Analysis of Speed Zoning Effectiveness

by

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Prepared in cooperation with

Michigan Office of Highway Safety Planning
and
U.S. Department of Transportation
Federal Highway Administration
National Highway Traffic Safety Administration
and
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Michigan State University
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16. Abstract

This study was undertaken to determine if the procedure used to establish the speed limit in speed zones on the Michigan State Trunkline System results in a significant savings in accidents. An additional objective was to determine if specific speed distribution characteristics, enforcement levels, or environmental and geometric factors are related to the reduction in accidents within speed zones.

Twenty speed zones established in 1982 and 1983 were analyzed. There is no evidence that the current procedure of using the 85th percentile of observed speeds is inappropriate from a safety perspective. In fact, the aggregate reduction in accidents in these twenty zones (when compared to control sites) was statistically significant. On an individual zone basis, nine of the twenty zones showed a reduction in accidents, three showed an increase in accidents and the remaining eight zones either showed no change or the number of accidents was too small to conduct an analysis. Four of the nine zones in which accidents were reduced demonstrated a statistically significant reduction in accident frequency.

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Executive Summary

This study was undertaken to determine if the procedure used to establish the speed limit in speed zones on the Michigan State Trunkline System results in a significant savings in accidents. An additional objective was to determine if specific speed distribution characteristics, enforcement levels, or environmental and geometric factors are related to the reduction in accidents within speed zones.

Twenty speed zones established in 1982 and 1983 were analyzed. There is no evidence that the current procedure of using the 85th percentile of observed speeds is inappropriate from a safety perspective. In fact, the aggregate reduction in accidents in these twenty zones (when compared to control sites) was statistically significant. On an individual zone basis, seven of the twenty zones showed a reduction in accidents and the remaining thirteen zones either showed no change or the number of accidents was too small to conduct an analysis. Four of the nine zones in which accidents were reduced demonstrated a statistically significant reduction in accident frequency.

When the zones were stratified by action taken (speed raised versus speed lowered) or by location (urban versus transition), the number of sites in any category was too small for meaningful statistical analysis. Only in the category of transition speed zones where the speed limit was lowered was there more than one zone which displayed a statistically significant accident reduction. In this category 2 of 12 zones had this result.

Because there were such a small number of zones with a significant accident reduction it was not possible to distinguish speed characteristics or geometric and environmental factors associated with effective speed zones.

A limited study of the effects of enforcement on driver speeds was conducted on one urban zone and two rural zones. In the urban zone speeds were closer to the 85th percentile, variance was reduced, and skewness was similar to the value found in a normal flow of traffic with few speeding drivers. The rural zones speed parameters were not changed significantly by strict enforcement. The small sample size of three prevents any conclusions from being formulated. However the data indicates that in the one urban setting where the speed limit was increased and enforcement was implemented the desired result of drivers obeying speed limits with reduced speed variation in the traffic flow was achieved.

Conclusions

1. The current procedure used by the Michigan Department of Transportation and the Michigan State Police to establish speed limits in speed zones resulted in a significant reduction in accidents in the aggregate. There were, however, differences in the effectiveness when zones were analyzed individually.

2. Speed data collected using radar can not be compared to speed data collected by pneumatic road tubes. Thus, a meaningful comparison of "before" and "after" speed data was not possible in this study.

3. The use of selective enforcement in a newly created urban speed zone resulted in a lowered speed variance and a reduction in the number of drivers exceeding the speed limit. However, this effect was not found when selective enforcement was applied to two zones in the transition area between rural and urban land uses.

4. It was not possible to analyze specific categories of speed zones (i.e. speed raised versus speed lowered) because of the small sample size available to the researchers. This small sample size precluded any analysis of why certain zones experienced a decrease in accidents while other zones do not.

Recommendations

1. The sample used in this study should be increased to add confidence to the results of this analysis and to provide a sufficient sample to conduct analyses of different categories of speed zones. This can be done in two ways;

   a.) Adding 1984 speed zones to the data set now that 1986 accident data is available. The speed zones established in 1985 can be added when 1987 accident data is available.

   b.) Increase the time period for accident analysis in the before and after period for 1982 and 1983 zones. Utilizing accident data for the years 1979 (before) and 1986 (after) will increase the before and after period.

Recommendations

2. The Michigan Department of Transportation should undertake a study to determine why the speed data collected by radar is different from that collected by pneumatic road tubes. This may be important as the Department increases the use of the Sarasota VC 1900 in speed data collection, and may permit the Department to convert these data into a format that can be compared to speed data collected by radar.

3. A study should be undertaken to determine what factors in addition to the 85th percentile speed (if any) should be incorporated into the procedure used to establish speed limits in newly created zones.

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Introduction

The ultimate objective of speed zoning is to reduce accidents and/or the potential for accidents. Given this objective, one would assume that some measure of highway safety would be used as either a criteria for the implementation of a speed zone or for the speed limit established in the zone. Instead, these decisions are either legislative (i.e., school zone) or are based on an assumed relationship between safety and the 85th percentile of observed speeds.

The problem to be addressed in this study is the determination of the means by which the identification of those locations where speed zoning will be effective in reducing accidents can be accomplished. The approach is to explore the relationship between accident rate, speed distribution parameters, and roadside development.

Early in the data collection phases of this study changes were discussed and approved by the Michigan Department of Transportation (MDOT) and the Federal Highway Administration (FHWA). These changes are the result of the fact that there were only three sites suitable for analysis in the manner originally described in the proposal. This limited number of sites eliminated the possibility of testing varying levels of enforcement as originally proposed. Instead, a proposal on how an enforcement study would be done is included as part of the changes agreed to by MDOT and the FHWA. This new proposal is included as Appendix C.

Chapter 1--Literature Review

Discussion in the literature on the appropriateness of driver speeds on roadways dates to the early 1900's, when general speed limits were introduced on roads to limit what was considered reckless driving. More recently the practice of setting speed limits (speed zoning) on sections of roadway consistent with the adjacent roadway environment has become common practice. The literature review discussed here focuses on : (1) several recent syntheses of literature on speed zoning and (2) studies that have focused on enforcement and speed zoning.

Speed and Safety

The earliest literature synthesis found was done by D.E. Cleveland in 1970 and focuses on speed-safety relationships and speed response to control. This review was conducted as one chapter of a synthesis of safety related topics published by the U.S. Bureau of Public Roads titled Traffic Control and Roadway Elements--Their Relationship to Highway Safety. The overall focus of this synthesis was a discussion of data relating speed to accidents and the analysis of the effects of speed regulations in reducing accidents. The author concluded from studies in the United States "that the minimum accident involvement rate occurs for those travelling at the average speed rather than those at high or low speeds and that single vehicle non-collision accidents increase exponentially with speed. However, currently we do not know precise means for achieving positive improvements by reducing or providing more uniform speeds."

In comparing studies between the U.S. and Europe, however, the results were at odds. Dr. Cleveland concluded that the U.S. studies did not provide evidence "that speed control on urban or rural highways has the potential for reducing accidents significantly. " However, in Europe there are a number of documented studies showing that speed control can reduce both the accident rate and severity of accidents." Dr. Cleveland's overall conclusion was that "either the effect of speed control on safety cannot be defined or is too small to measure."

Speed Zoning

A more recent synthesis of literature published by the Federal Highway Administration as part of its' Synthesis of Safety Research Related to Traffic Control and Roadway Elements, Vol. 2(1982) presented an overall review of speed zoning and control. Of particular interest were sections on speed-safety relationships, speed zoning, and enforcement effect on speed. The author, D.L. Warren, concluded from the literature on accident severity and speed that " it is apparent that the severity of accidents in terms of damage, injuries, and deaths increases exponentially with travel speed when an accident occurs."

Included in this synthesis were results of studies relating accident frequency and measures of the speed distribution. A number of studies indicated or statistically validated a positive relationship between various speed parameters and accident frequency. Those cited were Solomon [1], Taylor [2], West and Dunn [3], Michaels and Schneider [4], AASHTO [5], and Hauer [6]. Warren concluded "the weight of evidence would lead to the conclusion that speed variance and accident frequency are directly related."

In establishing the speed limit within a speed zone where the intent is to identify a "safe and reasonable limit for a given road section or zone" the 85th percentile speed was the most widely accepted method of setting speed limits. Warren reports that studies conducted by Solomon [1], West and Dunn [3], and Joscelyn et al. [7] indicate that speed zones set at the 85th or 90th percentile speeds would be good indicators of safe speed.

Where the effects of enforcement were measured in relation to speeds, numerous studies were cited by Warren where the average speed was reduced as a result of enforcement. The variability in speeds was reported to be reduced in some studies with enforcement presence(Smith [8], Council [9], Hauer [10]) while others found no change or an increase (Shumate [11], Joscelyn,et al [12], Rowan and Keese [13]).

Studies involving enforcement reported a "carry-over" effect of speed suppression after removal of the enforcement symbol. However the duration of the effect and factors which alter it are not well understood. Selective traffic enforcement programs have been shown to not only reduce speed but have a tendency to reduce accident severity as well. Cited were reports from California [14], North Dakota [15], and Illinois [16].

The most recent synthesis of research on speed zoning was undertaken by the FHWA, Synthesis of Speed Zoning Practices (1985). Authored by M.R. Parker, the synthesis examined State and local speed laws, regulations and practices. Data was gathered from a literature review and a survey of State and local highway officials. The primary focus in the synthesis was the current practice of individuals and agencies with responsibility for setting policies on and implementing speed limits. The literature review identified theoretical and documented techniques which if applied would address one or more shortcomings in current speed zoning practices. The literature review also documented foreign experience with speed zoning and relevant factors to include in the process of determining speed limits. The main conclusion is that while there is some variability in the techniques used in setting of speed limits in the U.S., the 85th percentile speed is a universal factor employed by all agencies surveyed.

Speed Zoning and Enforcement

Considerable interest in recent years has focused on the relationship between enforcement and speed zoning. A number of studies have examined this relationship in order to determine the effects on speed suppression and the short or long-term behavioral change with repeated enforcement applications. In general, the evidence is that drivers tend to slow down in the presence of enforcement.

A number of early studies by Baker [17], Mckay [18], Smith [8], and Calica et al [19], reported a 5 to 10 percent decrease in average speeds in the presence of enforcement. Shumate [11] in his study of rural Wisconsin highways found no decrease in average speeds with increased enforcement. Hauer [10] found that the average traffic speeds were reduced close to the speed limit. Reinfurt et al [20], Dart and Hunter [21], and Joscelyn [12] report 10 to 15 percent reductions in the average speed depending on the type of enforcement used. Summala et al [22] reports that during a police strike in Finland mean speeds increased slightly during the strike and speed violations increased 50-100%. Before, during, and after the strike speeds were measured with radar. There was a significant difference in daily speeds during the strike weeks as oppposed to after the strike. In a significant study conducted by Armour [23], she reports " that the presence of a police vehicle on an urban road may reduce the number of vehicles exceeding the speed limit by approximately two-thirds" . It was also demonstrated in this study that " it was possible to produce a memory effect of police presence in an urban situation, and this effect could last at least two days after the police presence had been removed".

Of greater concern is the question of enforcement reducing the variability in speeds since speed variance has been linked to accident involvement. Council [9] in his 1970 study reported that the variance of the speed distribution was reduced by a stationary enforcement vehicle but not by a moving enforcement vehicle. Hauer [10] reported that the variability of speeds was reduced at two sites but not at a third while enforcement was in effect. The measure used for variability was the standard deviation of the speeds measured at those sites. It must be noted that this variability was achieved with repeated(5 weekdays) exposures to the enforcement symbol and driver visibility of the enforcement vehicle at 200-300 meters. He also noted in this study that in tracking habitually fast and habitually slow drivers they reduced their speeds the most. Early studies by Shumate [11] and Rowan and Keese [13] found no change in speed variability. A study by Joscelyn et al [12] performed in 1971 suggests that in the presence of enforcement the entire speed distribution shifts in the direction of lower speeds without altering its' shape.

The speed suppression effect of the enforcement vehicle has been shown to have a distance " halo " effect on driver speed choice approaching and leaving the vicinity of the enforcement vehicle. This distance depends on the frequency or strategy of patrol, the patrol method, and the traffic situation. Joscelyn et al [12] reported that with differing stationary vehicles the effects upon speeds within short distances varied by location, but the speed suppression effect diminishes equally at distances slightly beyond three miles. Irrespective of the enforcement vehicle the suppression effect on the mean speed was generally diminished beyond 7,000 feet. For the second measure, percentages of speed limit violators, the effect was diminished beyond 14,000 feet. Others including Calica et al [19], Council [9], Reinfurt et al [20] and Hunter and Dart [21] all performed similar studies to Joscelyn and were able to confirm a speed suppression " halo " effect ranging from two to four miles. Brackett and Edwards [24] report in their 1977 study an effect up to 4 miles upstream of the enforcement and 10 miles downstream. Hauer [10] speculates that the upstream halo effect is brought about by CB radios, light flashing, and by prior experience.

In addition to the distance speed suppression " halo" effect a " time" halo effect or memory effect of police presence on drivers has also been detected. Brackett [24] determined that at least six weeks of enforcement employment on a randomized basis is needed to have an effect on speed distribution parameters when the enforcement vehicle is not present. Armour [23] demonstated that this memory effect could also be brought about and that the effect would last at least two days after removal of police presence.

Summary

The literature clearly demonstrates that there is a positive relationship between vehicle speed and accident severity. Therefore, safety benefits can be gained through speed zoning if the variance of the speed distribution can be decreased. While the preponderence of the literature indicates that the accident frequency (as opposed to the accident severity) can be reduced by reducing the speed variance, evidence is lacking that speed zoning accomplishes this desired result.

Speed zoning practice varies throughout the United States and the rest of the World. However, one common factor used throughout the United States is the 85th percentile speed. Various adjustments are made to this speed by agencies responsible for establishing limits within speed zones.

The role of enforcement is seen to have a localized but limited impact upon overall speed reduction, speed variability, distance of speed suppression, and speeding behavioral change over time. Enforcement deployment strategies discussed by Joscelyn [12] and Brackett [24] highlight various approaches to achieving the changes in speed parameters associated with uniform speeds and leading to a safer driving environment.

Chapter 2--Speed Zoning Effect on Accident Experience

Objective

The focus of this research effort was to identify locations where speed zoning resulted in a reduction in accident frequency, and to determine if there are identifiable variables that are associated with the zones where the reduction occurred.

Data collection and analysis in three primary areas formed the database for information used to identify relevant variables. These areas are Accidents, Speed Parameters, and Environmental/Geometric factors. A detailed description of the data collection and analysis procedures follow. The original proposal included enforcement as a fourth data set to be analyzed. However, it was not possible to relate enforcement data to specific highway locations.

Site Selection

The speed zones installed on the Michigan State Trunkline System 1981-1986 inclusive formed the population of speed zones available for accident analysis.

Each zone was reviewed in detail relative to the following procedure :

(a) Identify sections of trunkline roadway where there had been a speed study to determine if a speed limits change was warranted and an adjacent section where the speed limit was to remain unchanged.

Designate those sections with a proposed change in limits as "test" or "experimental" and those unchanged as "control".

(b) Include only those sections with a minimum length of 0.2 mile for both "test" and "control" sections.

A total of 49 zones were identified in this procedure. Twenty zones met the criteria specified in the procedure described above. Four zones were eliminated because they were less than the minimum length (0.2 miles); thirteen were eliminated because there was no change in the speed limit; three were eliminated because a suitable "control" section was not available; and the nine zones from 1984-1986 were eliminated because the 1986 accident data file was not available. Twenty zones were selected for analysis, ten from 1982 and ten from 1983.

Methodology

Using department accident files a listing of accidents by type, severity, and hazardous action for a "before" and "after" period of at least two years for the locations identified within the zones as "test" or "control"was compiled. The accident listing includes those accidents occurring within 50 feet of the intersection and all mainline accidents on the roadway. Zones were identified as transition, urban, or rural based on their surrounding land use identified in the departments photo-log files. No zones were identified as rural and therefore this category was dropped from consideration.

The study design is a before and after with comparison group. The control sites form the comparison group. Accident frequencies were computed on a "before" and "after" basis for each test and control section. The accident data in the control section was multiplied by the ratio of the length of the control section to that of the test sections for those locations where the lengths were not equal. Two data files were created for each section of roadway. The first data file contained all accidents, and the second data file contained only speed-related accidents. Speed-related accidents were identified from the hazardous action codes in the accident report.

Data Analysis--Accidents

A series of Chi-Square analyses were conducted to determine if there were statistically significant changes in accident frequency for the total group of zones and then by various groups of zones such as speeds lowered and speeds raised. The computed Chi-Square values were compared to the critical Chi-Square table values.

Tables 2.1 and 2.2 show the number of accidents in the test and control sections for the 10 zones installed in 1982 and the 10 zones installed in 1983 respectively. For those zones installed in 1982, the average number of accidents per year was decreased by 20 in the three years following the implementation of the speed zones. In the same time period, the average number of accidents in the control sections increased by 47 accidents per year.

For the zones installed in 1983, the net result was similar, but the phenomenon was different. For those zones, there was virtually no significant change in the accident frequency in the sections of highway where speed zoning was applied, while the adjacent sections of highway showed an increase of 59 accidents per year, from 120 to 179.

Table 2.1

Accident Data for the Speed Zones Studied-1982 Zones

Test Sites

1982 Zones TCO Number	Before Accidents(2 Yrs.)		After Accidents(3 Yrs.)	
	Total	Avg./Yr.	Total	Avg./Yr.
79-10-82	4	2.0	13	4.3
73-12-82(a)	15	7.5	26	8.7
73-12-82(b)	25	12.5	33	11.0
68-02-82	1	0.5	2	0.7
53-19-82	43	21.5	52	17.3
46-11-82	43	21.5	49	16.3
46-09-82	20	10.0	14	4.7
41-14-82	186	93.0	277	92.3
25-01-82	56	28.0	65	21.7
24-07-82	1	0.5	1	0.3

Control Sites

1982 Zones TCO Number	Before Accidents(2 Yrs.)		After Accidents(3 Yrs.)	
	Total	Avg./Yr.	Total	Avg./Yr.
79-10-82	2	1.0	12	4.0
73-12-82(a)	29	14.5	40	13.3
73-12-82(b)	14	7.0	22	7.3
68-02-82	13	6.5	24	8.0
53-19-82	21	10.5	40	13.3
46-11-82	12	6.0	15	5.0
46-09-82	15	7.5	26	8.7
41-14-82	239	119.5	485	161.7
25-01-82	12	6.0	14	4.7
24-07-82	2	1.0	2	0.7

Table 2.2

Accident Data for the Speed Zones Studied-1983 Zones

Test Sites

1983 Zones TCO Number	Before Accidents(3 Yrs.)		After Accidents(2 Yrs.)	
	Total	Avg./Yr.	Total	Avg./Yr.
81-24-83	74	24.7	47	23.5
73-10-83	55	18.3	58	29.0
43-14-83	0	0.0	1	0.5
39-12-83	360	120.0	213	106.5
32-02-83	9	3.0	12	6.0
29-16-83	0	0.0	3	1.5
28-08-83	48	16.0	41	20.5
15-03-83	10	3.3	7	3.5
14-17-83	13	4.3	4	2.0
02-15-83	5	1.7	3	1.5

Control Sites

1983 Zones TCO Number	Before Accidents(3 Yrs.)		After Accidents(2 Yrs.)	
	Total	Avg./Yr.	Total	Avg./Yr.
81-24-83	150	50.0	150	75.0
73-10-83	4	1.3	3	1.5
43-14-83	5	1.7	5	2.5
39-12-83	182	60.7	172	86.0
32-02-83	9	3.0	20	10.0
29-16-83	0	0.0	2	1.0
28-08-83	0	0.0	0	0.0
15-03-83	0	0.0	0	0.0
14-17-83	3	1.0	3	1.5
02-15-83	7	2.3	3	1.5

Based on a Chi-Square Analysis, it could be concluded that the speed zones installed in each year resulted in a statistically significant reduction in the accident frequency. Thus, the speed zoning policy currently in use did result in an overall decrease in accidents in each of the years tested. The results are shown in Table 2.3.

When looking at only those zones where the speed limit was lowered, the same results were found. That is, the accident reduction was statistically significant for each of these two years. The same result was found for a category including only urban zones. For the category including only zones where the speed limit was raised, there was an accident reduction each year, but only the reduction in the 1983 zones was statistically significant. (See Table 2.3)

A similar analysis using only speed related accidents was less conclusive. In this case, the accident reduction for all zones was still statistically significant for each year, as was the accident reduction in those zones where the speed limit was lowered. However, the categories of speed raised and urban both showed a statistically significant reduction in 1983, but not in 1982, and the transition zones did not show a statistically significant reduction in either year. (See Table 2.4).

Caution must be exercised in interpreting these results, as the aggregate effect is dominated by a few zones. When analyzed independently, 2 of 10 zones in each year demonstrated a statistically significant reduction in accidents, while the remaining 16 zones had a non-significant change in accidents compared to their respective control sections. (See Table 2.5)

When the two urban zones which dominated the accident data file (41-14-82 and 39-12-83) were removed, the aggregate accident reduction in the remaining 18 zones was still statistically significant. Thus, it can be concluded that the net effect of the policy currently used by the Michigan Department of Transportation and Michigan State Police is a reduction in accidents where speed zones are implemented.

Table 2.3

Effect of Speed Zoning on Total Accidents

1982 Zones

Group	Chi-Square	Significance Level	Chi-Square(critical)	Significance Level
Total	13.25	.99	2.706	.90
Speed Lowered	15.11	.99	2.706	.90
Speed Raised	.01	.08	2.706	.90
Urban	5.55	.98	2.706	.90
Transition	4.89	.97	2.706	.90

1983 Zones

Group	Chi-Square	Significance Level	Chi-Square(critical)	Significance Level
Total	14.92	.99	2.706	.90
Speed Lowered	7.06	.99	2.706	.90
Speed Raised	3.76	.95	2.706	.90
Urban	11.74	.99	2.706	.90
Transition	2.69	.90	2.706	.90

The numbers in Table 2.3 are the Chi-Square values obtained for the 20 zones used in this study.

Table 2.4

Effect of Speed Zoning on Speed-Related Accidents

1982 Zones

Group	Chi-Square	Significance Level	Chi-Square(critical)	Significance Level
Total	3.70	.95	2.706	.90
Speed Lowered	4.27	.96	2.706	.90
Speed Raised	.018	.107	2.706	.90
Urban	1.34	.75	2.706	.90
Transition	.089	.234	2.706	.90

1983 Zones

Group	Chi-Square	Significance Level	Chi-Square(critical)	Significance Level
Total	10.42	.99	2.706	.90
Speed Lowered	4.95	.97	2.706	.90
Speed Raised	4.37	.96	2.706	.90
Urban	8.34	.99	2.706	.90
Transition	2.61	.89	2.706	.90

The numbers in Table 2.4 are the Chi-Square values obtained for the 20 zones used in this study.

Table 2.5

Individual Zone Accident Reduction Analysis
All Accident Types

1982 Zones TCO Number	1982 Zones Signif. Level	A.R.F.	1983 Zones TCO Number	1983 Zones Signif. Level	A.R.F.
$46\text{-}09\text{-}82_{(L,T)}$	.95	60	$39\text{-}12\text{-}83_{(L,U)}$	.99	37
$41\text{-}14\text{-}82_{(L,U)}$	.98	27	$81\text{-}24\text{-}83_{(R,T)}$	.96	36
$53\text{-}19\text{-}82_{(L,T)}$	.82	37	$14\text{-}17\text{-}83_{(L,T)}$	ISS	0
$79\text{-}10\text{-}82_{(L,T)}$	ISS	0	$43\text{-}14\text{-}83_{(R,T)}$	ISS	0
$73\text{-}12\text{-}82(a)_{(R,U)}$	.43	0	$32\text{-}02\text{-}83_{(R,T)}$	.61	40
$73\text{-}12\text{-}82(b)_{(R,U)}$	.31	0	$73\text{-}10\text{-}83_{(L,T)}$	ISS	0
$68\text{-}02\text{-}82_{(L,T)}$	ISS	0	$02\text{-}15\text{-}83_{(L,T)}$	ISS	0
$46\text{-}11\text{-}82_{(L,T)}$	.17	9	$29\text{-}16\text{-}83_{(L,T)}$	ISS	0
$25\text{-}01\text{-}82_{(L,T)}$	.01	0	$28\text{-}08\text{-}83_{(L,T)}$	ISS	0
$24\text{-}07\text{-}82_{(R,T)}$	ISS	0	$15\text{-}03\text{-}83_{(L,T)}$	ISS	0

Note: (L,T) means "Lowered Transition" and (L,U) means "Lowered Urban". (R,T) means "Raised Transition", (R,U) means "Raised Urban". " ISS " means insufficient sample size.

$$\text{* Accident Reduction Factor (ARF)} = \frac{(\text{Expected}_{after} - \text{Observed}_{after})}{\text{Expected}_{after}} \text{ X100}$$

Data Analysis--Accident Type and Severity

Accident severity by type of accident was analyzed for the 20 zones in this study on a before and after basis. Tables 2.6 and 2.7 show the number of property-damage, injury, and fatal accidents by type.

Table 2.6

1982 Zones and 1983 Zones Test Section Accident Severity Data in the Before Period.

Accident Type	Total	PDO	Injury	Fatality
Rear End	310	237	73	0
Angle	126	74	52	0
Park-Drive	141	103	38	0
Lt. Turn	141	98	42	1
Rt. Turn	42	36	6	0
Park Veh	39	33	6	0
Head-On	23	12	11	0
Fixed Obj.	61	49	11	1
Sideswipe	25	23	2	0
Veh.-Over	8	4	4	0
Back Into	13	13	0	0
Pedestrian	8	0	8	0
Ped-Cycle	9	1	8	2
Other	24	21	3	0
Total	970	704	264	2

Table 2.7

1982 Zones and 1983 Zones Test Section Accident Severity Data in the After Period.

Accident Type	Total	PDO	Injury	Fatality
Rear End	294	210	84	0
Angle	103	63	40	0
Park-Drive	156	118	38	0
Lt. Turn	163	105	57	1
Rt. Turn	32	26	6	0
Park Veh	32	30	2	0
Head-On	21	13	8	0
Fixed Obj.	55	38	17	0
Sideswipe	4	3	1	0
Veh.-Over	15	9	6	0
Back Into	14	14	0	0
Pedestrian	8	0	8	0
Ped-Cycle	8	0	8	0
Other	24	23	1	0
Total	929	652	276	1

In the before period 27 % were injury or fatal accidents, a slight increase to 29.8 % was registered in the after period. For property-damage only accidents the before period was 73 %, with the after period being 70.3 %. Overall there was a 4.2 % reduction in total PDO and Injury and Fatality accidents from the before to after periods.

Data Collection--Speed

Speed data were collected on a before and after basis in those sections of roadway identified as test or control. The before data was obtained from the departments speed data files for speed zones implemented in the years of interest. This speed data was collected using radar based on the departments procedures for collecting speed data. The after data was collected in the summer and fall of 1986 using automated speed data collection equipment in the form of pneumatic road tubes and Sarasota speed and classification equipment.

Data Analysis--Speed

The resulting data printouts from the department's files and Sarasota's were used to attempt a comparison of speed data. The speed data from approximately the same hour it was collected in the before period was used as the sample of after data. Speed parameters reviewed were : 85th Percentile, Mean, Variance, and Skew.

It appears that the differences in the data collection procedure between the before period and the after period produced data which could not be compared. The before data was collected by radar, and the after data by pneumatic road tubes. As shown in Table 2.8 the variance obtained by the use of road tubes is consistently much greater than that obtained using radar. Since there is no reason to to believe the implementation of a speed zone would cause the speed variance to increase this dramatically, it was concluded that any before-after data analysis would not be a valid test of the effect of speed zoning, but would only reflect a difference in data collection techniques.

This result may be due to the fact that a radar operator excludes vehicles slowing to turn into driveways or accelerating as a result of just entering the traffic stream, while the road tubes are not capable of discriminating in this way. The differences may also be attributable to the choice of what constitutes "free flow" vehicles. With radar this is a subjective decision, while with the road tubes a pre-selected value is used to make this definition. In these data, a headway of 4 seconds was used as the definition of "free flow".

Table 2.8

Mean and Variance "Before" and "After"

TCO Number	Before		After	
	Mean Speed	Variance	Mean Speed	Variance
79-10-82	43	32	49	42
73-12-82(a)	34	21	38	37
73-12-82(b)	32	40	39	65
68-02-82	48	38	46	85
53-19-82	45	29	45	92
46-11-82	42	46	40	45
46-09-82	30	26	35	84
41-14-82	46	22	48	57
25-01-82	49	32	45	95
24-07-82	43	20	39	55
81-24-83	41	23	43	42
73-10-83	37	30	53	115
43-14-83	36	26	36	48
39-12-83	31	11	28	35
32-02-83	31	13	34	27
29-16-83	47	26	45	66
28-08-83	44	25	45	62
15-03-83	41	27	41	62
14-17-83	30	18	35	42
02-15-83	41	20	50	97

Data Collection--Environmental and Geometric

The departments photo-log file was accessed to numerically code the roadside and geometric features in each test and control section. Each direction in the test or control section was coded. The following provides a list of the major geometric and roadside features coded :

Table 2.9
Geometric; Operational; and Roadside Environmental Conditions

Geometric Features	Operational Control	Environmental Conditions
Laneage	Signal Control	Roadside Development
Lane Width	No. of Signals	Land Use
Shoulder Width	Passing Zone	No. of Driveways by Type
Shoulder Type	Posted Speed Limit	Type of Fixed Objects
Horizontal Curve	Turning Lane	No. of Fixed Objects by Type
Vertical Curve	Fixed Object Distance from Pavement	
	Pavement Surface	
	Number of Intersections	

Data Analysis--Environmental and Geometric

The features of both test and control sections were coded and analyzed. Roadside Development and Land Use were used to stratify the data set into major land use types such as : business, residential, agricultural, industrial and other. Geometric Features and Operational Control variables were identified within the test and control sections by milepoints. The density per mile of fixed objects and driveways were calculated. Accident Reduction Factors for each test section were used as the dependent variable and density of fixed objects and driveways as independent variables in simple regression. Tables indicating the results of selected analyses are contained in Appendix B.

Conclusion

Following the collection and reduction of the accident, speed and roadside environment data it was clear that it would not be possible to establish meaningful relationships among these variables. The reasons for this conclusion are :

1.) The total sample size is relatively small, and consists of several locations that are dissimilar and thus need to be separated for analysis. Homogeneous groups would include :

a) Transition zones where the speed limit was lowered (12)
b) Transition zones where the speed limit was raised (4)
c) Urban zones where the speed limit was lowered (2)
d) Urban zones where the speed limit was raised (2)

Thus, only the group " Transition zones where the speed limit was lowered" has a sufficient number of data points to conduct an analysis.

2.) The current procedure used by the Michigan Department of Transportation and the Michigan State Police to establish speed limits in speed zones resulted in a significant reduction in accidents in the aggregate. There were, however, differences in the effectiveness when zones were analyzed individually.

3.) Only 4 of the 20 zones showed a statistically significant (.90 or higher) accident reduction, and thus could be used to determine factors related to accident reduction. Two of these zones were in the "lowered urban" group; one in the "lowered transition" group; and one in the "raised transition" group. These sample sizes are not suitable for analysis as a category, as the data may reflect individual site characteristics rather than those of a generic group of sites. (Table 2.5)

4.) The accident totals are dominated by two zones (SP 41-14-82 and SP 39-12-83). These zones located in Grand Rapids and Kalamazoo respectively, account for 546 of the total 970 accidents contained in all 20 zones in the before period. In six of the twenty zones, the "before" accident experience was less than 5 accidents. Using the Chi-Square analysis charts in NCHRP 162, even a reduction to one accident would not lead to the conclusion that the accident reduction is significant. Thus, they can not be meaningfully analyzed. (Table 2.2)

5.) There appears to be a significant bias in the speed data between the "before" and "after" period as a result of the data collection techniques. The before data was collected by radar, and the after data was collected by road tubes and a Sarasota VC 1900 machine. The variance in the before period ranged from 11 to 46, and in the after period it ranged from 35 to 115. It was concluded that this difference is too large to be explained by a change in the speed distribution, and is the result of the data collection procedures. (Table 2.8)

Conclusion

This difference in range for the variance in the two data collection periods is related directly to specific speed data collection procedures. Radar speed data collection includes free-flow vehicles with no defined headway as opposed to Sarasota data collection with free-flow vehicles with defined (4 sec.) headways. Radar speed data collection involves data collected and summarized together for both directions. Sarasota speed data is collected simultaneously in both directions (bi-directional). Radar speed data collection is for a maximum of 200 "shots" (vehicles) or 2 hours, as opposed to Sarasota allowing up to 900 vehicles/hour to be tabulated for speed in both directions.

Chapter 3--Enforcement Effect on Speed Zoning

Objectives

As part of the overall evaluation of the effectiveness of speed zoning one of the factors often cited as increasing driver awareness that speed limits are in effect and are being monitored is enforcement. The intent of this study was to measure drivers responses to newly implemented speed zones with stricter enforcement levels present. Measures of effectiveness include changes in speed measures such as the 85th percentile speed, variance, and skewness.

Site Selection

The sites available for study were speed zones under review for implementation by the department in 1986. These sites were screened using the same criteria as the 1982 and 1983 zones in this study. During 1986 only four zones were implemented for speed limit changes on the State Trunkline System. Due to length considerations one zone was not included for stricter enforcement. The remaining three zones are listed in Table 3.1 below. Only one of the three locations involved a decrease in the speed limit, while two sites involved an increase.

Table 3.1

Selected 1986 Speed Zones

TCO NUMBER	ROUTE	COUNTY	ZONE TYPE	SPD. BEFORE	SPD. AFTER
33-32-86	M-36	INGHAM	TRANSITION	50	45
41-30-86	BS-196	KENT	URBAN	25	35
79-33-86	M-81	TUSCOLA	TRANSITION	45	50

Methodology

Working with the enforcement agencies, a program of selective enforcement was implemented within these three zones. Enforcement levels were of two types : Strict or Normal. Normal enforcement consisted of whatever routine patrols took place in the zones of interest prior to initiation of this study. Strict enforcement consisted of patrolling the zones during morning and evening peak hours for a minimum of two hours for each of two days. Following implementation of new speed limits, speed measurements were taken before, during, and after strict levels of enforcement. Citations and verbal warnings were administered to motorists who exceeded the new speed limits.

Data Collection

Speed data was collected using the departments automated speed data collection equipment and pneumatic road tubes. Unfortunately inclement weather and snow removal equipment eliminated some periods of data collection which could not be recouped. Co-ordination between the departments' volume and traffic data collection crews and local enforcement officials was undertaken to coincide with enforcement and equipment availability.

The timeframes for data collection before the speed limit change, during, and after strict enforcement are presented in Table 3.2 below.

Table 3.2

Time Lag between Zone Implementation and Enforcement Strategies

		FROM EFFECTIVE DATE		
TCO NUMBER	EFFECTIVE DATE	BEFORE	DURING	AFTER
33-32-86	Sept. 2, 1986	3 wks.	12 wks.	14 wks.
41-30-86	Sept. 2, 1986	3 wks.	8 wks.	14wks.
79-33-86	Oct. 14, 1986	3 wks.	5 wks.	8 wks.

Data Analysis

The first speed parameter analyzed is the 85th percentile speed. In both cases the transition zones which were in rural locations maintained a higher 85th percentile speed than the new speed limit throughout the enforcement periods. Only in the urban location(41-30-86) was the 85th percentile speed at or below the new speed limit during the periods of strict enforcement. The results are presented in Table 3.3 below.

Table 3.3

Comparison of 85th Percentile Speed with Normal and Strict Enforcement

TCO NUMBER	BEFORE SPEED LIMIT	AFTER SPEED LIMIT	85TH PERCENTILE(MPH) BEFORE SPEED LIMIT CHANGE	DURING STRICT ENFORCE.	AFTER STRICT ENFORCE.
41-30-86					
PM 1500-1700	25	35	32	32	37
AM-700	25	35	34	34	38
PM-1500	25	35	32	32	----
33-32-86					
PM-1600	50	45	64	68	56
79-33-86					
PM-1600	45	50	60	55	58
AM 800	45	50	58	----	58

Data for the variance follows a pattern similar to the 85th percentile. The urban zone (41-30-86) has a higher variance in the before period compared to the during and after periods. Significantly, the variance is lowest during the period of strict enforcement in this zone. Results are shown in Table 3.4 below.

Table 3.4

Comparison of Variance with Normal and Strict Enforcement

	VARIANCE		
TCO NUMBER	BEFORE	DURING	AFTER
41-30-86			
PM 1500-1700	47	27	37
AM 700	54	30	32
PM 1500	50	31	-----
33-32-86			
PM 1600	209	204	562
79-33-86			
PM 1600	77	57	77
AM 800	134	-----	62

The skewness data indicates that the urban zone (41-30-86) speeds were affected by enforcement to create a more normal speed distribution. The speed of traffic became more uniform as enforcement was applied and remained so after its' removal.

The data for the skewness index follows in Table 3.5 below.

Table 3.5

Comparison of Skewness with Normal and Strict Enforcement

	SKEWNESS INDEX		
TCO Number	BEFORE	DURING	AFTER
41-30-86			
PM 1500-1700	.73	.82	.87
AM 700	.75	.90	.96
PM 1500	.75	.83	.96
33-32-86			
PM 1600	.79	.56	1.27
79-33-86			
PM 1600	1.11	.89	.96
AM 800	.88	-----	.87

Note : A Skewness index of 1.0 represents a normal distribution with no skew. (Statistics with Applications to Highway Traffic Analyses, Second Edition, Pg. 59.)

Summary

Reviewing all three speed measures the most consistent effect of enforcement was found to occur in the urban zone. Speeds were closer to the 85th percentile, variance was reduced, and skewness consistently improved to those of speeds found in a normal flow of traffic with few speeding drivers. The rural zones speed parameters were not changed significantly by strict enforcement.

The small sample size prevents strong conclusions being formulated. However the data indicates that in the one urban setting where the speed limit was increased and enforcement was implemented the desired result of drivers obeying speed limits with reduced speed variation in the traffic flow was achieved.

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Appendix A

1982 and 1983 Speed Zones Accident Analysis

Table A.1
Speed Zone Listing and Speed Change

1982 ZONES

TCO NUMBER	ROUTE	COUNTY	ZONE TYPE	SPD. BEFORE	SPD. AFTER
79-10-82	M-81	TUSCOLA	TRANSITION	55	45
68-02-82	M-33	OSCODA	TRANSITION	55	35
53-19-82	U.S. 31	MASON	TRANSITION	55	45
46-11-82	U.S. 223	LENAWEE	TRANSITION	55	45
46-09-82	U.S. 223	LENAWEE	TRANSITION	45	35
41-14-82	M-11	KENT	URBAN	50	45
25-01-82	M-54	GENESEE	TRANSITION	55	45
73-12-82A	M-46	SAGINAW	URBAN	30	35
73-12-82B	M-46	SAGINAW	URBAN	35	40
24-07-82	M-119	EMMETT	TRANSITION	40	50

1983 ZONES

TCO NUMBER	ROUTE	COUNTY	ZONE TYPE	SPD. BEFORE	SPD. AFTER
73-10-83	M-54	LAKE	TRANSITION	55	45
39-12-83	U.S. 131	KALAMAZOO	URBAN	35	30
29-16-83	U.S. 27	GRATIOT	TRANSITION	55	45
28-08-83	U.S. 31	GD. TRAVERSE	TRANSITION	55	45
15-03-83	M-75	CHARLEVOIX	TRANSITION	55	45
14-17-83	M-60	CASS	TRANSITION	55	45
02-15-83	M-28	ALGER	TRANSITION	55	50
81-24-83	U.S. 23	WASHTENAW	TRANSITION	35	40
43-14-83	M-37	LAKE	TRANSITION	30	40
32-02-83	M-53	HURON	TRANSITION	30	40

Appendix B

Roadside Environment and Fixed Objects

Table B.1

FIXED OBJECTS--DENSITY PER MILE

Speed Zone	Statistical Significance	Mean Business Egresses/Mi.		Mean Residential Egresses/Mi.	
		T	C	T	C
41-14-82	Yes	9	2	1	1
46-09-82	Yes	22	0	13	47
39-12-83	Yes	2	5	0	0
81-24-83	Yes	2	5	4	30
79-10-82	No	12	4	15	1
73-12-82(a)	No	10	3	10	11
68-02-82	No	6	32	0	32
73-10-83	No	6	0	15	8
32-02-83	No	0	9	21	18

FIXED OBJECTS--DENSITY PER MILE

Speed Zone	Statistical Significance	Mean Business Utility Poles 0-8'/Mi.		Mean Residential Utility Poles 0-8'/Mi.	
		T	C	T	C
41-14-82	Yes	2	1	0	0
46-09-82	Yes	10	0	10	47
39-12-83	Yes	4	8	0	0
81-24-83	Yes	2	12	2	14
79-10-82	No	3	1	0	1
73-12-82(a)	No	7	3	10	8
68-02-82	No	0	4	0	20
73-10-83	No	2	0	0	0
32-02-83	No	0	0	7	0

Table B.2

FIXED OBJECTS--DENSITY PER MILE

Speed Zone	Statistical Significance	Mean Business Traffic Signs 0-8'/Mi.		Mean Residential Traffic Signs 0-8'/Mi.	
		T	C	T	C
41-14-82	Yes	1	0	0	0
46-09-82	Yes	10	0	6	37
39-12-83	Yes	4	5	0	0
81-24-83	Yes	1	7	2	12
79-10-82	No	--	--	--	--
73-12-82(a)	No	3	2	3	3
68-02-82	No	0	4	0	0
73-10-83	No	2	0	0	0
32-02-83	No	0	6	0	3

FIXED OBJECTS--DENSITY PER MILE

Speed Zone	Statistical Significance	Mean Business Trees/Shrubs 0-8'/Mi.		Mean Residential Trees/Shrubs 0-8'/Mi.	
		T	C	T	C
41-14-82	Yes	0	0	1	0
46-09-82	Yes	0	0	6	34
39-12-83	Yes	--	--	--	--
81-24-83	Yes	0	4	0	12
79-10-82	No	--	--	--	--
73-12-82(a)	No	3	0	7	2
68-02-82	No	--	--	--	--
73-10-83	No	--	--	--	--
32-02-83	No	--	--	--	--

Appendix C

Proposal on Speed Zoning Effectiveness with (a) Enforcement Compliance Strategies and (b) Traffic Conflicts as a Surrogate Measure for Accident Potential in Speed Zones.

Research Project Title : Speed Zoning Effectiveness

Specific Problem Area : Speed Zone Enforcement Compliance Strategies

Part A

Research Problem Statements

Experience over the years indicates that speed limits, based on the 85th percentile speed, often require a significant amount of enforcement to control the errant driver. Many police agencies see enforcement as their primary tool to encourage safe driving and to increase compliance with posted speed limits, yet there is little documentation on the impact of various levels of enforcement on the average and 85th percentile speeds. This raises questions as to what level of enforcement, via ticketing and visual presence by police, should be expended at a time when the number of police officers is not increasing at the same pace as the driver population? What is the trade-off between benefits and costs to maintain or control motorists' speed?

New, less labor-intensive speed zoning enforcement compliance strategies need to be considered which can be used to effectively maintain or control the number of errant motorists in a cost-effective manner. Speed zone criteria need to be developed to enable the engineer to set realistic speed limits. Speed zoning should not be used to create speed traps, but to encourage motorists to behave in a reasonable manner, minimizing the operating speed difference between drivers in the same traffic flow and minimizing the accident experience.

Objectives

The objectives of the proposed research are to :

1.) Identify driver performance measures such as the speed distribution, the average speed, and the 85th percentile speed along roadways as a function of the purpose of the speed zone, the adjacent land use, and the prevailing speed distribution (mean, variance, pace, 85th percentile speed) prior to implementation of the speed zone.

2.) Quantify the relationship between driver performance and speed enforcement and recommend criteria to use in setting speed limits. This information will be used to avoid speed limits that are considered "speed traps" by the motorist and are often difficult to enforce.

Work Statement

Task 1

Develop a list of sites to be used in the analysis of speed zoning enforcement. This initial list should include at least two sites in each cell of a four dimensional matrix. The axes of this matrix (a,b,c,d) and the entries along each axis are :

a) Land Use

1. rural-restricted geometry

2. rural-specific activity center

3. suburban-frequent access points or within a village

4. transition-speed reduction to an urban or suburban area

5. urban-high design standards through commercial zones

b) Accident experience

1. high accident rate

2. low accident rate

c) Speed differential between zone and adjacent roadway.

1. $\leq$ 10 mph

2. > 10 mph

d) Relationship to 85th percentile speed before zoning.

1. limit set at (or above) 85th percentile speed

2. limit set below 85th percentile speed

These zones would be selected by reviewing existing records for zones established as a result of the joint action of the Michigan Department of Transportation (M-DOT) and the Michigan State Police (MSP) in the years 1980-84 (to provide at least two years of "after" accident data). These records would include the ordinance establishing the zone, the "before" speed distribution and the accident file. The land use category would likely require a site visit.

A total of 80 sites would be identified at this stage (5x2x2x2 cells with two entries in each cell). The duplicate cell entry would be used if construction has changed the site or if the local jurisdiction will not participate in the enforcement phase of the project.

Task Products : A listing of sites to be used in this study, including a computer file of accident data, speed data, adjacent land use, and number and type of driveways in each zone.

Task 2

Determine the type of control and level of enforcement at the selected sites (if possible). Our experience in the current research project indicates that enforcement data is probably not available. However, the density of signing will be determined, and discussions with the enforcement agencies will be held to determine if any special enforcement was used in these zones.

Task Product : A report on measures used to define level of enforcement and a historical perspective of enforcement at each of the study sites.

Task 3

Obtain speed data at each site. These data will be used to establish the speed distribution parameters for the base condition at each site.

Task Product : A computer tape and table summary of speed distribution parameters for each of the study sites.

Task 4

Collect traffic conflict data for the sub-set of sites to be used in Part B of this study.

Task Product : A listing of conflict data (by type) for each of the study sites.

Task 5

Analyze the data to identify those sites where the 85th percentile speed is significantly higher than the speed limit. These sites are candidates for an increase in the level of enforcement.

Task Product: The study sites will be divided into two lists. List one will contain those study sites where the 85th percentile speed is consistent with (or below) the zoned speed limit. The second list will be the task product, the list of sites for further study.

Task 6

For those sites identified in Task 5, sequentially change the type of control and/or level of enforcement, obtain new speed data, collect conflict data and analyze the data to determine changes in the speed distribution.

The sequence of control changes would be :

a) Increase the signing by increasing the density of speed limit signs or adding additional signs (such as "Speed Limit Enforced by Radar").

b) Park an unoccupied police vehicle in the speed zone.

c) Initiate selective speed enforcement in the zone.

Several weeks must be allowed between successive changes to obtain data unbiased by the previous treatment.

Task Products : The task products will be the same as for tasks 3,4, and 5 for each of the levels of enforcement tested in this study.

Task 7

Analyze the site data to determine any differences in the characteristics for those sites identified needing additional enforcement and those sites where additional enforcement was not necessary. These differences will be used to identify factors that can be used as criteria for establishing speed limits.

Task Product : A report describing those factors which are common to speed zones where the resulting 85th percentile speed is consistent with the speed limits.

Task 8

Prepare a report of the results of the study.

Expected Research Product

Part A of this research study will produce a written report that will detail the work performed and recommend new supplemental criteria for use in setting more driver acceptable speed limits requiring minimal enforcement.

Research Project Title : Speed Zoning Effectiveness

Specific Problem Area : Traffic Conflicts as a Surrogate Measure for Accident Potential in Speed Zones

Part B

Research Problem Statement

As land use adjacent to a roadway is developed, the number of intersections and driveways increase, resulting in an increase in the number of vehicular and pedestrian conflicts. As the opportunity for conflicts increase, so does the opportunity for accidents.

Since accidents are rare events, but traffic conflicts occur frequently, if the relationship between conflict patterns and accident patterns were known, and if the relationship between speed characteristics and conflict patterns were also known, it would be possible to predict the accident pattern that would result from any given speed pattern. Such information would be a valuable aid in selecting the appropriate speed limit for a speed zone.

Objective

The objectives are to :

1. Find the relationship between accident patterns and conflict patterns and conflict patterns and the speed distribution. Both of these relationships may be dependent upon roadway geometry, operation, and the roadside environment.

2. Develop a procedure to conduct traffic conflict analysis at a speed zone that will lead to an estimate of the accident potential for different alternative speed limits.

Work Tasks

Task 1

Develop a list of sites to be used in this study. The list from part A of this proposal can be used to identify the sites. One additional criteria will be that the sites are sufficiently close to Lansing to facilitate efficient collection of conflict data. Approximately 10 sites will be selected with as wide a range of accident rates as possible from the database developed in part A.

Task Product : A listing of 10 proposed study sites, with accident data, speed data and land use identified.

Task 2

Obtain conflict data at one or more mid-block locations in each of the selected sites. Observers will be trained to collect reliable conflict data, and these observers will be used to obtain conflict data within each of the selected sites. These data will be stratified by conflict type and by location within the study section.

Task Product : A table of results indicating the conflict rate, stratified by type of conflict for each of the 10 study sites.

Task 3

Determine the relationship between the accident characteristics (number, type, etc.) and the conflict characteristics (number, type, etc.) at these 10 sites. Linear and non-linear regression will be used to identify this relationship.

Task Product : A mathematical model expressing the relationship between conflicts (by type), and accidents (by type and severity) for the study sites.

Task 4

Obtain data on conflicts and the speed distribution parameters at those sites in part A where the level of enforcement is being changed.

Task Product : A table similar to that produced in task 3, but with data collected following implementation of a change in enforcement.

Task 5

Determine the relationship between the change in the speed distribution parameters (Δ 85th percentile) and the change in conflict characteristics (Δ number) in the before and after periods. Linear and non-linear regression techniques will also be used for this task.

Task Product : A mathematical model expressing the relationships between a change in the speed profile (following a change in enforcement) and a change in the conflict rate.

Task 6

Using the relationship between speed characteristics and conflicts, and conflicts and accidents, develop a procedure for estimating the accident potential at a speed zone by observing the conflict pattern for alternative proposed speed limits.

Task Product : A manual of procedure to be used to obtain conflict data following implementation of a speed zone, and to predict the accident rate based on the conflict rate.

Task 7

Prepare a report of the project results.

Expected Research Product

This project will produce a written report that :

1. Describes the work performed and the rational for the relationships found.

2. Describe the relationship of accidents, conflicts, speeds, roadway environment, and other factors.

3. Provide a step-by-step procedure for conducting a conflict analysis and processing of the data so that a reasonable estimate of the accident potential under different speeds can be calculated.