Alternative Merge Sign at Signalized Intersections

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16. Abstract

A research study was performed to develop, field test and evaluate a trial merge warning sign to be used for merging at some signalized intersections. At the present time, the "Lane Ends" sign (W4-2) is commonly used in the United States to alert drivers that a merge ahead is required. One location where this sign is used is after signalized intersections where an additional through-lane ends. To encourage an alternating merge pattern, a trial sign was developed and field tested at two intersections in Connecticut. Merging patterns were monitored via video cameras before and after the sign was installed. An evaluation was completed to determine the effectiveness of this experimental sign, in accordance with Section 1A.10 of MUTCD 2000.

The experimental merge sign was successful in improving the traffic flow and safety of the merges. After placement of this sign, the number of desirable merges, with no visible change in speed from any of the merging vehicles, increased by 10 percent. The number of undesirable merges, with excessive visible change in speed, decreased by 4 percent.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: volumes greater than 1000 L shall be shown in m^3			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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Alternative Merge Sign at Signalized Intersections

Background and Significance

Warning signs alert road users to conditions that might call for a reduction of speed or an action in the interest of safety and efficient traffic operations [1]. One condition that drivers should be made aware of is when a lane is about to end. This requires drivers to merge, which is defined in the Merriam-Webster's Collegiate Dictionary as "to blend or come together without abrupt change" [2]. At the present time, the "Lane Ends" Sign (Federal Sign No. W4-2), as depicted in Figure 1, is being used in Connecticut and many other states to alert drivers when an additional through-lane is ending after a signalized intersection.

At some signalized intersections, an additional through-lane approaching the intersection is necessary to increase capacity due to high volumes of traffic during peak hours of the day. To meet the level-of-service criteria, the additional through-lane must extend through the intersection. Level-of-service at signalized intersections is defined by delay, which not only indicates the amount of lost travel time and fuel consumption, but it is also a measure of the frustration and discomfort of motorists [3]. At the location where the additional through-lane ends, the drivers must merge into one lane in order to proceed safely. Typically, the W4-2 "Lane Ends" Sign is used to indicate that the right or left lane is ending, but it does not warn the driver to merge or advise how the driver should merge. Therefore, the flow of traffic is often disrupted due to the merge location, and the driver's safety decreases as the frustration level increases.

Figure 1 W4-2, “Lane Ends”, MUTCD 2000, Millennium Edition

In Germany, whenever traffic is heavily congested, normal right-of-way rules are suspended and the “zipper rule” goes into effect. This means that cars feed one at a time alternating from each lane, regardless of who has the posted right-of-way. The “zipper rule” also applies when one lane ends and merges into another. Each vehicle in the through lane must allow one vehicle from the truncated lane to merge in [4]. Figure 2-A is the present sign being used in Sweden to indicate the “zipper rule” and Figure 2-B is a sign being used in Great Britain and Ireland to indicate that double lanes merge.

Figure 2-A “Zipper Rule” Sign

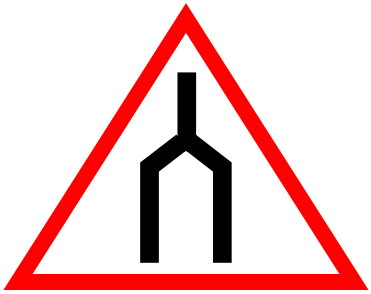


Figure 2-B “Double Lanes Merge” Sign

The Texas Transportation Institute conducted a survey in the early 1990s of 1,745 Texas drivers aged 16-65+, to measure their comprehension of selected traffic control devices. The “Lane Reduction Transition Sign” otherwise known as the “Lane Ends” Sign was 1 of 18 warning signs included in the survey. The survey results for proper interpretation for this sign are as follows: 61.2 percent “Correct”; 34.2 percent “Incorrect”; and, 4.6 percent “Not Sure”. The surveyors concluded that the difference between fewer lanes, one lane, and narrow lanes ahead was not apparent to 39 percent of the respondents [5].

In 1994, a study including drivers in Texas, Idaho, and Alberta, Canada, was done on elderly drivers and their comprehension of traffic signs. Data indicated that the percentage of people in the U.S. over 70 who had driver licenses doubled from the early 1950’s to 1984. The population of older drivers will continue to increase, as will our dependence on personal transportation. The study surveyed 480 volunteer licensed drivers, aged 18-88. It was evident that many signs are well understood, while others are not. The “Lane Ends” sign was understood by fewer than 40 percent of the drivers in the study [6].

On March 20, 2001, the American Traffic Safety Services Association (ATSSA) – Federal Highway Administration (FHWA) Manual of Uniform Traffic Control Devices (MUTCD) Satellite Video Conference was held. During the conference, Linda Brown of the Office of Transportation Operations (HOTO) for FHWA, encouraged that a new sign should be proposed and researched to replace the W4-2 sign [7] (see Figure 3).

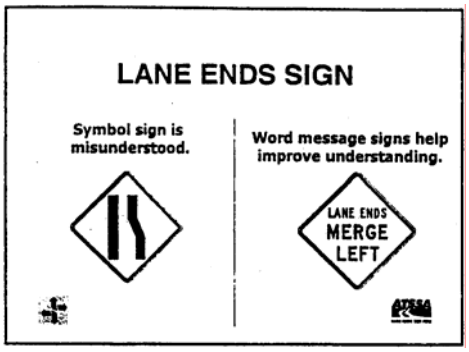


Figure 3 ATSSA-FHWA MUTCD Satellite Video Conference
Chapter 2C: Warning Signs

During the term of this "Alternative Merge Sign at Signalized Intersections" research project, the new MUTCD 2003 Edition [8] was published and the W4-2 sign was modified. The intent is to help motorists better understand the sign, as shown in Figure 4 below. The new design sign must be within 10 years from the effective date of the Final Rule for the 2003 MUTCD, therefore the compliance date is December 22, 2013.

Figure 4 W4-2 Sign, Modified,
MUTCD 2003 Edition

Study Objective

The objective of this study was to develop, field test, and evaluate a prototype warning sign that would allow for improvement in

the traffic flow and merging pattern when a through lane ends after a signalized intersection. Traffic flow is disrupted when drivers do not alternate to merge. This can lead to a reduction in the level-of-service and safety of the roadway.

With a more clearly defined instruction and understanding of the intent to merge, driver safety and the traffic flow should improve. The frustration level of the drivers will be reduced, thereby potentially reducing “road rage”. Merging traffic patterns will be smoother and safer. The occasions of altering intersection geometry and reconfiguring approach lanes will be reduced and money will be saved. If the new sign is successful, acceptance and support by the public is anticipated.

Study Design

Description of Survey Process and Results

An “Alternative Merge Sign” paper survey was used to solicit the advice of Connecticut drivers on possible prototype signs for consideration of field evaluation. The purpose of the survey was to seek out the most understood symbol sign. Word signs were included to help understand how motorists think in this particular driving situation. Moreover, the word sign gives the Department a better understanding of what supplemental plaque would be useful. Before partaking in the survey, the participant was asked to provide data on gender and years of driving experience.

The survey consisted of six different symbol signs and four different word signs. Each participant was requested to rank six symbol signs (A-F) from 1 to 6, 1 being the best and 6 being the worst; then, to rank the four word signs (G-J) using 1 to 4, 1 being the best

and 4 being the worst. The paper survey with signs A-J are shown in Appendix A.

Over 360 surveys were distributed, mostly in Connecticut. The respondents' driving experience ranged from 0 to 40+ years. Of the 360 surveys distributed, 276 were returned and 241 surveys were completed correctly. After reviewing the results of the survey, symbol signs "C" and "D", and word sign "I", were found to have the lowest mean rank (i.e., most preferred) as shown in Tables 1-A and 1-B below. Appendix A indicates the distribution of ranking for each sign.

Table 1-A Ranking Results of Symbol Signs from Paper Survey

Symbol Sign (See Page A-3)	**Mean Rank (Rank: 1 Best to 6 Worst)**
A	3.87
B	3.26
C	2.85
D	2.94
E	4.97
F	3.11

Table 1-B Ranking Results of Word Sign from Paper Survey

Word Sign (See Page A-4)	**Mean Rank (Rank: 1 Best to 4 Worst)**
G	2.56
H	2.76
I	2.09
J	2.59

With relation to driving experience: 0-9 years chose sign "C" and "D", 10-25 years chose "C" and "D"; 25-40 years chose sign "C"; and, greater than 40 years chose sign "B" and "F". In reference to

gender: the male participants preferred signs “C” and “D”; the female participants preferred sign “C” and “F”.

Subsequent to the paper survey, the three top ranked symbol signs (C, D, & F) were selected for an oral survey. The oral survey proceeded as follows: a graphic representation of each prototype sign was created; then, each sign was presented on separate days to the general public at a Department of Motor Vehicles building in Connecticut; Research engineers approached 40 Connecticut drivers at random each day and asked specific questions pertaining to what the sign meant to them; the answers were recorded; and, the results were used to assist in the decision-making process for the selection of the sign that was ultimately used for experimentation.

The results of the oral survey showed that sign “C” was understood 85 percent of time, sign “D” was understood 50 percent, and sign “F” was understood 35 percent. A comparison of these results using a Chi-Square Distribution determined, with a 95 percent confidence level, that sign “C” was significantly better understood by the subjects than the other two signs.

Prototype Sign Acceptance and Development

Following the two surveys, sign “C” (see Figure 5) was chosen as the proposed experimental sign based on engineering judgment and survey results. This sign was designed to represent the Merriam-Webster definition of merge mentioned earlier.

There are two main parts of the sign: the arrow and the roadway display. The arrow, which warns to merge ahead, was designed to encourage an alternating merge pattern; with no one having the right-of-way. The display of the roadway shows two lanes going into one lane, but does not indicate what the roadway geometry is ahead. This was

done purposely so the sign can be used with any lane reduction scenario (left or right lane ending, or road narrows). After the determination of the trial sign, a request for permission to experiment, according to Section 1A.10, "Interpretations, Experimentations, and Changes", of the MUTCD 2000, Millennium Edition, was initiated and submitted to the Federal Highway Administration (FHWA), Office of Transportation Operations. The complete application is in Appendix A, page A-9. After review of the request for experimentation of alternative merge symbol signs at signalized intersections, the proposed sign was approved and assigned an official experimentation number and title as 2-500(Ex) – "Alternative Merge Symbol Signs at Signalized Intersections-CTDOT". Refer to Appendix A, page A-14 for the acceptance letter.

The graphic representation was then forwarded to the Division of Traffic, for the development of sign details for a 36" and 48" sign, as shown in Appendix A, page A-13. This was done in order to have the ConnDOT sign shop make the signs required for each test site.

Figure 5 2-500(Ex) Experimental Merge Sign

Selection of Test Sites

The process for choosing two test locations was established by several criteria, which included type of roadway, annual average daily traffic (AADT), road alignment, number of lanes, vehicle lane use, lane reduction geometry and size of existing sign (36″ vs. 48″). The foremost criterion was the AADT, because the test locations need, a large volume of traffic in order to observe the greatest possible number of merging events. Therefore, principal arterial roads were the best candidate for the test sites. Following this determination, signalized intersections with an additional through-lane ending after the intersection were targeted. At these locations, there usually is a W4-2 "Lane Ends" sign used when the additional through-lane ends and the driver must merge into one lane in order to proceed safely. This is where the experimental sign was used to replace the existing sign. After reviewing possible test sites, other information was collected regarding the sites. The road alignment, number of lanes, vehicle lane use, lane reduction geometry and size of existing signs were compiled.

The first location selected was on Route 4, eastbound, intersecting Town Farm Road in Farmington, Connecticut (see Figure 6-A). The 2003 AADT, in the eastbound direction, is approximately 14,000 vehicles per day east of the intersection. The Route 4 site has two approaching through-lanes with the left through lane also serving left turns into Town Farm Road, which may encourage more vehicles to travel in the right lane. The two through-lanes travel through the intersection and, for approximately 200 feet past the end of the intersection, then begin to merge with a taper length of approximately 570 feet. Visually, the right lane tapers, merging into the left lane, which the W4-2 sign indicates. The roadway has minimal horizontal and

vertical change in geometry. The roadway speed limit is 40 m.p.h. and the existing warning sign is 36 inches.

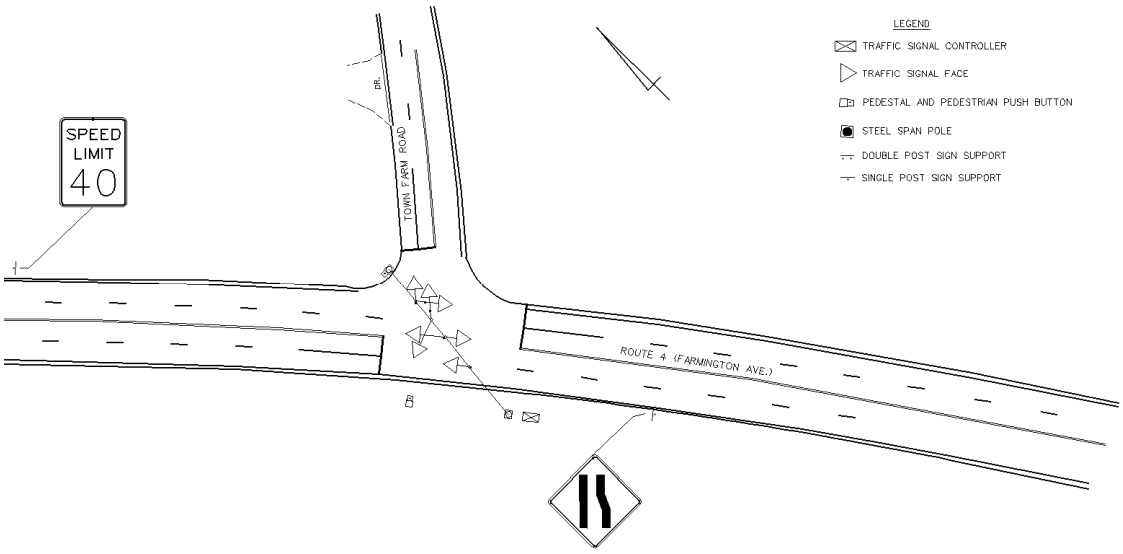


Figure 6-A Intersection of Route 4 and Town Farm Road, Farmington

The second location was on Route 229, southbound, intersecting West Street #1 in Southington, Connecticut (see figure 6-B). The 2003 AADT in the southbound direction was approximately 12,500 vehicles per day, south of the intersection. The Route 229 site has three approaching lanes, of which two are through-lanes and one is an exclusive left-turn lane. The two through-lanes end approximately 208 feet past the end of the intersection, and then begin to merge with a taper length of approximately 400 feet. Visually, the road narrows into one lane, not suggesting which lane is ending, but the W4-2 sign is also used at this location. The roadway has a horizontal curve to the right with a vertical curve as well. The roadway speed limit is 40 m.p.h. and the existing warning sign is 48 inches.

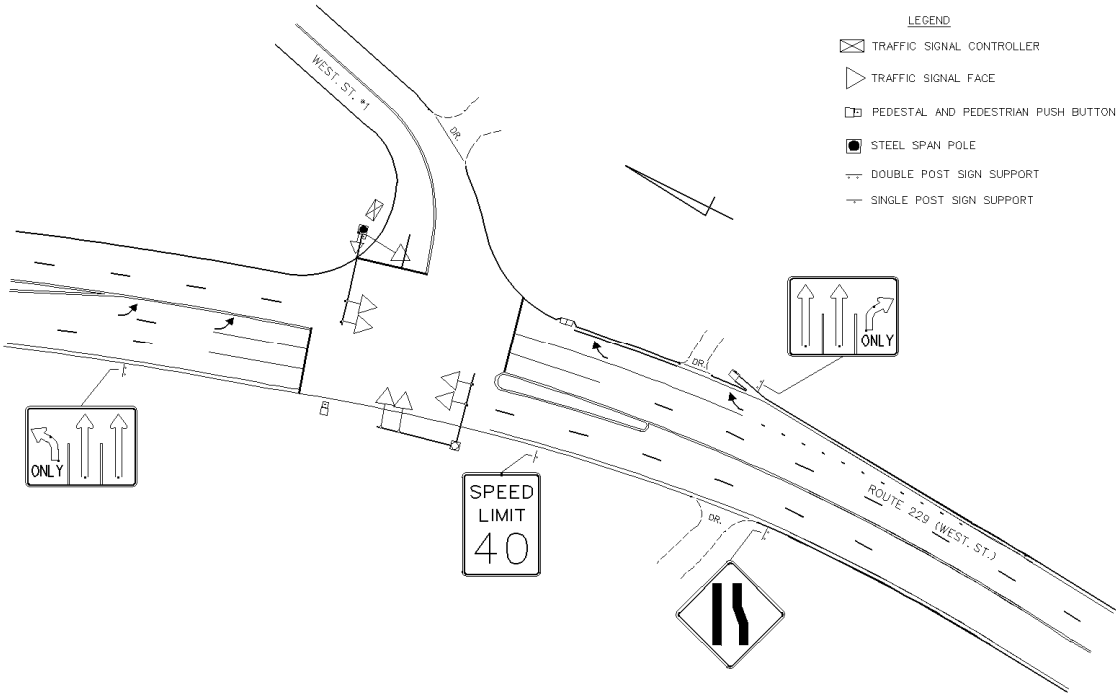


Figure 6-B Intersection of Route 229 and West Street #1, Southington

Field Monitoring

The purpose of the field study phase was to compare traffic behavior with the existing (W4-2) and the experimental [2-500(Ex)] signs in place. In order to monitor this behavior, cameras were installed at both locations. Traffic-monitoring cameras with speed detection and volume counting capabilities were chosen to monitor each merge location. The video from each camera was captured by a stand-alone digital video recorder (DVR) onto 80-gigabyte hot-swappable hard drives. The hard drives were capable of saving approximately 24 hours of video at 30 frames-per-second. The hard drives were routinely exchanged with another hard drive so the video could be reviewed in the office on another digital video recorder.

At the Farmington site, the camera was installed by a contractor. A sign pattern was provided by a Connecticut Department of Transportation maintenance crew to protect the workers but a lane closure was not necessary. The camera was attached to a 6-foot pole that was attached to the span pole on the eastbound side of the roadway. The camera's wire connection was then pulled through an existing conduit to the traffic cabinet used for the intersection. The cabinet housed the data acquisition system and digital video recorder. A small video monitor was utilized during the time of installation to view real time video in order to adjust the camera to optimize recording of merges.

Photograph 1 Route 4, Eastbound, Farmington, CT

Photograph 2 Traffic Cabinet with Data Acquisition System and DVR

At the second site in Southington, the camera was also installed by a contractor. A sign pattern was provided by a ConnDOT maintenance crew for a necessary lane closure. The camera was attached to a 6-foot pole and then attached to the mast arm above the intersection. The camera was pointed in the southbound direction and adjusted using the same procedure as the Farmington site. The camera's wire connection and housing of the data acquisition system and digital video recorder were identical to the Farmington site.

Photograph 3 Camera Installation, Route 229, Southbound, Southington, CT

Photograph 4 Route 229, Southbound, Southington, CT

After installation and adjustment of the cameras at each location, the cameras needed to be calibrated for their traffic-counting and speed-detection capabilities. A vendor representative for the cameras assisted in the calibration of these camera systems. A

video monitor and laptop computer were necessary for the setup of the cameras. Proprietary software was installed on the laptop in the office prior to installation. The traffic counting calibration was completed and was evaluated during data collection. Secondly, the speed-detection was calibrated by using an imprinted box on the video image and, then, repeatedly driving a ConnDOT vehicle through the intersection at a noted speed from the speedometer. The driver in the ConnDOT vehicle and vendor representative at the cabinet would communicate through two-way radios so the driver could relay how fast he/she was driving through the intersection. The vendor representative would then compare it to the speed display on the video output. The software would be adjusted until the software/video output was +/- 1 m.p.h. of the vehicle's speedometer reading. The comparison of the software and vehicle speed was repeated 6 to 10 times for verification of precision. At each location, the camera's speed detection had an accuracy of +/- 2 m.p.h. The speed output was acceptable to the study's need, because the speed was only used to help observe driving behavior.

Viewing and Rating Description

The study compares the effectiveness of the old warning sign (W4-2) to the experimental warning sign [2-500(Ex)]. In order to collect enough data for evaluation, it was determined that the W4-2 sign would be monitored for a six month period prior to installation of the 2-500(Ex) sign. Once installed, the experimental sign was evaluated for one year, a minimum established by MUTCD guidelines.

As previously mentioned, the camera's video images were recorded onto removable 80-gigabyte hard drives using digital video recorders. The hard drives were swapped with blank drives routinely, so the

recorded hard drives could be reviewed in the office on a third DVR and a monitor. The video was recorded in one-hour intervals. Three research engineers reviewed the video and rated the merging events.

Rating guidelines were created for the reviewers to follow while evaluating a merge event. Using guidelines and engineering judgment, the reviewers were able to consistently evaluate the merge events. The guidelines were established so that each engineer would uniformly assess a merging event. The rating specifications are defined numerically as follows: 1 = rating is a very desirable merging pattern with no visible change in speed from any of the merging vehicles (e.g., there is no braking); 2 = rating is a desirable merging pattern with some visible change in speed from any of the merging vehicles (e.g., some braking); 3 = rating is a less than desirable merging pattern with excessive visible change in speed while vehicles are merging together (e.g., a great deal of braking). Other examples are a vehicle not being allowed to merge, therefore having to force its way in, or some driver aggressiveness (e.g., speeding up to pass someone, or cars straddling the dash line approaching the merge); 4 = rating is an undesirable merging pattern with vehicles not being allowed to merge, causing a traffic violation to occur before or during the merge (e.g., vehicles forced outside of through lane, crossing center line into opposing traffic lane, or crossing edge line onto the shoulder); and, 5 = rating is an undesirable merging pattern resulting in an accident.

The next phase was to define a merging event. A merging event consists of two or more vehicles, which, after traveling in parallel through-lanes, are required to merge into one lane. It is not considered a merging event when vehicles are in the same through-lane or if the vehicles are in parallel through-lanes but are more than two car lengths apart, in which case neither vehicle would have to yield.

The determination of the variables of the merging events to be recorded was an important step in the evaluation process. The data recorded per merging event were date, time of day, number of cars, number of trucks, road surface conditions, even approaches, rating, and other miscellaneous comments. The number of cars and trucks are specific to each merge event. The road surface conditions were categorized as dry, wet or ice/snow. The even approaches were when two vehicles approached the lane reduction area side-by-side, in the parallel through-lanes, at approximately the same speed. This was considered a worst-case scenario. For rating, a number 1 through 5 was assigned using the rating guidelines previously stated, as well as engineering judgment. Miscellaneous comments noted included, (e.g., a school bus or a motorcycle involved in the merging event).

Data Collection

Following the selection of the two test locations, volume and traffic accident data on these signalized intersections were collected. The annual average daily traffic (AADT) for both directions on Route 4, east of Town Farm Road, for the year 2000, was 27,800. The AADT in the eastbound direction was 13,700. In August 2002, 24-hour traffic counts were collected west of Town Farm Road, for the left and right through-lanes. The left lane carried approximately 24 percent of the vehicles and the right lane carried 76 percent of the total vehicles. In April 2003, 24-hour traffic data was collected at the same location. The left lane carried approximately 23 percent of the vehicles and the right lane carried 77 percent of the total vehicles. The reason for the difference in lane use was that there is no exclusive turning lane, so vehicles going straight may opt to travel in the right lane to avoid vehicles waiting to turn left.

Traffic accident data were examined at the Route 4 test site between mileposts 42.23 to 42.40 from the intersection to the end of the taper. During three years prior to installation of the experimental sign, from March 1, 2000, to February 28, 2003, there were eight accidents that may have occurred because of the merging pattern. This is 0.22 crashes per month prior to installation of the experimental sign. Following the installation of the experimental sign, from March 1, 2003, to June 30, 2004, there were two accidents that may have occurred because of the merging pattern. This corresponds to 0.13 crashes per month after the installation of the experimental sign. This represents a 0.09 crashes per month reduction with the trial sign in use. Once a full three years of accident data is available, the crash experience will be evaluated again.

The AADT for both directions on Route 229, north of West Street #1, for the year 2000, was 18,700. The AADT in the southbound direction was 9,700. In August 2002, 24-hour traffic counts were collected north of West Street #1, for both through-lanes combined and the exclusive left-turning lane. The through-lanes, together, carried 98 percent of the vehicles, and the exclusive left-turning lane 2 percent of the vehicles. Again in April 2003, 24-hour traffic data was collected in the same location. Both through-lanes together carried 97 percent of the vehicles and the exclusive left-turn lane carried 3 percent of the vehicles. Field observations were performed and found that the motorists did not favor traveling in one through-lane.

Traffic accident data was examined at the Route 229 test site between mileposts 2.30 to 2.46, from the intersection to the end of the taper. Three years prior to installation of the experimental sign from March 1, 2000, to February 28, 2003, there was one accident that may have occurred because of the merging pattern. This corresponds to 0.03

crashes per month prior to installation of the experimental sign. Following the installation of the experimental sign, from March 1, 2003, to June 30, 2004, there were no accidents that may have been influenced by the merging pattern. Appendix B includes more details of the traffic accident experience reports for both locations.

On September 3, 2002, video collection began for the W4-2 “Lane Ends” sign at both test locations. Video was collected on the existing signs until February 28, 2003, for a total of six months. The experimental sign video was recorded from March 1, 2003, to March 31, 2004, for a period of 13 months. These evaluation periods were necessary in order to get enough data on merging events for a before/after study using on statistical comparisons. The video was recorded in one-hour intervals for approximately three hours each week, on average. The weekly amount of video per week varied due to problems encountered throughout the project. Damaged hard drives, power outages and surges are some of the common reasons why the video would not record, and would prolong until an engineer made a field visit to each location. When these situations occurred, extra video in the following weeks were recorded to make up for the lost hours. One instance that occurred, at the Route 229, Southington location, was when a vehicle collided with, and damaged, the traffic cabinet. The traffic cabinet was replaced within 48 hours, but the monitoring system was down for one week.

The hours recorded were usually between 7:00 a.m. and 7:00 p.m., for best visibility and the desired amount of traffic volume. At the Farmington test site, hours between 7:00 a.m. to 9:00 a.m. were mostly avoided due to the extremely high volume of traffic, which usually created a traffic jam and eliminated ratable merging events. Following

the recording, usually for three to four weeks, an engineer would visit each location and swap the hard drive with an empty one.

When the video was brought back to the office, the video was then reviewed by the research engineers. Due to the large amount of video recorded, three research engineers were assigned to review and rate the merge events. Observation previously described in the "Viewing and Rating Description" section of this report, were recorded on an evaluation data collection form as shown in Appendix B (page B-6). The W4-2 sign was evaluated, at both locations for a total of 142 hours. From the 142 hours of video reviewed, 7,700 merge events were rated and recorded. The 2-500(Ex) sign was evaluated, at both locations, for a total of 242 hours. From the 242 hours of video reviewed, 19,500 merge events were rated and recorded. Observations of the essential variables as stated previously for each event were also recorded.

Data Analysis and Results

Following the rating of each merge event, for the period of each sign evaluation, data comparison and statistical analysis were performed to meet the study's objective. To begin, the three research engineers who rated the video were evaluated for their consistency and reproducibility. On three separate occasions, the three evaluators viewed and rated the same hour of video. In order to examine each merging event recorded by all the engineers, the time stamp for each event was also recorded. A comparison of the research engineers' performance for the three hours was made and statistically evaluated using the Friedman Test. The null hypothesis was that the evaluators do not differ from each other. After running the Friedman Test with a 95 percent confidence level, the null hypothesis was not rejected; therefore, the evaluators were found to be consistent.

Since the evaluators were found to be consistent, the three research engineers were not considered a variable in the rating procedure. Following this analysis, the data recorded for each sign at each location were examined. The old and experimental signs were compared at both locations, combined, and at each location individually. To begin, the rating number distribution for merging events was investigated with both locations, combined. Figure 8 demonstrates that the experimental sign had an increase from 56 percent to 66 percent for very desirable merges (rating of 1) and a 4 percent reduction in undesirable merges (ratings of 3 & 4).

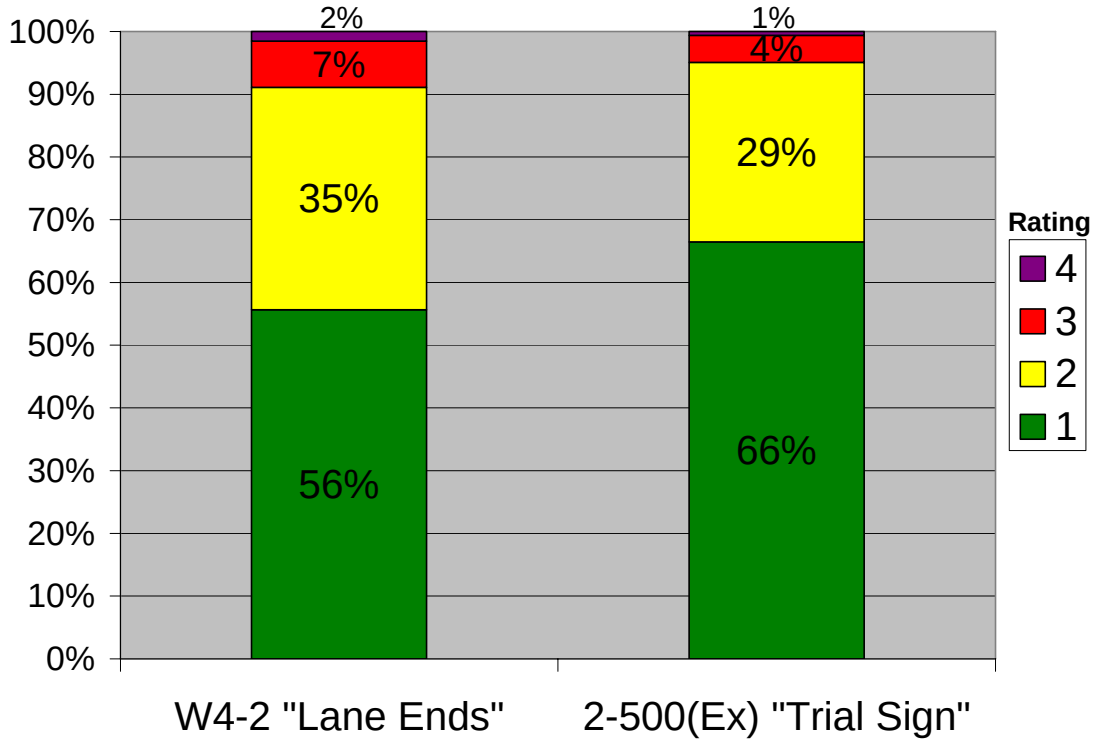


Figure 8 Rating Number Distributions for Merging Events
(Rating: 1 Best to 4 Worst)

Secondly, the Mean of Rating Categories was compared at each location, separately. The rating categories ranged from 1 to 5. However, since there were no accidents, a rating of 5 was not used for

any observed merges. The table below shows the Rating Means for each sign at each location. The lower the Rating Mean, the better the merging pattern.

Table 2 Rating Means

	Farmington	Southington
W4-2	1.58	1.53
2-500(Ex)	1.39	1.39

Next, by way of statistical testing, the data was examined to determine if the presence of the experimental sign significantly reduced the rating (i.e., improved the merge). The Mann-Whitney test was utilized to confirm that the null hypothesis, which says that there is no change in the ratings when the experimental sign replaced the existing sign, can be rejected.

For both the Farmington and Southington test sites, the Mann-Whitney test was calculated with a 95 percent confidence level and the results found that the presence of the experimental sign significantly reduced the rating. This indicates the merging pattern behavior improved with the experimental sign in place.

To determine if the variables collected were significant, Ordinal Regression was performed. The test showed that the correlation of the following parameters; Before/After, number of Cars, number of Trucks and Even Approaches, were low; therefore, each parameter is treated independently and are considered significant variables. The Road Surface Condition variable showed a high correlation; therefore, it was not significant. Appendix C contains the full statistical output for the Mann-Whitney test and Ordinal Regression analysis.

Throughout the length of the project, a few e-mails were received from citizens asking questions, making comments, giving suggestions or just giving their opinion. An e-mail in Appendix C (page C-8) demonstrates a citizen's concern for the sign because of his/her self-perceived misunderstanding of who has the right-of-way. This, however, indicates that he/she actually understood the sign.

Summary of Findings

A paper survey was initiated to solicit the advice of Connecticut motorists and citizens. The paper survey consisted of six different signs and asked the participant to rank the signs from best to worst. The experimental sign was included in the paper survey, and was contained in the top three preferred signs, and actually was the most preferred sign. Following the paper survey, the three preferred signs were selected for an oral survey, which was conducted at a local Department of Motor Vehicles office. The oral survey results indicated that the experimental sign was better understood for what the sign was meant to warn and encourage, than the other two signs. The participants recognized that there was no right-of-way indicated and that there was a merge ahead. This was also conveyed in some e-mails received from motorists.

Following the surveys, the sign was chosen for experimentation based on the results of the surveys and engineering judgment. A formal request was made to the MUTCD national committee and approval was granted for experimentation.

Next, data collection began for the existing warning sign using video cameras and digital video recorders. The cameras downloaded the video onto a hard drive, which gives the capability to record data at anytime of day and enabled reviewers to evaluate the video at anytime.

The existing “Lane Ends” sign (W4-2) was evaluated for six months and the experimental sign [2-500(Ex)] was evaluated for one year, at both locations.

Finally, the statistical data analysis was performed and it was found that the experimental sign improved the merging patterns at both locations. Moreover, the significant variables found to contribute to the driving behavior were: the old sign versus the experimental sign; the number of cars involved in the merge; the number of trucks, if any, involved in the merge; and, if two vehicles approached the merge side by side. It was found that the road conditions were not significant to the merging behavior.

Conclusion

The experimental merge sign was successful in improving the traffic flow and safety for merges. After placement of this sign, the number of desirable merges, with no visible change in speed from any of the merging vehicles, increased from 56 percent to 66 percent. The number of undesirable merges decreased from 9 percent to 5 percent.

Recommendations/Implementation

The results from this study suggest the experimental merge sign should be considered for use at intersections with lane reductions. Additional research can include the use of this sign at other lane reduction locations, such as lane closures in work zones.
This sign should be considered for acceptance in the Manual of Uniform Traffic Control Devices. Presentations and dissemination of results were offered at the 2005 Annual Transportation Research Board Joint Committee Meeting for Traffic Control Devices (AHB50) and Signing and Marking Materials (AHD55) on January 10, 2005. Further implementation

efforts are recommended to promote the use of this experimental sign in Connecticut, as well as for inclusion in the MUTCD for national implementation.

References Cited

1. Federal Highway Administration. *Manual of Uniform Traffic Control Devices 2000*. December 2000.

2. Merriam-Webster Online. *Merriam-Webster's Collegiate Dictionary.* Merriam-Webster Incorporated, 2001. http://www.merriamwebster.com. Accessed April 20, 2005.

3. Garber, N. J. and L. A. Hoel. *Traffic and Highway Engineering*, Second edition, PWS Publishing Company, Boston, MA, 1997, p. 382.

4. Purcell, B. K. *German Traffic Laws and Regulations, Right-of-Way.* 2000. http://home.att.net/~texhwyman/regeln.htm. Accessed June, 11, 2001.

5. Hawkins Jr., H. G., K. N. Womack, and J. M. Mounce. Driver Comprehension of Regulatory Signs, Warning Signs, and Pavement Markings*. Transportation Research Record 1403*, TRB, National Research Council, Washington, D.C., 1993, pp. 67-82.

6. U.S. Roads. Elderly Drivers and the Comprehension of Traffic Signs. *Road Management and Engineering Journal,* 1997. http://www.usroads.com/journals/rej/9705/re970503. Accessed April 16, 2001.

7. Federal Highway Administration. *Manual of Uniform Traffic Control Devices, Millennium Edition, ATSSA/FHWA Millennium MUTCD Satellite Video Conference Participants Notebook*. March 2001.

8. Federal Highway Administration. *Manual of Uniform Traffic Control Devices, for Streets and Highways*, Including Revision 1, November 2004, page 2C-17.

Appendix A

Study Design

ALTERNATIVE MERGE SIGN RESEARCH SURVEY

At the present time, the "lane ends" sign, (Figure 1, Federal Sign No. W4-2) is commonly used in Connecticut to alert drivers that a merge ahead is required. One example is when a through lane ends after a signalized intersection.

A ConnDOT research study has been initiated to develop, field test, and evaluate a prototype warning sign that should allow for improvement in the traffic flow and merging pattern at the signalized intersections. Two to three alternative merge signs will be tested and evaluated in the field to determine the most effective merge sign for advising drivers to take turns merging. The trial signs may consist of a symbol, text, and/or combination of symbol and text.

Federal Sign No. W4-2
(Figure 1)

This survey solicits your advice on which prototype-warning signs should be tested and evaluated in the field. Please rank the proposed symbol signs (A-F) in the boxes below them. Use numbers from 1 to 6, 1 being the best and 6 being the worst. Then rank the proposed text signs (G-J) in the boxes below them. Use numbers from 1 to 4, 1 being the best and 4 being the worst. For sign (K), please indicate the best combination of symbol (A-F) and text (G-J). The following signs are NOT NECESSARILY TO SCALE.

Before continuing, please fill in the appropriate circles:

Sex

☐ Male ☐ Female

Years of Driving Experience

☐ 0-9
☐ 10-25
☐ 25-40
☐ >40

A.

B.

C.

D.

E.

F.

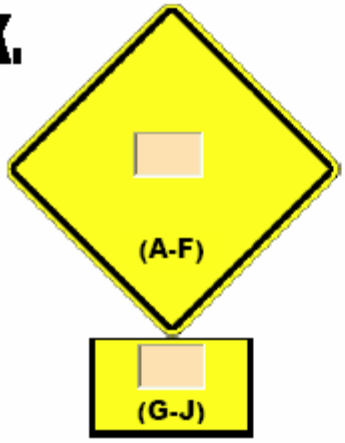
G.

H.

I.

J.

K.



Example

3

Comments:

Please return this survey to Eric Feldblum at 280 West Street, Rocky Hill, CT 06067.

If you would like to create a symbol or text sign, fax Eric Feldblum at (860) 258-0399.

The following supplemental warning plaques are the samples for the combination sign (K).

Optional: Cut out the plaques for creating combination signs in conjunction with the symbols signs on page 2.

Cut along perforation

This half is for your use only. Does not need to be returned.

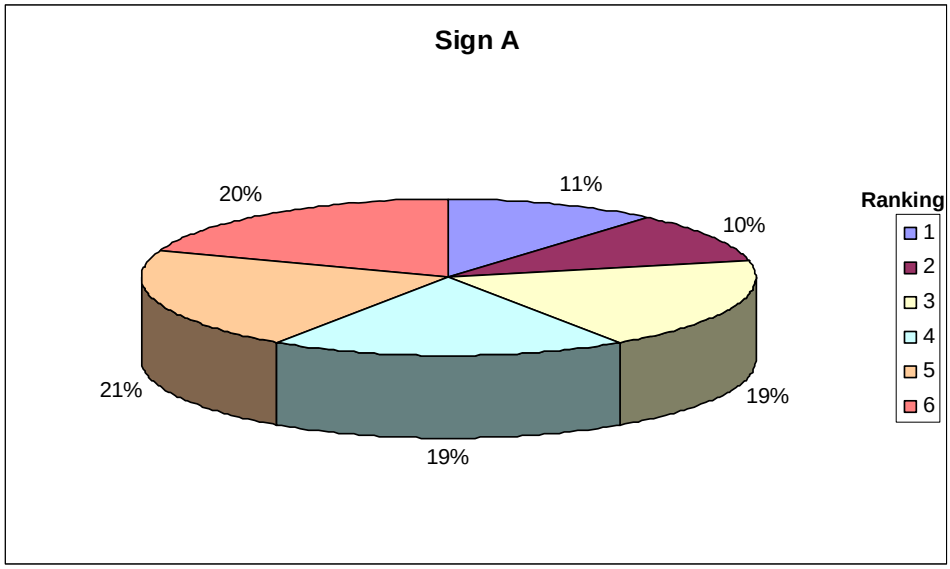


Figure A-1 Distribution Ranking for Sign "A"

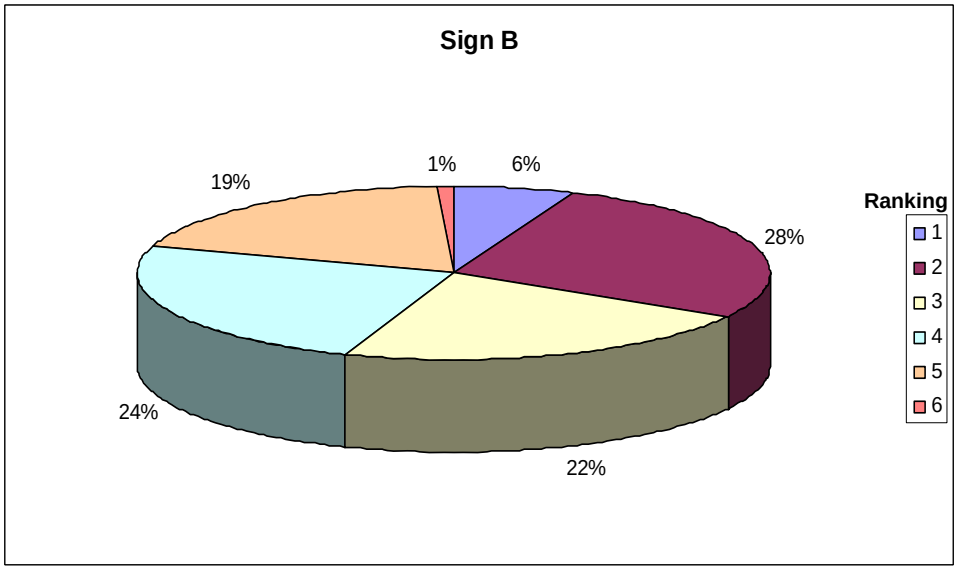


Figure A-2 Distribution Ranking for Sign "B"

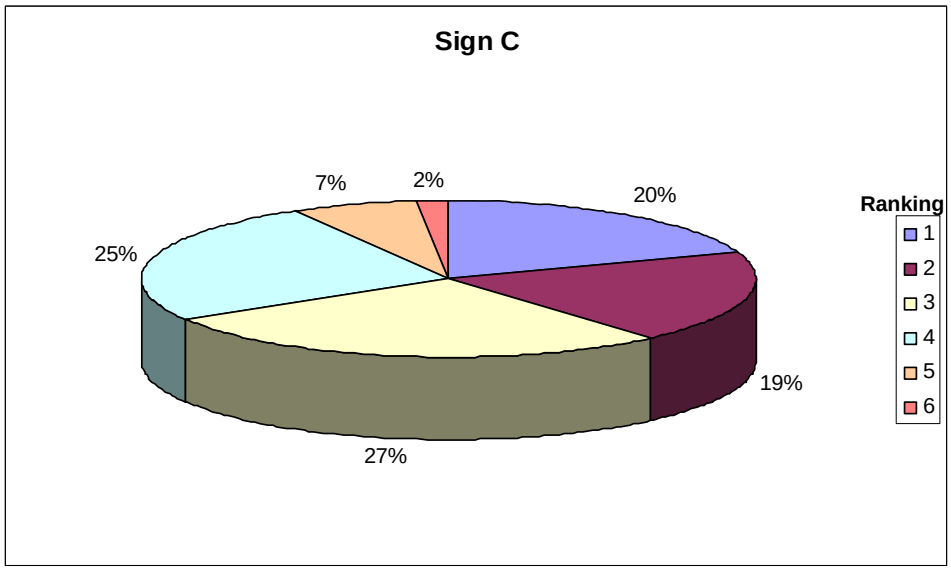


Figure A-3 Distribution Ranking for Sign "C"

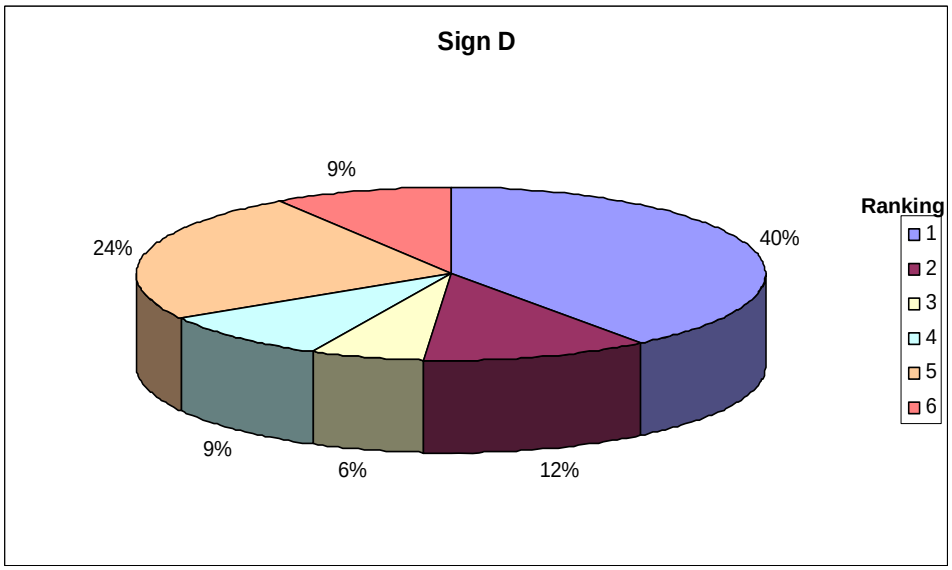


Figure A-4 Distribution Ranking for Sign "D"

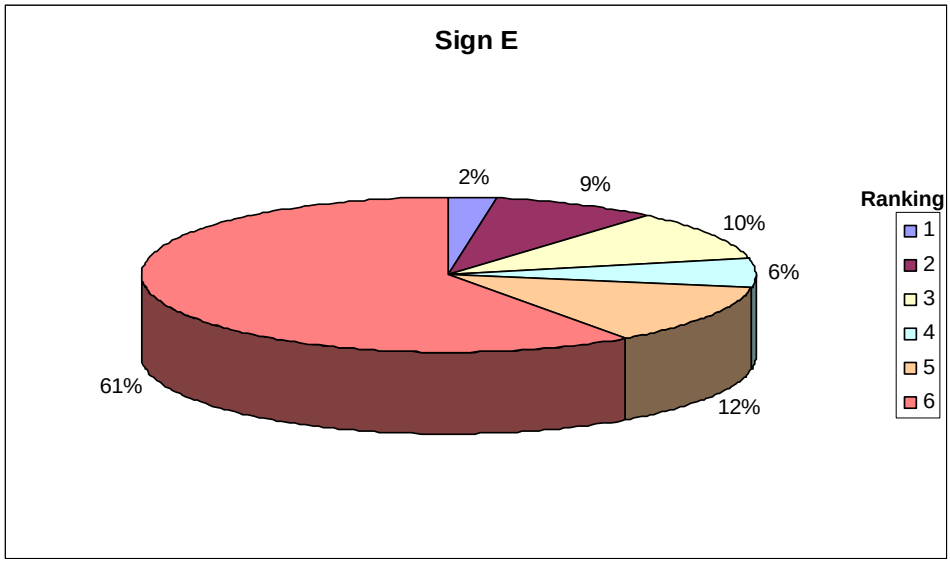


Figure A-5 Distribution Ranking for Sign "E"

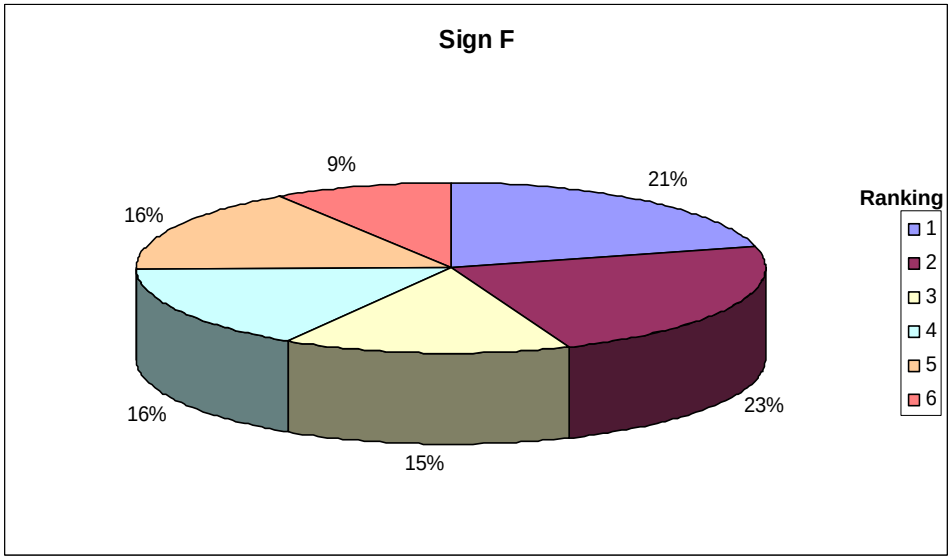


Figure A-6 Distribution Ranking for Sign "F"

REQUEST FOR PERMISSION TO EXPERIMENT
Connecticut Department of Transportation
Division of Research

Introduction:

This is a request for permission to evaluate new experimental traffic control warning signs for merges after signalized intersections. The additional information below is based on and follows:
Section 1A.10 Interpretations, Experimentations, and Changes of the MUTCD 2000, Millennium Edition, December 2000.

Experimental Plan:

A. At some signalized intersections, an additional through lane approaching the intersections is used to carry the high volume of traffic at the peak hours of the day. To meet the level-of-service criteria, the additional through lane must extend through the intersection in order to benefit from the additional capacity. At the location where the additional through lane ends, the drivers must merge into one lane in order to proceed safely. Typically, a sign “Lane Ends” (Federal Sign No. W4-2) is used to indicate that the right lane is ending, but it does not warn the driver to merge or advise how the driver should merge. Therefore, at the peak hours, the flow of traffic is usually disrupted due to the merging pattern and the driver’s frustration level increases.

B. One to two prototype-warning signs will be developed for the purpose of advising the driver to alternate merging. Motorists will be surveyed in order to determine the best understood signs to be field-tested. A standard warning sign diamond shape and color will be maintained. The sign will deviate from the standard W4-2 through symbols and/or text only.

   Expected improvements over the existing standards are that driver safety and the traffic flow will be improved. The frustration level of the drivers will be reduced, thereby reducing conditions contributing to “road rage”. Merging patterns are anticipated to be smoother and safer.

C. Figure 1-A and 1-B are illustrations of the selected test sites, which show the location of the “Lane Ends” sign that will be replaced with the experimental signs (See pages 3 & 4). Figure 2-A is an illustration of the proposed experimental warning sign to be evaluated at each of the test sites (See page 5). Figure 2-B is an illustration of an optional experimental warning sign in the event that proposed experimental warning sign does not succeed (See page 5). Presently Connecticut uses a supplemental plaque (Alternate Merging) that may accompany the proposed experimental warning sign (Figure 2-A).

D. Initially, an in-depth literature search was performed for any previous studies based on merging patterns and signs. Moreover, searches were done on the different types of merge signs used around the world.

E. I Keith R. Lane certify that the proposed experimental traffic control devices (warning signs) are not protected by patent or copyright.

F. The experimental traffic warning sign will be monitored for a 12-month period at each experimental site. The first site is in Farmington, CT on Route 4 eastbound (Figure 1-A). It is at the intersection of Route 4 and Town Farm Road. The second site is in Southington, CT on Route 229 southbound (Figure 1-B). It is at the intersection of Route 229 and West Street #1.

G. See attached proposal entitled "Alternative Merge Sign at Signalized Intersections," for the research and evolution plan.

Notes:

1. Task 5 - The information sign and information phone number will not be used.
2. Schedule of Activities has been changed.

H. Connecticut Department of Transportation (ConnDOT), Division of Research agrees to restore the sites of the experiment to a condition that complies with the provisions of the MUTCD within 3 months following the end of the time period of the experiment. Research also agrees to terminate the experimentation at any time that it determines significant safety concerns exist that are directly or indirectly attributable to the experimentation.

I. ConnDOT, Division of Research agrees to provide semiannual progress reports for the duration of the experimentation, and to provide a copy of the final results of the experimentation to the FHWA's Office of Transportation Operations within 3 months following completion of the experimentation. Quarterly progress reports are also provided to the FHWA, Connecticut Division Office, as required for the State Planning and Research program.

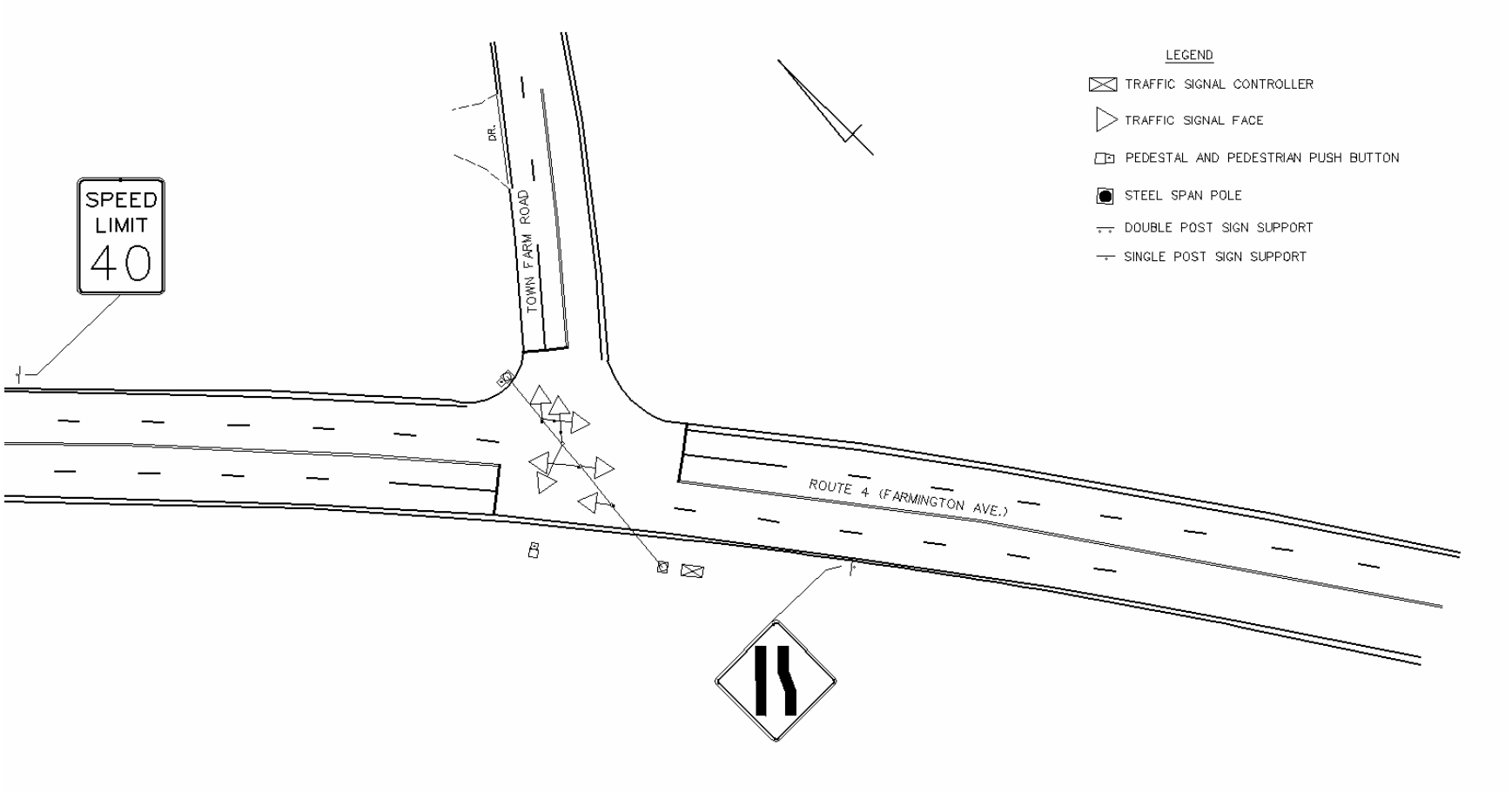


Figure 1-A
(Route 4 - Farmington)

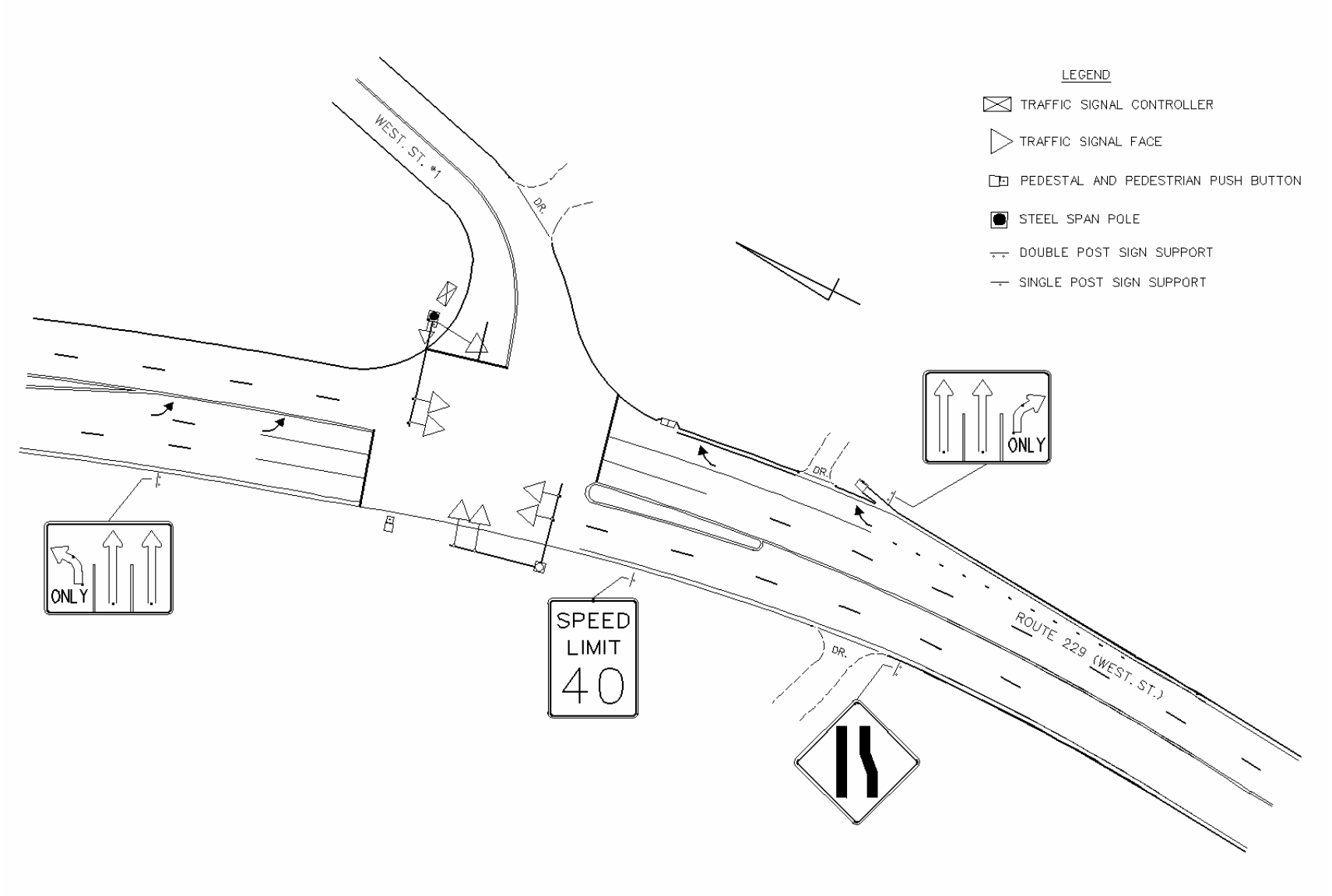


Figure 1-B
(Route 229 - Southington)

Figure 2-A
(Experimental warning sign to be evaluated)

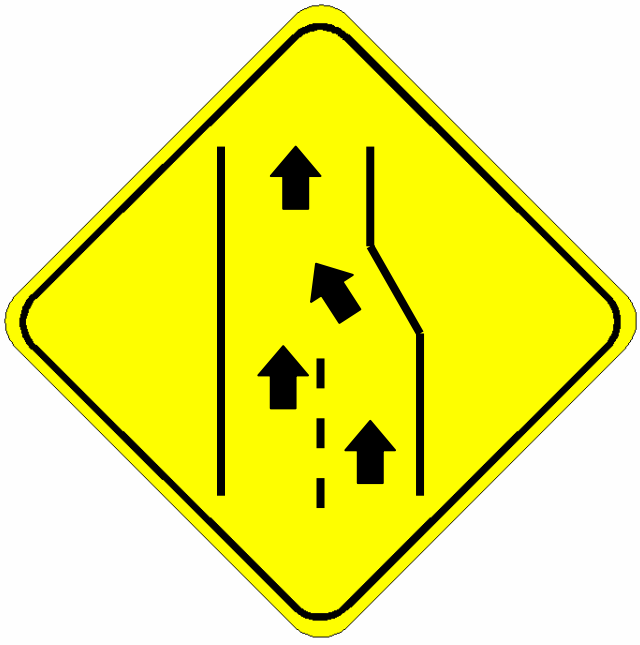


Figure 2-B
(Optional experimental warning sign)

U.S. Department
of Transportation
Federal Highway Administration

400 Seventh St., S.W.
Washington, D.C. 20590

May 7, 2002

Refer to: HOTO-1

Mr. Keith R. Lane
Director of Research & Materials
Bureau of Engineering and Highway Operations
280 BerlinTurnpike
Newington, CT 06131

Dear Mr. Lane:

Thank you for your e-mail of April 16 requesting experimentation with Alternative Merge Symbol Signs at Signalized Intersections.

We have reviewed and approved your request to experiment; for future reference purposes, we have assigned the following official experimentation number and title to your request: 2-500(Ex)–"Alternative Merge Symbol Signs at Signalized Intersections–CTDOT." Please refer to this number and title in future correspondence.

We look forward to receiving notifications of implementation dates and to your semiannual progress reports and final report. If we can be of further assistance, please contact Mr. Fred Ranck, Safety Engineer, in the Midwestern Resource Center at 708-366-0857.

Sincerely yours,

for Shelley J. Row, P.E.
Director, Office of Transportation Operations

RECEIVED

MAY 21 2002

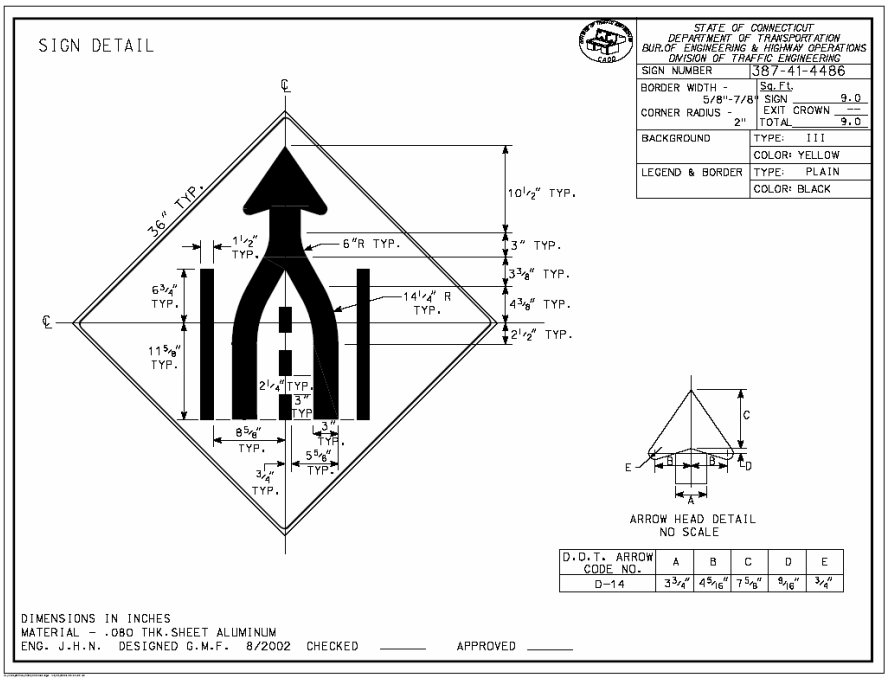


Figure A-7 2-500(Ex) 36″x36″ Sign Detail

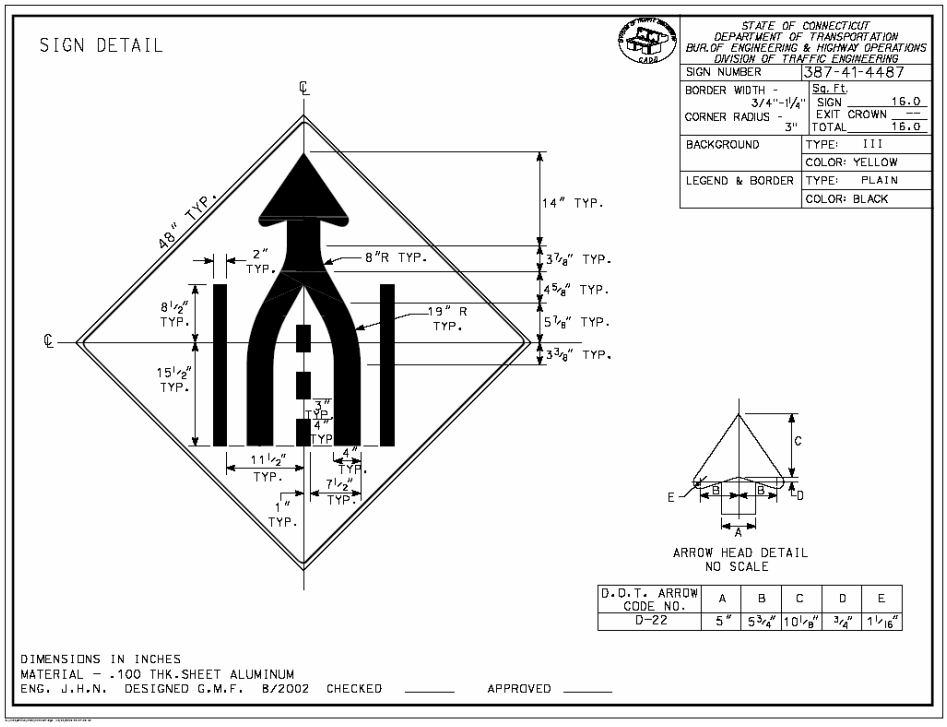


Figure A-8 2-500(Ex) 48″x 48″ Sign Detail

Appendix B

Data Collection

Farmington Traffic Experience Report

Before

042.33 Thursday, January 18, 2001
404041 0800 Daylight Dry No Adverse Condition
FARMINGTON
Collision Type: Sideswipe-Same Direction Contributing Factor:
Failed to Grant ROW
At-Fault Traffic Unit: # 2
EB Automobile 0 Injuries Maneuver: Vehicle Going Straight
EB Passenger Van 0 Injuries Maneuver: Vehicle Changing
Lane(s) to Left

042.34 100 FT E OF WESTERBERG DR Friday, March 30, 2001
112280 0733 Daylight Wet Rain
FARMINGTON
Collision Type: Sideswipe-Same Direction Contributing Factor:
Following Too Closely
At-Fault Traffic Unit: # 1
EB School Bus 0 Injuries Maneuver: Vehicle Passing Same
Direction on Left
EB Automobile 0 Injuries Maneuver: Vehicle Going Straight

042.33 ? .01 MI E OF WESTERBERG DR Monday, May 07, 2001
121694 0748 Daylight Dry No Adverse Condition
FARMINGTON
Collision Type: Sideswipe-Same Direction Contributing Factor:
Improper Passing Maneuver
At-Fault Traffic Unit: # 2
EB Passenger Van 0 Injuries Maneuver: Vehicle Stopped For Traffic
EB Single Unit Trk/2axle/6tire
0 Injuries Maneuver: Vehicle Passing Same
Direction on Left

042.32 500 FT E OF TOWN EAST RD Friday, June 01, 2001
131795 1612 Daylight Dry No Adverse Condition
FARMINGTON
Collision Type: Sideswipe-Same Direction Contributing Factor:
Unknown
At-Fault Traffic Unit: # 2
EB Other 0 Injuries Maneuver: Vehicle Going Straight
EB Automobile 0 Injuries Maneuver: Vehicle Going Straight

042.38 300 FEET E OF WESTERBERG DR Tuesday, June 05, 2001
130624 0820 Daylight Dry No Adverse Condition
FARMINGTON
Collision Type: Sideswipe-Same Direction Contributing Factor:
Improper Passing Maneuver
At-Fault Traffic Unit: # 2
EB Automobile 0 Injuries Maneuver: Vehicle Going Straight
EB Passenger Van 0 Injuries Maneuver: Vehicle Passing Same
Direction on Left

042.26 40 FT W OF RT 10 Saturday, March 02, 2002
109325 0948 Daylight Dry No Adverse Condition
FARMINGTON
Collision Type: Sideswipe-Same Direction Contributing Factor:
Improper Lane Change
At-Fault Traffic Unit: # 2
EB Single Unit 0 Injuries Maneuver: Vehicle Going Straight
Trk/2axle/4tire
EB Automobile 0 Injuries Maneuver: Vehicle Changing Lane(s) to Right

042.26 150 FT EAST OF TOWN FARM RD Wednesday, October 09, 2002
156693 1553 Daylight Dry No Adverse Condition
FARMINGTON
Collision Type: Sideswipe-Same Direction Contributing Factor:
Failed to Grant ROW
At-Fault Traffic Unit: # 1
EB Single Unit 0 Injuries Maneuver: Vehicle Going Straight
Trk/2axle/4tire
EB Automobile 0 Injuries Maneuver: Vehicle Going Straight

042.26 150 FT EAST OF TOWN FARM RD Wednesday, October 09, 2002
156693 1553 Daylight Dry No Adverse Condition
FARMINGTON
Collision Type: Sideswipe-Same Direction Contributing Factor:
Failed to Grant ROW
At-Fault Traffic Unit: # 1
EB Single Unit 0 Injuries Maneuver: Vehicle Going Straight
Trk/2axle/4tire
EB Automobile 0 Injuries Maneuver: Vehicle Going Straight

042.25 100 FT EAST OF TOWN FARM RD Thursday, September 04, 2003
149235 0738 Daylight Wet Rain
FARMINGTON
Collision Type: Sideswipe-Same Direction Contributing Factor: Speed
Too Fast for Conditions
At-Fault Traffic Unit: # 1
EB Automobile 0 Injuries Maneuver: Vehicle Skidding in Roadway
EB Automobile 0 Injuries Maneuver: Vehicle Going Straight

After

042.23 AT TOWN FARM RD Monday, June 16, 2003
132800 0813 Daylight Dry No Adverse Condition
FARMINGTON
Collision Type: Sideswipe-Same Direction Contributing Factor:
Improper Lane Change
At-Fault Traffic Unit: # 2
EB Automobile 0 Injuries Maneuver: Vehicle Going Straight
EB Automobile 0 Injuries Maneuver: Vehicle Changing Lane(s) to Right

042.25 100 FT E OF TOWN FARM RD Friday, June 14, 2002
130687 1152 Daylight Wet Rain
FARMINGTON
Collision Type: Rear-end Contributing Factor:
Following Too Closely
At-Fault Traffic Unit: # 3
WB Automobile 0 Injuries Maneuver: Vehicle Stopped For Traffic
WB Automobile 0 Injuries Maneuver: Vehicle Stopped For Stopped Vehicle
WB Single Unit Trk/2axle/4tire 0 Injuries Maneuver: Vehicle Skidded Slowing or Stopping For Stopped Vehicle

Southington Traffic Experience Report

Before

002.37 300 FT N OF WESTWOOD RD Friday, November 10, 2000
172682 0731 Daylight Wet Rain SOUTHINGTON
Collision Type: Sideswipe-Same Direction Contributing Factor: Unknown
At-Fault Traffic Unit: # 1
SB Automobile 0 Injuries Maneuver: Vehicle Going Straight
SB Truck-Trailer Combination 0 Injuries Maneuver: Vehicle Going Straight

After

No related accidents reported.

TOWN: Farmington DATE: 3/11/04 TIME: 16:00 - 17 WEATHER: Sunny

#cars	#trucks	rating	notes	#cars	#trucks	rating	notes
3		2		3		2	
2	1	2		2		2	
2		1		2		2	even
4		2		3		2	
3		2		2		1	
2		1		2		2	
m		2		m		2	
2		2		3		2	
2		1		2		1	
4		2		4		2	even
3		2		2		2	
2		1		2		1	
4		2		3		1	
2		2		3		2	
2		1		3		1	
3		2		2		2	
2		1		2		3	
3	1	2	Fun	2		2	
2		3		2		1	
3		2		2		1	
2		1		2		2	
2		1		3		1	
2		1		2		1	
2		1		4		2	
2		2		2		2	
3	1	2		3		2	
2		1		2		1	
3		1		2		2	
2		2		2		1	
3		2		3		2	
2		2		3		2	
1	1	2		2		1	
3		2		2		1	
3		2		2		1	
3		2		3		1	
3		2		2		2	
4		2		3		2	
2		1		3		2	
2		2		3		2	
2		1		2		1	
2		1		2		2	
3		3		4		2	
2		1		2		2	
2		2		m		2	
3		2					
2		2					
2		1					
2		2					
3		2					

Figure B-1 (Example) Evaluation Data Collection Form

Appendix C

Data Analysis and Results

Farmington Test Site

NPar Tests

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
Rating	12241	1.44	.646	1	4	1.00	1.00	2.00
Before(0)/After(1)	12241	.75	.434	0	1	.00	1.00	1.00

Mann-Whitney Test

Ranks

	Before(0)/After(1)	N	Mean Rank	Sum of Ranks
Rating	0	3088	6717.82	20744632.00
	1	9153	5919.65	54182529.00
	Total	12241		

Test Statistics[a]

	Rating
Mann-Whitney U	1.2E+07
Wilcoxon W	5.4E+07
Z	-12.823
Asymp. Sig. (2-tailed)	.000
Exact Sig. (2-tailed)	.000
Exact Sig. (1-tailed)	.000
Point Probability	.000

a. Grouping Variable: Before(0)/After(1)

Farmington Test Site

PLUM - Ordinal Regression

Warnings

There are 137 (39.4%) cells (i.e., dependent variable levels by combinations of predictor variable values) with zero frequencies.

Case Processing Summary

		N	Marginal Percentage
Rating	1	7798	63.7%
	2	3569	29.2%
	3	789	6.4%
	4	85	.7%
Before(0)/After(1)	0	3088	25.2%
	1	9153	74.8%
# of Cars	0	21	.2%
	1	834	6.8%
	2	8116	66.3%
	3	2584	21.1%
	4	431	3.5%
	5	255	2.1%
# of Trucks	0	10893	89.0%
	1	1278	10.4%
	2	65	.5%
	3	5	.0%
Road Surface Condition	Dry	10059	82.2%
	Snow	309	2.5%
	Wet	1873	15.3%
Even Approach	No	12007	98.1%
	Yes	234	1.9%
Valid		12241	100.0%
Missing		0	
Total		12241	

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	2119.666			
Final	929.201	1190.465	12	.000

Link function: Logit.

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	663.859	246	.000
Deviance	506.589	246	.000

Link function: Logit.

Pseudo R-Square

Cox and Snell	.093
Nagelkerke	.113
McFadden	.057

Link function: Logit.

Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Rating = 1]	-3.656	.872	17.571	1	.000	-5.365	-1.947
	[Rating = 2]	-1.509	.872	2.996	1	.083	-3.217	.200
	[Rating = 3]	.923	.876	1.110	1	.292	-.794	2.640
Location	[Before0After1=0]	.449	.043	110.151	1	.000	.365	.533
	[Before0After1=1]	0[a]	.	.	0	.	.	.
	[@#ofCars=0]	-2.492	.525	22.560	1	.000	-3.521	-1.464
	[@#ofCars=1]	-2.301	.160	207.437	1	.000	-2.614	-1.988
	[@#ofCars=2]	-1.510	.122	153.997	1	.000	-1.748	-1.271
	[@#ofCars=3]	-.410	.125	10.863	1	.001	-.654	-.166
	[@#ofCars=4]	-.135	.150	.820	1	.365	-.428	.158
	[@#ofCars=5]	0[a]	.	.	0	.	.	.
	[@#ofTrucks=0]	-2.403	.855	7.902	1	.005	-4.078	-.728
	[@#ofTrucks=1]	-1.006	.854	1.389	1	.239	-2.680	.667
	[@#ofTrucks=2]	-.541	.881	.377	1	.539	-2.267	1.185
	[@#ofTrucks=3]	0[a]	.	.	0	.	.	.
	[RoadSurface Condition=Dry]	-.176	.052	11.349	1	.001	-.278	-.074
	[RoadSurface Condition=Snow]	.007	.126	.003	1	.958	-.240	.253
	[RoadSurface Condition=Wet]	0[a]	.	.	0	.	.	.
	[EvenApp=No]	-.748	.131	32.632	1	.000	-1.005	-.491
	[EvenApp=Yes]	0[a]	.	.	0	.	.	.

Link function: Logit.

a. This parameter is set to zero because it is redundant.

Southington Test Site

NPar Tests

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
						25th	50th (Median)	75th
Rating	14854	1.43	.623	1	4	1.00	1.00	2.00
Before(0)/After(1)	14854	.69	.462	0	1	.00	1.00	1.00

Mann-Whitney Test

Ranks

	Before(0)/After(1)	N	Mean Rank	Sum of Ranks
Rating	0	4586	7978.58	36589760.50
	1	10268	7181.37	73738324.50
	Total	14854		

Test Statistics[a]

	Rating
Mann-Whitney U	2.1E+07
Wilcoxon W	7.4E+07
Z	-12.369
Asymp. Sig. (2-tailed)	.000
Exact Sig. (2-tailed)	.000
Exact Sig. (1-tailed)	.000
Point Probability	.000

a. Grouping Variable: Before(0)/After(1)

Southington Test Site

PLUM - Ordinal Regression

Warnings

There are 158 (38.7%) cells (i.e., dependent variable levels by combinations of predictor variable values) with zero frequencies.

Case Processing Summary

		N	Marginal Percentage
Rating	1	9382	63.2%
	2	4708	31.7%
	3	617	4.2%
	4	147	1.0%
Before(0)/After(1)	0	4586	30.9%
	1	10268	69.1%
# of Cars	0	43	.3%
	1	969	6.5%
	2	8418	56.7%
	3	3493	23.5%
	4	1008	6.8%
	5	923	6.2%
# of Trucks	0	13047	87.8%
	1	1685	11.3%
	2	119	.8%
	3	3	.0%
Road Surface Conditon	Dry	11525	77.6%
	Snow	771	5.2%
	Wet	2558	17.2%
EvenApp	No	14597	98.3%
	Yes	257	1.7%
Valid		14854	100.0%
Missing		0	
Total		14854	

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	2774.139			
Final	1223.631	1550.508	12	.000

Link function: Logit.

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	969.318	291	.000
Deviance	696.392	291	.000

Link function: Logit.

Pseudo R-Square

Cox and Snell	.099
Nagelkerke	.122
McFadden	.063

Link function: Logit.

Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Rating = 1]	-6.428	1.139	31.841	1	.000	-8.661	-4.195
	[Rating = 2]	-3.875	1.138	11.597	1	.001	-6.106	-1.645
	[Rating = 3]	-2.150	1.138	3.568	1	.059	-4.381	.081
Location	[Before0After1=0]	.336	.037	80.680	1	.000	.263	.410
	[Before0After1=1]	0[a]	.	.	0	.	.	.
	[@#ofCars=0]	-3.310	.426	60.301	1	.000	-4.145	-2.475
	[@#ofCars=1]	-2.121	.111	366.520	1	.000	-2.338	-1.904
	[@#ofCars=2]	-1.480	.069	460.787	1	.000	-1.615	-1.345
	[@#ofCars=3]	-.511	.072	50.577	1	.000	-.652	-.370
	[@#ofCars=4]	-.219	.088	6.162	1	.013	-.391	-.046
	[@#ofCars=5]	0[a]	.	.	0	.	.	.
	[@#ofTrucks=0]	-5.455	1.128	23.376	1	.000	-7.666	-3.244
	[@#ofTrucks=1]	-4.021	1.128	12.703	1	.000	-6.233	-1.810
	[@#ofTrucks=2]	-3.645	1.120	10.593	1	.001	-5.839	-1.450
	[@#ofTrucks=3]	0[a]	.	.	0	.	.	.
	[RoadSurface Conditon=Dry]	-.039	.046	.714	1	.398	-.130	.052
	[RoadSurface Conditon=Snow]	-.161	.089	3.290	1	.070	-.335	.013
	[RoadSurface Conditon=Wet]	0[a]	.	.	0	.	.	.
	[EvenApp=No]	-.690	.128	29.167	1	.000	-.940	-.439
	[EvenApp=Yes]	0[a]	.	.	0	.	.	.

Link function: Logit.

a. This parameter is set to zero because it is redundant.

Sample E-Mail from a Concerned Citizen

From:
Sent: Friday, September 26, 2003 6:12 PM
To: sue.maloney@po.state.ct.us
Subject: Concern over new traffic sign

Hi,

I would like to express my concern about a new traffic sign that has begun to appear on our roads. The sign shows two lanes merging and is replacing the "lane drop" sign that indicated a situation where one lane ends and the other lane continues.

The problem with the new sign is that it does not indicate which lane has the right of way, which the old sign did.

I understand that the old sign may have been confusing to many motorists in Connecticut as they seem to have had inadequate driver training and do not know what the sign means. Still, changing the sign seems like a foolish solution to this lack of education.

Best wishes,