads it also corresponds to the upper bound of a speed range where crash involvement rates are lowest (page 93). It recommends that traffic engineers should consider an expert-system approach as a systematic and consistent method of determining speed limits in speed zones. The decisions and judgments required to establish speed limits were thought to be particularly amenable to an expert system approach. Chapter 6 provides guidance on setting and enforcing speed limits.

Consultation with State Practitioners

Illinois

Contact: Larry Gregg, Acting Engineer of Traffic Operations, Illinois Department of Transportation, (217) 782-2076, lawrence.gregg@Illinois.gov.

Illinois has a unique system using several factors other than the 85th percentile speed. (See also Methods and Practices for Setting Speed Limits in **National Resources** and Policy on Establishing and Posting Speed Limits on the State Highway System in **State Practices** for more information). Illinois averages the 85th percentile speed, upper limit of the 10 mph pace and average test run speeds, and then modifies the results based on crash rate, access control, pedestrian activity and other factors. It uses the same methods for determining posted speed limits on city streets and on rural highways, and for speed collection uses handheld or tripod-mounted radar. It does not make use of expert systems such as USLIMITS.

Texas

Contact: Darren McDaniel, Speed Zone Engineer, Texas Department of Transportation, (512) 416-3331, darren.mcdaniel@txdot.gov.

Speed limits on Texas highways are set by the 85th percentile method, which represents the speed the majority of drivers will be traveling at or below. This is a sound engineering principle by which speed limits have been set on highways nationwide for the past 60 years.

Texas DOT’s goal is to set speed limits in accordance with state law and to have speed limits that motorists respect and obey. If speed limits are set below what the 85th percentile of drivers believe is appropriate, they tend to have a limited impact on drivers. Crashes can be prevented if motorists practice safe driving habits. They should obey speed limits, use safety belts properly, pay attention to traffic and never drink and drive. Motorists should always drive at a speed that is safe and appropriate for the conditions. Speeds should be reduced during bad weather or other poor driving conditions.

See Procedures for Establishing Speed Zones under **State Practices** for more information.

Washington

Contact: Mike Dornfeld, Program and Performance Manager, Traffic Operations Office, Washington State Department of Transportation, (360) 705-7281, dornfem@wsdot.wa.gov.

Washington State DOT follows MUTCD directions on using the 85th percentile as a base and then making changes based on such factors as land use, collision history and road geometry. It uses the same method for urban and rural roadways. The 85th percentile speed is often higher than the posted speed limits, and compliance is not good. Washington State DOT also has problems with transition for rural areas that run through small towns.

For variable speed limits, in some locations regional TMCs have the option of reducing speed limits based on weather and traffic conditions (usually the former, during winter snow storms or operations). These reductions are based on the discretion of an engineer rather than on an algorithm or systematic method.

Washington State DOT is reviewing and considering adopting some elements of Illinois' system. It finds expert systems such as USLIMITS too constraining—it's not something that traffic engineers want to get locked into.

For speed collection, WSDOT uses primarily handheld radar guns and sometimes pneumatic tubes.

State Practices

Most states —including Texas and Washington—use the 85th percentile speed as a base and make modifications based on crash risk, land use, road geometry and other factors. Illinois also incorporates the 10 mph pace and average test run into its determination of base speed, and Florida also uses the 10 mph pace.

Florida

Speed Zoning for Highways, Roads, and Streets in Florida, Manual Number 750-010-002, Florida Department of Transportation, March 2010.
http://www.dot.state.fl.us/trafficoperations/speedzone/Speed_Zoning_Manual_Complete_03_17_2011.pdf
This manual provides guidelines and recommended procedures for establishing uniform speed zones on state, municipal and county roadways throughout Florida. It cites research showing that higher traveling speeds are not necessarily associated with an increased risk of being involved in a crash (page 2-2). For traffic engineering investigations, Florida DOT collects the 85th percentile speed as well as the upper limit of 10 mph pace (the 10 mph range containing the highest number of such vehicles contained in the study sample data) and the average test run speed (measured using agency vehicles) (page 4-1). Measurements are taken using one of two methods (page 5-1):

- Measurement of travel times as vehicles traverse a short, predetermined distance along a roadway segment.
- The use of handheld or fixed-mounted radar or other electromagnetic wave detection devices.

The first method often involves pneumatic tubes and automatic time-stamp microprocessor traffic data recorders. Other technologies using the trap method include low power infrared scanning and light beam interrupt.

Three categories of device can be used for the second method: the Doppler-Shift (handheld or fixed-mounted radar units, pole-mounted microwave units and the fixed-mounted ultrasound units); Field Magnetic Interrupt (in-roadway inductive loops); and Vehicular Acoustic Energy detection. Regardless of the method used, every effort must be made to disguise or conceal the fact that speeds are being recorded on any roadway segment; otherwise distorted data will be collected, the analysis of which can lead to unrealistically low speed limits due primarily to the driver's reaction to a perceived speed trap.

When it comes to deviations of posted speed limits from the base speed (85th percentile or 10 mph pace), Florida DOT takes the following approach (page 9-1): A speed limit should not differ from the 85th percentile speed or upper limit of the 10 mph pace by more than 3 mph and it shall not be less than 8 mph. A speed limit of 4 to 8 mph less than the 85th percentile speed shall be supported by a supplemental investigation, which identifies the following:

- There are road or roadside features not readily obvious to the normally prudent driver, such as length of section, alignment, roadway width, surface condition, sight distance, traffic volume, crash experience, maximum comfortable speed in curves, side friction (roadside development), signal progression, etc., or;
- Other standard signs and markings have been tried but found ineffective.

As to taking into account crash data in determining posted speed limits, Florida DOT is cautious and notes that generally a higher number of crashes occur when the speed differential is greatest and that individual speeds at the 85th percentile level are by definition the safest speed for travel (page 9-2).

Illinois

Policy on Establishing and Posting Speed Limits on the State Highway System, Illinois Department of Transportation, March 2011.
http://willowroadfuture.org/Exhibits/2011March_IDOT_PolicyOnEstablishingPostingSpeedLimits.pdf
Illinois statutory speed limits may be altered based on the following method:

- Determine the prevailing speed, which is an average of the 85th percentile speed, the upper limit of the 10 mph pace and the average test run speed rounded to the nearest 5 mph increment.
- Modify the prevailing speed-based elevated crash risk, access control and other factors such as pedestrian activity, adjacent parking and road geometry to determine a preliminary speed limit.
- Determine the speed limit either as the preliminary speed limit or the 50th percentile speed, whichever is greater.

Texas

Procedures for Establishing Speed Zones, Texas Department of Transportation, November 2006.
http://onlinemanuals.txdot.gov/txdotmanuals/szn/szn.pdf
This manual provides procedures for establishing speed zones and advisory speeds in Texas. It notes that a 1992 Michigan study found that the safety benefits of posting speed limits within 5 mph of the 85th percentile speed are small but that it has a major effect on improving driver compliance (page 1-7). Further, posting speed limits more than 5 mph below the 85th percentile speed does not reduce crashes and has an adverse effect on driver compliance. When it comes to equipment for measuring the 85th percentile speed, radar underestimates it by approximately 3 mph (page 1-8). Texas generally adheres to the 85th percentile method, and gives guidelines for determining it using speed check stations and radar (pages 3-4 to 3-9). Only on special conditions does the posted speed vary by more than 5 mph from the 85th percentile speed (pages 3-18 to 3-19). These include crash rates, traffic volumes, land use and road geometry.

Washington

Speed Limits, Traffic Operations, Washington State Department of Transportation, 2012.
http://www.wsdot.wa.gov/Operations/Traffic/speedlimits.htm
Washington State DOT uses the 85th percentile speed as a base and makes modifications for:

- Roadway characteristics, shoulder condition, grade, alignment and sight distance
- Roadside development and lighting
- Parking practices, e.g., angle parking, and pedestrian and bicycle activity
- Collision rates and traffic volume trends
- Right lane/entering traffic conflicts (for freeways)

Other States

Review of procedures for a selection of other states found common use of the 85th percentile method with modifications for engineering factors and the use of the 10 mph pace or test run as a check:

- Alaska Department of Transportation and Public Facilities
  http://www.dot.state.ak.us/admsvc/pnp/assets/chapt_5/05_05_020.pdf
- Maine Department of Transportation
  http://www.maine.gov/mdot/community-programs/csd/howlimit.php
  Maine DOT also uses test runs as a check.
- Massachusetts Highway Department
  http://www.mit.edu/~jfc/speed/MassHighway/manual.html
  Massachusetts Highway Department also uses test runs as a check.
- Michigan Department of Transportation
  http://www.michigan.gov/documents/Establishing_Realistic_Speedlimits_85625_7.pdf
  Michigan DOT also collects the 10 mph pace during speed studies.
- Ohio Department of Transportation
  http://www.dot.state.oh.us/Divisions/Operations/Traffic/publications2/TEM/Documents/Part_12%20complete_101708.PDF
  Ohio DOT uses 10 mph pace and test runs as a check.
- Wisconsin Department of Transportation
  http://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwasa09028/resources/Setting%20speed%20limits%20on%20local%20roads.pdf
  Wisconsin DOT also uses pace speed.

It is less frequent for states to use a method similar to that of Illinois in incorporating both the 10 mph pace and the average test runs into calculations of base speed limits. Montana is an exception:

- Montana Department of Transportation
  http://www.mdt.mt.gov/other/traffic/external/pdf/chapter_40.pdf

These documents also contain information about speed collection equipment and procedures.

International Practices

Australia and Abu Dhabi

Australia makes use of expert systems in setting posted speed limits, and Abu Dhabi has used USLIMITS in some locations. See Expert Systems and Mathematical Models in **Related Research**.

Canada

Canadian Guidelines for Establishing Posted Speed Limits, Transportation Association of Canada, 2009.
Presentation: http://www.citevancouver.org/quad/presentations/Quad%202009%20-%20Sany%20Zein%20Presentation%20-%20%20Posted%20Speed%20Limit%20Study.pdf
Citation at http://trid.trb.org/view.aspx?id=911707
Canada uses the road risk method to determine posted speed limits according to road engineering characteristics, geometry, roadside, classification, land use, access and intersection density, and vulnerable road users. The 85th percentile speed used as a check, not as a determining factor.

Review and Analysis of Posted Speed Limits and Speed Limit Setting Practices in British Columbia, Final Report, British Columbia Ministry of Transportation, Spring 2003.
http://www.th.gov.bc.ca/publications/eng_publications/speed_review/Speed_Review_Report.pdf
From the report: This report contains a review and assessment of speed limits posted in speed zones on Provincial rural highways in British Columbia, and practices used by the Ministry of Transportation (MoT) to determine the appropriate speed limit. It considers the 85th percentile speed, road geometry, roadside development, and crash history.

Greece

Greek Guidelines for Setting Speed Limits, *Advances in Transportation Studies*, Vol. 19, 2009: 27-34.
Citation at http://trid.trb.org/view/2009/C/918606
From the abstract: The purpose of this paper is to present the main points (technical information, rules, and data) that were used to develop guidelines for setting speed limits in the Greek National Road Network in order to address road safety problems for both rural and urban roads. The guidelines emphasize the concept that is necessary to set a speed limit when it is considered or realized that even when drivers with increased attention are not capable to safely navigate a road section with a certain speed. The establishment of local speed limit is acceptable only if the responsible services have exhausted or excluded all possible engineering solutions for a given roadway section. The 85th percentile speed is the characteristic traffic parameter that is related better with that speed limit which is considered reasonable and safe. In any case the study of determination speed limits is a complicated and complex process.

New Zealand

Speed Limits New Zealand: Guidelines for Setting Speed Limits and Procedures for Calculating Speed Limits, Land Transport Safety Authority, 2003.
http://www.nzta.govt.nz/resources/speed-limits/speed-limits-nz/speed-limits-nz.html
From the guidelines: New Zealand uses the road risk method for determining posted speed limits, and takes into account:

- The existing speed limit
- The character of the surrounding land environment (eg, rural, fringe of city, fully developed)
- The function of a road (ie, arterial, collector or local)
- Detailed roadside development data (eg, number of houses, shops, schools, etc.)

- The number and nature of side roads
- Carriageway characteristics (eg, median divided, lane width and number of lanes, road geometry, street lighting, footpaths, cycle lanes, parking, setback of fence line from carriageway)
- Vehicle, cycle and pedestrian activity
- Crash data
- Speed survey data

Norway and Sweden

See Safe System/Harm Minimization in **Related Research**.

Related Research

85th Percentile Evaluations

"Setting Speed Limits on Rural Two-Lane Highways by Modeling the Relationship between Expert Judgment and Measurable Roadside Characteristics," *Journal of Transportation Engineering*, Vol. 137, Issue 3, 2011: 184-192.
Citation at http://trid.trb.org/view/2011/C/1101642
From the abstract: In the present paper a multinomial logit (MNL) discrete choice model for selecting speed limits is presented as an exploratory method for relating measurable roadside characteristics and speed limits over the full length of rural two-lane highways. The model was developed using as a case study 34 km of rural roads in the region of Coimbra (Portugal). The choice of four traffic safety experts was recorded for each 200 m segment, in both directions, permitting the estimation of the MNL. Only straight and nearly straight roadway segments were considered, and speed limitations resulting from restrictive geometric properties of the segments were disregarded in this study. The explanatory variables were collected to describe the built-up characteristics of the different segments of the road and its surrounding environment. The model adjusted well to the data; and an external data set was shown to be consistent with the expert judgment. Variables that were added to translate lateral roadside constraints were those with a higher significance in explaining the choice of lower limits. Comparing the model with the actual speed limits posted in situ, it was possible to conclude that there is a clear mismatch between these limits and the surrounding environment with a significant tendency for lower posted speed limits compared with the limits at which experts believe that it would be safe to drive.

Actual Speeds on the Roads Compared to the Posted Limits, Sherry L. Skszek, Arizona Department of Transportation, October 2004.
http://www.azdot.gov/TPD/ATRC/publications/project_reports/PDF/AZ551.PDF
From the abstract: The findings of this report support the premise that speed limits should be raised to the 85th percentile where roadway design, accident history, road type and surface, and traffic volume warrant an increase. Enforcement efforts should be targeted at urban interstate highways using traffic data for optimal use of limited resources.

Is 85th Percentile Speed Used To Set Speed Limits? ITE 2002 Annual Meeting and Exhibit, 2002.
Citation at http://trid.trb.org/view/2002/C/732310
From the abstract: Most agencies responding to a recent survey stated that the 85th percentile speed is the predominant factor used in setting speed limits. While 85th percentile speed remains the goal for posted speed limits, a majority of sites are being set at more than 5 mph less than the measured 85th percentile speed. Reviewing the operating speeds on a sample of roads found that the posted speed was equal to only 23-52% of the drivers on suburban/urban collectors and local streets, respectively. On rural roads, the speed limits were equal to as high as 72% of the drivers. Data for 128 speed zone study surveys was

available for analysis. At only 10% of the sites did recommended posted speed limit reflect a rounding up to the nearest 5 mph increment. At about 33% of the sites, the posted speed limit was rounded to the nearest 5 mph increment. For the remaining 67% of sites, the recommended posted speed limit was greater than 3.6 mph below the 85th percentile speed. A review of these studies shows that the 85th percentile speed is used only as a starting point, with the posted speed limit being almost always set below the 85th percentile value by as much as 8-12 mph.

Evaluations of Posted Speed Limits

“**Setting Speed Limits on Rural Two-Lane Highways by Modeling the Relationship between Expert Judgment and Measurable Roadside Characteristics,”** *Journal of Transportation Engineering*, Volume 137, Issue 3, 2011: 184-192.
Citation at http://trid.trb.org/view/2011/C/1101642
From the abstract: In the present paper a multinomial logit (MNL) discrete choice model for selecting speed limits is presented as an exploratory method for relating measurable roadside characteristics and speed limits over the full length of rural two-lane highways. The model was developed using as a case study 34 km of rural roads in the region of Coimbra (Portugal). The choice of four traffic safety experts was recorded for each 200 m segment, in both directions, permitting the estimation of the MNL. Only straight and nearly straight roadway segments were considered, and speed limitations resulting from restrictive geometric properties of the segments were disregarded in this study. The explanatory variables were collected to describe the built-up characteristics of the different segments of the road and its surrounding environment. The model adjusted well to the data; and an external data set was shown to be consistent with the expert judgment. Variables that were added to translate lateral roadside constraints were those with a higher significance in explaining the choice of lower limits. Comparing the model with the actual speed limits posted in situ, it was possible to conclude that there is a clear mismatch between these limits and the surrounding environment with a significant tendency for lower posted speed limits compared with the limits at which experts believe that it would be safe to drive.

Expert Systems and Mathematical Models

Towards Safe Speeds and Credible Speed Limits, 4th International Symposium on Highway Geometric Design, 2010.
Citation at http://trid.trb.org/view/2010/C/1098915
From the abstract: The SaCredSpeed algorithm uses input data of road design and image, and traffic characteristics of stretches of roads in order to calculate a safe speed and speed limit for that particular situation. This means that, depending on the legal traffic situation and further road design details, safe speed limits are defined. The safe speed is related to the real speed (V90 as a default) if this data is available. The SaCredSpeed algorithm can then check the credibility of the speed limit (current or ideal) and the enforcement situation (optional). Depending on the fit between the results of all these assessments, SaCredSpeed offers suggestions for adaptations. These can consist of a) speed limit adaptations, b) road design adaptations or c) additional adaptations in enforcement. These suggestions can also take into account the road network function, the condition of the adjacent roads, the traffic volume, and the priorities the decision maker wants to set. The first draft of the SaCredSpeed algorithm was tested in a number of regions in the Netherlands. The results from the safe speeds and credible speed limit assessments are discussed, as well as the SaCredSpeed suggestions for improving the situation. The paper will conclude with suggestions for further steps to take.

“Setting Appropriate Posted Speed Limits in the Emirate of Abu Dhabi,” *Road Safety on Four Continents: 15th International Conference Proceedings,* March 2010: 1177-1188.
Citation at http://trid.trb.org/view/2010/C/968839
From the abstract: The objective of the study is to provide rational posted speed limits in the Emirate, based on engineering studies and by using a computer program developed by the Federal Highway Administration (FHWA) called USLIMITS2. USLIMITS2 is a web-based expert advisor system designed

to assist practitioners in determining appropriate speed limits in speed zones. USLIMITS2 calculates the appropriate speed limit for a section of road through the consideration of the following information input including but not limited to: the operating speeds (85th percentile speed and median speed), the number of interchanges, the number of driveways, crash statistics, and presence/absence of adverse alignment, current statutory limit, average daily traffic, and roadside hazards. The findings from the 60 sites are summarized in a table where most of the posted speed limits were found to be appropriate, and new posted speed limits were recommended for 7 locations.

A Novel Modular System to Determine a Vehicle Safe Speed Limit, 16th ITS World Congress and Exhibition on Intelligent Transport Systems and Services, 2009.
Citation at http://trid.trb.org/view/2009/C/906654
From the abstract: The main objective of this paper is to develop an assistance system permitting the determination of a vehicle safe speed limit taking into account the parameters influencing the vehicle speed. The system developed here is a novel approach that determines the safe speed limit using mathematical speed model which is adjusted by the suitable parameters.

"Development of a Web-Based Expert System for Setting Speed Limits in Speed Zones," Raghavan Srinivasan, David L. Harkey, Dwayne Tharpe, Roy Sumner, Martin R. Parker, *TRB 87th Annual Meeting Compendium of Papers DVD*, Paper #08-2243, 2008.
Citation at http://trid.trb.org/view/2008/C/848440
From the abstract: This paper describes the development of USLIMITS2, a knowledge-based expert system that can be used by decision-makers to aid in the selection of a safe and operationally efficient speed limit for speed zones on all road systems in the United States. The expert system is based on the results of previous research including feedback from users of the current USLIMITS program developed by the Australian Road Research Board, an examination of current speed zoning practices, and the need to improve and aid practitioners in recommending appropriate speed limits for specific road and traffic conditions. USLIMITS2 is a web-based application that can be accessed by anyone with a computer with web-browsing software and access to the Internet. In addition to the program, the web site, www2.uslimits.org, also contains a copy of the research report, the decision logic, and a User Guide to assist the user through the decision-making process. The system was designed to be user friendly and not require intensive data collection and analysis. Emphasis was placed on having the system explicitly consider safety along with other factors in the speed limit decision process. The tool was specifically developed to provide expert resource information based on logic used by experts in the United States. The system does not provide recommendations for statutory limits or temporary limits such as those posted in work zones and school zones.

"An Expert System for Recommending Speed Limits in Speed Zones," *NCHRP Research Results Digest 318*, May 2007.
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rrd_318.pdf
From the summary: This digest presents the results of NCHRP Project 3-67, "Expert System for Recommending Speed Limits in Speed Zones," which was conducted to develop a knowledge-based expert system decision-support tool for recommending speed limits in speed zones on highways and local roads that are considered credible and enforceable. This system, USLIMITS2, improves upon the original USLIMITS system by making available complete information about the system's logic and factors influencing speed-limit recommendations. The core of USLIMITS2 is a set of decision rules developed with the help of two selected groups of experts. This document includes a flowchart of these rules. The application can be accessed through the Internet at http://safety.fhwa.dot.gov/USLIMITS/ and is available for download and installation on an Internet server from the TRB website at http://www.trb.org/news/blurb_detail.asp?id=7568.

"A Mathematical Model to Set Speed Limits for Vehicles on the Highway," *Transport: Research Journal of Vilnius Gediminas Technical University and Lithuanian Academy of Sciences*, Vol. 21, Issue 4, 2006: 278-283.
Citation at http://trid.trb.org/view/2006/C/802821
From the abstract: This paper develops a mathematical model that can be used for establishing specific speed limits for vehicles traveling on roads. The model is developed on a measure of the impact force of two vehicles involved in a head-on collision. A hypothetical case study based on the impact of force on the human body is examined. Results reveal a variation of speed with regard to the occupied position distance. The authors also examine the role that seatbelts play as a safety feature for vehicle occupants. The authors contend that developing a quantitative approach for evaluating the impacts of speed would help in reducing accidents as well as in helping to track speed violators.

Criteria for Setting Speed Limits in Urban and Suburban Areas in Florida, University of South Florida, Tampa, March 2003.
http://ntl.bts.gov/lib/23000/23100/23120/FDOT_BC353_14_rpt.pdf
From the abstract: The purpose of this study was to develop mathematical models to set speed limits using more objective approaches than the subjective adjustments to the 85th percentile speed based on practitioners' subjective decision making. The adjustment factors developed in this study are for such variables as access density, road class, lateral clearance, lane width, and signal spacing. It was found that the model developed in this study predicted speed limits more realistic than using 85th percentile speed solely.

Safe System/Harm Minimization

Rationalisation of Speed Limits Within the Safe System Approach, Australasian Road Safety Research, Policing and Education Conference, 2011.
Citation at http://trid.trb.org/view/2011/C/1131398
From the abstract: This paper summarises the calculation of the optimum speeds for the range of Australian rural road types: rural freeways, multi-lane divided roads, and single-lane undivided roads, with and without shoulder-sealing. The system-wide impacts if cars and trucks were to travel at their optimum speeds, as a basis for setting speed limits in each road environment, are then calculated. A rationalisation of speed limits to reflect the innate expectations of drivers, but also based on rational analysis of all the costs and benefits, may result in greater compliance with speed limits and make intensive speed enforcement more palatable and even unnecessary long-term.

Infrastructure/Speed Limit Relationship in Relation to Road Safety Outcomes, Austroads, 2010.
Citation at http://trid.trb.org/view/2010/M/1096957
From the abstract: The project consisted of a review of Australasian and international literature regarding the harm minimization approach in road safety and speed limits. Data analysis was carried out to identify the relationships between different elements of road infrastructure and crash outcomes. This body of research was evaluated by an expert group of Austroads stakeholders to identify the road infrastructure features relevant in speed limit setting. The stakeholders provided input into guidance on appropriate speed limit setting policy in the context of harm minimisation. The project provides a set of revised guiding principles for speed limit setting based on harm minimisation (the Safe System approach), road function, road infrastructure and driver selection of speeds.

"Speed Limits in the Safe System Concept," *Journal of the Australasian College of Road Safety*, Vol. 21, Issue 2, May 2010.
Citation at http://trid.trb.org/view/2010/C/935005
From the abstract: This paper proposes a set of new principles for setting speed limits based on harm minimisation, the cornerstone of the Safe System approach. The Safe System approach seeks to develop and manage the road transport system so that death and serious injury are eliminated. Safer Roads and Safer Speeds are two of its main elements. The new speed limit setting principles have been developed for

Austroads by the Australian Road Research Board (ARRB) and road jurisdiction stakeholders. As part of the new principles, a process is proposed to analyse the Safe System readiness of a road and identify the speed limit options and road improvement options required to achieve safe travel. It is recognised, however, that in the short and medium term, many of the Safe System road features may not be economically viable and not all speed limits would be immediately acceptable to the public. Thus, various harm reduction measures are proposed as interim steps towards the Safe System.

Setting Speed Limits for a Safe System, Jim Langford, Monash University Accident Research Centre, June 2006.
http://www.whiteandblack.co.nz/wp-content/uploads/2010/06/9._Setting_speed_limits__16_Nov_06_.pdf
From the paper: This paper describes the safety benefits if Australasian jurisdictions were to adopt harm reduction criteria in setting speed limits. The development of a safe system entails an examination of the complete driving environment (vehicles, roads, the surrounding physical environment, traffic mix, different road users and their behavior and so on), and setting speeds such that in the event of a crash, no user is exposed to possible impact forces capable of causing death or serious injury.

Optimal Speed Limits

"Optimal Speed Limits: Limits of Optimality Models," R. Elvik, *Transportation Research Record 1818*, 2002: 32-38.
Citation at http://pubsindex.trb.org/view.aspx?id=732067
From the abstract: Recent estimates of optimal speed limits on public roads in Norway and Sweden are presented. An optimal speed limit is set to minimize the total costs to society of transport. Travel time, vehicle operating costs, road accidents, traffic noise, and air pollution were considered in the determination of optimal speed limits for Norway and Sweden.

Road Risk Method

A Consistent Method for Rural Speed Zoning: 85^{th} Percentile Speed Profile vs. Risk Based Calculation, 22^{nd} ARRB Conference, 2006.
Citation at http://trid.trb.org/view/2006/C/805954
From the abstract: The current speed zoning project in New Zealand is considering two methods of determining speed limits for rural roads: using an 85^{th} percentile speed profile; or using a risk based calculation. This paper considers the issues for both methods and discusses which method produces the best results. Comments made in this report are based on the experiences from the speed zoning project. The paper reaches the conclusion that combining both the 85^{th} percentile speed profile and the risk based calculation methods means a speed limit based on the 85^{th} percentile speed can be set conservatively, targeting only the most antisocial drivers, while the risk based calculation can be used to determine whether the speed limit should be lowered if the road is deemed to have a high crash risk. Some subjective judgments will be required by experts for the risk based calculation. However, the end result should be a method that will meet the expectations of most drivers, except where there is a definite safety risk and a lower speed limit is required.

"Speed Zoning Based on the Road Environment," Andrew Edgar, *ITE 2005 Annual Meeting and Exhibit Compendium of Technical Papers*, 2005.
Citation at http://trid.trb.org/view/2005/C/762541
From the abstract: This paper looks at the proposed policy and processes for speed zoning in New Zealand. The three important aspects are: determining whether speed zoning is appropriate for a road; determining the best speed limit based on the 85^{th} percentile speeds; and calculating the best speed limit based on the actual risk of a speed related crash.

Rational Speed Limits

"Long-Term Speed Compliance and Safety Impacts of Rational Speed Limits," *Journal of Transportation Engineering*, Vol. 135, Issue 8, August 2009: 536-544.
Citation at http://trid.trb.org/view/2009/C/898884
From the abstract: This paper summarizes the results of a deployment of the rational speed limits (RSLs) approach on two limited access highways in Virginia. The RSL approach involves a coordinated campaign to post sound and credible speed limits, increase speed enforcement, and implement public information and education (PI&E). Two limited access highways where speed limits were increased from 55 to 65 mph were examined. Public perception survey results showed that the new 65 mph speed limits were well supported with over 80% agreeing with the new speed limits. The speed analysis showed that the average speed increased by a statistically significant margin immediately after the speed limit was increased, but compliance with the new posted speed limit was also significantly higher than what was observed with the old, 55 mph limit. There were practically no significant changes in speed during the increased enforcement and PI&E campaign or when speeds were examined one year after the end of the campaign. In addition, the standard deviation of speeds was fairly consistent throughout the before and after periods, which suggests that crash likelihood was not increased due to the increased posted speed limit. In fact, crash data showed that safety at the two demonstration sites was actually better than anticipated based on trends at similar comparison sites where speed limits were increased but no additional enforcement or PI&E were present. The results of the study imply that compliance and safety improvements can be sustained for at least a year after a coordinated enforcement and education campaign is completed, provided that speed limits are set appropriately.

"Evaluation of Rationally Implemented Speed Limits on Collector Roadways," Michael A. Knodler Jr., David Hurwitz, Heather A. Rothenberg, *TRB 87th Annual Meeting Compendium of Papers DVD*, Paper #08-2757, 2008.
Citation at http://trid.trb.org/view/2008/C/848747
From the abstract: To address speed-related safety issues the U.S. Department of Transportation established a Speed Management Team which, in turn established an experimental projects related to the implementation and evaluation of rationally established speed limits. By definition, a rationally established speed limit is one that is based upon formal review and engineering study and is reflective of realistic roadway speeds, which are reasonable under normal travel conditions. Data from almost 1.5 million free flow vehicles was collected over a 20-month time frame and provided 85th, 95th, and mean speeds for each of 12 data collection locations.

Field Test of the Impact of Setting and Enforcing Rational Speed Limits in Gulfport, Mississippi, National Highway Traffic Safety Administration, October 2007.
http://ntl.bts.gov/lib/26000/26600/26695/4063-MS-Final.pdf
Speed limits were raised by 5 mph to 15 mph on a 7.5-mile road segment in Mississippi and tested for great compliance, more uniform speeds and improved safety. Results showed that speed violations were reduced by three quarters, there were small increases in mean and 85th percentile speeds, there was no significant evidence of changes in speed variation, a reduction in the proportion of extreme speeders (95th percentile speeders) occurred only on the +15 mph segment, and the average monthly frequency of crashes was lower than for the preceding year but higher than for the preceding three years (matching similar changes in a control comparison community). The NHTSA conducted similar demonstration projects in Massachusetts, Indiana and Virginia.

Speed Collection Technologies

"Comparison of Portable Speed Measurement Devices," *Transportation Research Record 1870*, 2004: 139-146.
Citation at http://trid.trb.org/view/2004/C/741322

From the abstract: The accuracy and precision of five common portable speed measurement systems were evaluated in a controlled field evaluation. The following systems were evaluated: traffic classifier with pneumatic tubes, traffic classifier with piezoelectric sensors, tape switches, radar, and lidar (i.e., police laser). A test vehicle with a calibrated Nitestar distance-measuring instrument (DMI) made 100 passes through the test site at two speed levels (50 passes at 55 mph, 50 passes at 35 mph), and speed was recorded by each device for each pass. DMI speed was deemed the true speed for each pass, and deviations from the DMI speed for a given device were considered errors. Paired t-tests were performed on the speed data measured by each device versus the DMI. The following conclusions were drawn: (a) All devices performed equally well for the 35-mph trials. (b) Lidar and radar were the most accurate and precise devices for the 55-mph trials. (c) For all devices, any errors that occurred for a single speed measurement were relatively small (less than +/- 1.5 mph). (d) With the exception of radar, all devices were slightly less accurate and less precise at higher speeds. (e) There was little difference in performance between on-pavement devices (i.e., tubes, piezoelectric sensors, and tape switches). (f) Inaccuracies observed in on-pavement equipment likely were caused by slight measurement errors during placement of the sensors or movement of the sensors resulting from repeated tire hits. Because all devices were relatively accurate, the researchers recommended that portable speed measurement equipment be selected to suit the characteristics of a given data collection situation.

Investigation of Traffic Detectors for Use in Hawaii: Detector Installations and Tests, P.D. Prevedouros, University of Hawaii, Manoa, 2004.
Citation at http://trid.trb.org/view/2004/M/755007
From the abstract: This report presents the results and lessons learned from field deployments and tests of eight portable and semi-portable traffic detector systems. These tests are the culmination of research conducted to determine suitable, primarily non-intrusive, traffic detectors for use in Hawaii. These tests were conducted at nine freeway and arterial road sites on the islands of Oahu and Hawaii. The systems tested, grouped by how the sensors were installed, are as follows: Underground or underbridge: (1) 3M microloops and Canoga 800 Series detectors; On-ground: (2) Optical Sensor Systems fiber optic sensors and ITC TRS counter/classifier, (3) pneumatic tube sensors and JAMAR TRAX RD counter/classifier, (4) Roadtrax BL piezoelectric sensors and PEEK ADR-2000 counter/classifier, (5) Spectra Research ORADS (NTMS) portable laser sensor and IRD TCC 550 counter/classifier; and Above ground, side-fired: (6) RTMS model X2 and RTC data unit by EIS, (7) SAS-1 acoustic sensor and SAS-CT board by Smartek, and (8) SmartSensor microwave sensor by Wavetronix. Several emerging telecommunications and data retrieval services were installed and tested as part of these systems: TrafInfo's Trafmate satellite modem and digital pager, and TrafficWerks' near-real time data retrieval via cellular subcarrier (CDPD or CDMA modem) and integrated archival system. These were tested against some current telemetry practices such as those using standard Hayes 9600 modems and cellular analog technology and found to be greatly superior. Of the four on-ground sensors capable of providing vehicle classification data (in 13 classes), the Roadtrax BL is the only one judged capable of providing adequate and reliable data. All three side-fired, unintrusive sensors can provide reliable and reasonably accurate volume and speed data if properly installed and calibrated. Adequate offset is needed for near-lane detection. Coverage of lanes adjacent and behind median barriers can be difficult. Whereas the underbridge installation of the 3M microloop sensors revealed a number of limitations, further testing of the Canoga detector cards with some existing in-ground loop systems yielded promising results. Specifically, the remote collection of volume data from a traffic cabinet of an actuated Type 170 controller at a signalized intersection was accomplished with Canoga loop boards, TransHub and TrafInfo digital pager installed in Hilo, Hawaii. The remote collection of near-real time freeway data from a station with a 332 cabinet and a Type 170 controller was accomplished with Canoga detector cards, CDMA modem and service integration including web-based data retrieval by TrafficWerks.