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PEDESTRIAN SIGNALIZATION ALTERNATIVES

November 1983

Appendixes

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16. Abstract

The purpose of this study was to determine the operational and safety effects of various pedestrian signalization alternatives. An analysis was conducted of pedestrian accidents, traffic and pedestrian volumes, geometrics, and signal data for 1,297 signalized intersections in 15 U.S. cities to determine the safety effects of pedestrian signals and signal timing. The presence of standard-timed pedestrian (WALK/DONT WALK) signals was found to have no significant effect on pedestrian accidents. However, scramble (or exclusive) pedestrian timing was associated with significantly lower pedestrian accidents. Current MUTCD warrants for pedestrian signals were evaluated and Warrant 3 (Minimum Pedestrian Warrant) was found to be ineffective. An improved warrant was developed and is recommended for adoption.

Several new sign and signal alternatives were developed and field tested to indicate the clearance interval and to warn of pedestrian-vehicle conflicts. The alternatives recommended for inclusion in the MUTCD at high pedestrian hazard intersections include the WALK WITH CARE signal, a YIELD TO PEDESTRIANS WHEN TURNING regulatory sign, a PEDESTRIANS WATCH FOR TURNING VEHICLES warning sign, and a pedestrian signal explanation sign (word and symbolic). A three-phase pedestrian signal using DONT START to indicate the clearance interval was recommended for additional testing, and little or no benefit was found from the flashing WALK or the steady DONT WALK. Allowing pedestrians to yield to traffic and cross against the pedestrian signal was found to be undesirable based on safety considerations.

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Executive Summary

During the past twenty years, cities throughout the U.S. and Europe have installed different types of pedestrian signals in an effort to improve the safety and operational aspects of urban intersections. The purpose of this report is to summarize the state-of-the-art of pedestrian signals in terms of the safety, operational, and behavioral aspects of pedestrians.

Pedestrian Signals and Safety

A total of six papers were reviewed that attempted to address the issue of pedestrian signals and safety. Only one of these studies attempted to analyze pedestrian accident data, but the small sample size (11 sites) and the infrequency of pedestrian accidents per site prevented the researchers from making statistically sound conclusions. Other studies which utilized compliance as a safety measure generally concluded that pedestrian signals result in increased compliance rates and thus contribute to increased safety.

Experiences with push-button pedestrian signals (Pelican Crossings) in England and Australia revealed similar findings. Again, the nonavailability of accident data posed major problems to the researchers. The use of push-button pedestrian signals was found to be as safe or safer than similar locations with no pedestrian control. However, in cases where definite positive effects were felt (after the installation of push-button signals), it was difficult to isolate the singular effect of the pedestrian signal from the other countermeasures installed concurrently. Overall, most researchers and traffic engineers are of the opinion that pedestrian signals are likely to contribute to increased safety, even though no conclusive studies were found which support this contention.

Pedestrian Signals and Traffic Operations

A total of five papers were reviewed that relate to the effect of pedestrian signals on traffic operations. It was apparent from these studies that pedestrian signals almost always increase pedestrian delay, and at locations with heavy vehicular volume, overall vehicular delay is also likely to increase. Several authors noted that pedestrians often "jump-the-gun", regardless of the presence or absence of pedestrian signals.

Pedestrian Signals and Behavior

A total of eight papers were reviewed on the topic of pedestrian signals and behavior. The studies reviewed generally showed that: (1) unsafe pedestrian behavior is related to high hazard intersections; (2) compliance rates for flashing signals are generally lower than that of steady signals; and (3) the presence of a clearance interval with a pedestrian signal tends to increase compliance rates. There were also indications from the studies reviewed that pedestrians are likely to ignore signal indications under low vehicular volume conditions, particularly when the clearance interval exceeds the minimum.

Introduction

The prime objective of Task A is to determine if significant safety benefits can be derived by the installation of pedestrian signals. A two-phase procedure is being used in this study to address this question. In the first phase, a comprehensive literature review was conducted to determine what exactly is known relative to traffic signals and pedestrian safety. During the second phase, actual pedestrian accident data were collected from a number of cities and analyzed to develop further insights into the question. The purpose of this report is to describe the results of the literature review (Phase I) as it pertains to pedestrian signals and safety.

At the outset of the literature review, the subject of pedestrian safety was categorized into a total of seven topical areas as follows:

1. Pedestrian characteristics
2. Pedestrian signals
3. Pedestrian accidents and safety
4. Pedestrian behavior
5. Accident surrogates
6. Evaluation of countermeasures
7. Pedestrian ordinance/legislation

Each of the topical areas was then further subdivided into a number of functional subareas depending upon its complexity and content. This classification scheme resulted in a total of 49 functional areas. A total of 125 technical papers/articles/reports dealing with the general area of pedestrian safety were then identified through an extensive and comprehensive search of the current literature. Next, each of these papers was reviewed and identified as falling into one or more of these 49 subject areas. Table 1 shows this classification scheme and the categorization of these papers into these subareas. Concurrently with this matrix, an abstract has been prepared for each of these articles to aid in the recording of relevant research findings.

The literature review presented in this report has been categorized into three subareas as follows:

1. Pedestrian signals and safety
2. Pedestrian signals and operations
3. Pedestrian signals and behavior and compliance

Following the review, a summary has been presented that attempts to synthesize the relevant research findings.

Pedestrian Signals and Safety

The subject of pedestrian signals and traffic safety has been a topic of research among traffic engineers for a number of years. The concern for pedestrian safety is amply justified when one considers that between 18 and 22 percent of annual highway fatalities in the U.S. are accounted for by pedestrians and further, a majority of these pedestrian accidents occur in urban areas. In cities such as New York, Chicago and Washington D.C., pedestrians represent approximately half of the annual highway fatalities and most of these accidents take place at urban intersections.

While pedestrian fatalities constitute an alarming proportion of all highway fatalities, pedestrian accidents may be regarded as "rare" events at a single urban intersection, particularly in the context of statistical significance. The relative infrequency of pedestrian accidents (in the context of all highway accidents) is the prime reason why the traditional 'Before and After' approach of analyzing accident data has not been successfully used in assessing the safety benefits of pedestrian signals. A number of technical articles were reviewed in the general area of pedestrian safety and signals. It will be evident from the discussion below, that the issues of safety, operation, and behavior (compliance) have overlapped in some of these papers.

1. Abrams and Smith, as a part of a FHWA sponsored study on "Urban Intersection Improvements for Pedestrian Safety", attempted to address the safety (and delay) aspects of pedestrian signals [1]. Three types of pedestrian signal phasing were analyzed, i.e., early release, late release, and scramble timing and the results were compared with the effects of combined pedestrian-vehicle interval (see Figure 1). The authors performed compliance studies in Sioux City, Iowa, to assess the safety benefits of different signal phasing and concluded that:

- The early release technique may provide a measure of additional safety, but the benefits were not precisely determined.
- Higher compliance rates associated with late release techniques are indicative of increased pedestrian safety.
- Scramble timing has the capability of increasing pedestrian safety by completely eliminating pedestrian-vehicular conflict. However, violation rates for scramble timing were found to be higher, particularly at narrow streets.

Table 1. Categorization of pedestrian literature into different subareas.

Reference (Author & Title) (1)	Location of Study (2)	Pedestrian Characteristics (3)	Pedestrian Signals (4)	Pedestrian Accidents & Safety (5)	Behavior (6)	Accident Signals (7)	Evaluation of Countermeasures (8)	Pedestrian Ordinance/ Legislation (9)
1. Abrams, C. Selecting Pedestrian Signal Phasing. TRB Record 629	U.S.		X		X		X	
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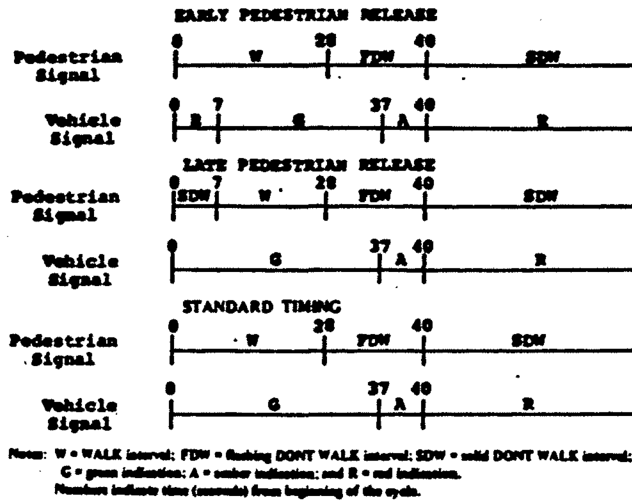

Figure 1. Timing used in the analysis of early and late release of pedestrians.

Source: Reference 1.

2. Mortimer, as a part of a research project at Eastern Michigan University, compared the compliance rates of pedestrian crossings at intersections with and without pedestrian signals [2]. His methodology consisted of: (1) identifying similar signal controlled intersections with and without pedestrian phases (WALK versus DONT WALK); (2) Collecting data at these intersections on pedestrian crossing, both on compliance (start mode, legal versus illegal) as well as completion of crossing (successful versus unsuccessful); and (3) developing two types of hazard index data and other similar statistics on pedestrian crossing. Mortimer found that:

- An estimated 76.6 percent of the pedestrians crossed on green at intersections with pedestrian signals, and 63.7 percent crossed on green at intersections without pedestrian signals.

- Better signal compliance was found at intersections with pedestrian signals, than at those without them.

- There were 34.4 percent fewer illegal starts and 14.4 percent more successful crossings at intersections with pedestrian signals than at those without pedestrian signals (Table 2).

- Hazard index values, calculated for intersections with pedestrian signals were slightly lower than those calculated for intersections without pedestrian signals (Tables 3 and 4).

Table 2. Percent of start and arrival modes in two signal conditions.

Arrival Mode	Without Pedestrian Signal			With Pedestrian Signal		
	Start Mode			Start Mode		
	Legal	Illegal	Total	Legal	Illegal	Total
Successful	69.5	7.5	77.0	82.9	6.0	89.9
Unsuccessful	10.2	12.8	23.0	2.8	8.3	11.1
Total	79.7	20.3	100.0	85.7	14.3	100.0

Source: Reference 2.

Table 3. Hazard index I: proportion of run to walk frequencies.

Hazard Index I	Without Pedestrian Signal				With Pedestrian Signal				
	Start Mode				Start Mode				
	Green	Amber	Red	Mean	Walk (Green)	Don't Walk (Green)	Don't Walk (Amber)	Don't Walk (Red)	Mean
# Run / # Walk	0.20	1.12	0.48	0.33	0.09	0.75	0.82	0.81	0.29

Source: Reference 2.

Table 4. Hazard index II: proportion of pedestrian and driver actions to walk and run frequencies.

Hazard Index II	Without Pedestrian Signal				With Pedestrian Signal				
	Start Mode				Start Mode				
	Green	Amber	Red	Mean	Walk (Green)	Don't Walk (Green)	Don't Walk (Amber)	Don't Walk (Red)	Mean
# Ped. + Driver Actions / # Walk + Runs	0.20	0.32	0.15	0.20	0.18	0.20	0.19	0.21	0.20

Source: Reference 2

- There was an estimated 27 percent reduction of potentially serious pedestrian-vehicle conflicts at intersections with pedestrian signals.

- The use of pedestrian signals was instrumental in improving compliance, and more information to pedestrians resulted in more comfortable crossings and fewer crossing hazards.

3. Fleig and Duffy in a study conducted in the City of New York in the early sixties examined behavioral data at a given intersection and limited accident data at a number of urban intersections before and after the installation of pedestrian signals [3]. The authors mention that they used safety behavior rather than accidents as a primary measure of effectiveness of signals "because the infrequent occurrence of accidents requires that too much time must elapse before sufficient data are available upon which to base conclusions." Thus, in evaluating the effect of WALK - DONT WALK signals, the authors postulated that if pedestrians were persuaded by these signals to conduct themselves more carefully, there would be fewer accidents and thus the signals would be performing a useful safety function.

In evaluating the safety behavior of pedestrians, the authors identified a number of pedestrian actions or violations as unsafe acts, and determined the trends in these unsafe acts before and after the installation of a pedestrian signal with a Barnes Dance type of phasing. For the accident study, they analyzed the pedestrian accident data at a total of 11 (eleven) intersections one year before and one year after the installation of the pedestrian signals. They found that:

- There was no significant reduction in the proportion of unsafe acts before and after the installation of the pedestrian signals at the intersections studied. Based upon this evidence, the authors went on to conclude that "pedestrian signals are not an effective method for reducing pedestrian accidents."

- There was a slight reduction in the number of pedestrian accidents at the eleven intersections studied (27 versus 25) before and after the installation of the pedestrian signals (Table 5). However the distribution of these accidents at individual intersections, when compared between the before and after period, does not indicate any trends. The relative infrequency of accidents at each intersection presented problems to the authors in drawing sound conclusions regarding the effectiveness of the signals. Based on the limited accident data the authors came to the same conclusion that "pedestrian traffic signals are not an effective method for reducing pedestrian accidents."

It must be mentioned that the validity of the second conclusion can be seriously questioned based upon issues raised by the authors themselves, namely working with a limited data base that precludes the development of conclusions with statistical significance. Also, a gross comparison of pedestrian accidents without carefully analyzing actual accident reports may not necessarily be indicative of the effectiveness of signals. In particular, accidents that are attributable to factors such as vehicle failure, drunken driving, etc., (that are often totally unrelated to signal operation) should be screened out in such an analysis. The authors do not report on any such screening effort. This study, however, appears to be one of the very few that attempted to analyze actual pedestrian accident data to assess the effectiveness of pedestrian signals. In spite of this effort and the categorical statement made by the authors (as quoted above), the study does not show any conclusive evidence about either positive or negative effect of pedestrian signals with respect to accidents.

Table 5. Accident record search data.

Intersection Number	No. of Pedestrian Accident 1 Year Prior to Signal Installation	No. of Pedestrian Accident 1 Year After Signal Installation
1	7	4
2	2	4
3	1	0
4	2	1
5	3	1
6	2	4
7	3	0
8	1	3
9	1	1
10	3	3
11	2	4
	27	25

Source: Reference 3.

4. Inwood and Grayson in a study conducted for the Transport Road Research Laboratory, England analyzed injury accident data, pedestrian counts and vehicle flows for lengths of road on and near pedestrian crossings [4]. A total of 140 crossings were studied. The prime objective of this study was to compare pedestrian accident rates at Zebra and Pelican crossings. These crossings were located in similar conditions at

sites throughout England which were selected on the basis of good visibility and not being too close to busy intersections. The study showed that:

- There was no significant difference in accident rates between Zebra crossings with and without pedestrian refuges.
- There was no evidence of a difference in pedestrian accident rates between Pelican and Zebra crossings[1].
- Pelican crossings tended to have a lower total injury accident rate than Zebras when the road length in the vicinity of the crossings is taken into account.

The second and third conclusions presented above may have some relevance to the present study. It appears from the second conclusion that push-button types of signals (Pelicans) are not any more effective than pavement markings (Zebras) in reducing pedestrian accidents. However, the third conclusion suggests that when all injury accidents are considered, pedestrian actuated signal crossings are more effective.

5. Skelton and Trenchard, in another study related to the effectiveness of Pelican crossings, conducted surveys at a number of sites in the city of Newcastle-upon-Tyne and in a town in rural Northlumberland, England [5]. The study did not analyze any accident, operational or compliance data, but mainly focused on an opinion survey among pedestrians on the understanding and effectiveness of Pelican crossings.

The study concluded that there was a lack of understanding on the part of the general public (pedestrians as well as drivers) of the complicated way in which the crossings are designed to work. The study recommended that if the potential of the crossing devices are to be fully realized, significant operational and design improvements must be made. Specific recommendation in this regard included: extension of "Green Man Stage" (crossing interval), providing a better visibility to the signal head and arranging greater publicity prior to the installation of the signals.

The above study is not to be categorized as a safety study as it does not deal with any accident or compliance data. However, it provides significant information relative to the effectiveness of new or innovative control devices and public acceptability. The study suggests that ade-

[1] Pelican crossings are pedestrian actuated crossings in which the pedestrian phase is initiated by a pedestrian push-button. Zebra crossings are crossings with alternate black and white stripes and are occasionly marked with flashing beacons.

quate publicity and appropriate placement are necessary prerequisites to the successful utilization of any new control device. The message of these devices must be properly received and understood by the motorists and pedestrians, if the intended purpose is to be properly served.

6. Williams, in his paper entitled "Pelican Crossings - Myth or Miracle", presented at the Joint ARRB/DOT Pedestrian Conference (1978), discusses the evolution of the Pelican concept in England and in Australia [6]. His paper summarizes the findings and experiences of different researchers on safety, operation and behavior. The discussion is primarily oriented towards a comparison with its predecessor, the Zebra crossing. The author mentions that uncontrolled Zebra crossings originally introduced in 1951, were reported to cause delay and congestion in heavy vehicle and pedestrian flows. Once one group established right-of-way over the crossings, it was very difficult for the other group to change it unless most of the crossing demand was satisfied. A signal controlled crossing on the other hand, could cause unnecessary delays to motorists particularly in cases of low pedestrian volumes even after all pedestrians had completed the crossing. The Pelican crossing, which is intermediate in characteristics between a Zebra and signal controlled crossings thus appeared to present considerable advantages.

Williams mentions at least one study in Australia found that accidents had fallen by 60 percent at a group of Pelican crossings which had replaced its predecessor, the Zebra crossings. In other studies reported by Lalani and Rayner, the result appeared to be less favorable in the context of pedestrian accidents. In a study conducted by Willett on three Pelican crossings in Perth, Australia, pedestrian accidents did not appear to change after the installation of the Pelican signals.

It thus appears that the safety advantages of Pelican crossings are not as clear and unquestionable as originally postulated. Based upon these findings, Williams suggests that it is not possible to definitely conclude that Pelican crossings significantly increase pedestrian safety. He mentions that in most of the sites where positive safety benefits were indicated, the results appear to be masked by the presence of other factors. In most of these cases, there were a number of other countermeasures installed, (e.g., antiskid surfacing, guardrails, etc.) the effects of which are very difficult to isolate from the overall safety effect of the Pelicans.

Williams' paper should be regarded as an excellent documentation of the evolution and safety experience with Pelican crossings in England and Australia. Although the studies reported by Williams do not provide conclusive evidence of positive safety benefits of Pelican crossings, there was also no indication of any adverse effect in the studies reviewed. The paper also presents similar historical information on the operational and behavioral aspects of Pelican crossings, which is presented in a later part of this report.

Pedestrian Signals and Operations

The impact of pedestrian signals on traffic operation at or near urban intersections has been studied by a number of researchers. Traffic engineers, in particular, have been concerned about the possible effects of pedestrian signals on delay (to pedestrians as well as to motorists) and on intersection capacity. A brief review of the research conducted in this area is presented below.

1. Abrams and Smith in their FHWA sponsored study evaluated the delay effects of three types of pedestrian signals early release, late release and scramble timing, relative to combined vehicle-pedestrian interval [1]. They used the technique of time-lapse photography to record events and computed delay from the recorded data. For the purpose of this study, delay was defined as "the difference between the time required for a right-turning movement with pedestrians in the crosswalk and the time required for a right-turning movement without pedestrians in the crosswalk." Thus, the definition of delay did not include any effect of the traffic signal itself.

The study showed that the standard (concurrent) pedestrian vehicle interval will almost always result in lower overall pedestrian and vehicle delay than other pedestrian signal timing schemes (i.e., scramble, early release, or late release). The only exception to this situation occurs in cases of long queues of vehicles in a right-turning lane (or left-turning lane of a one-way street) caused by pedestrian-vehicle conflicts. The specific conclusions of this study relative to each of the three signal phases are:

- The early release technique always increases total intersection delay (Table 6).
- The late release technique may result in a reduction of total intersection delay only under certain combinations of volume and geometrics (Table 7).
- Scramble timing always increases pedestrian delay.

2. Pretty analyzed the relative delays to pedestrians and vehicles with two methods of signal control: (1) exclusive pedestrian phase (scramble timing); and (2) shared phase with motor vehicles as shown in Figures 2 and 3 [7]. As these two figures demonstrate, the method of pedestrian control at intersections can have a considerable influence on pedestrian routing patterns and resulting delays.

Table 6. Increase in delay from early release timing over standard timing.

Pedestrian Volume per Cycle	Pedestrian Delay (person-s)	Vehicle Delay (person-s/cycle) 2 Veh/Cycle Max	Min	4 Veh/Cycle Max	Min	6 Veh/Cycle Max	Min	8 Veh/Cycle Max	Min	Total Delay (person-s/cycle) 2 Veh/Cycle Max	Min	4 Veh/Cycle Max	Min	6 Veh/Cycle Max	Min	8 Veh/Cycle Max	Min
0	—	21	0	42	0	63	0	84	0	21	0	42	0	63	0	84	0
2	0	18	0	36	0	54	0	72	0	18	0	36	0	54	0	72	0
5	0	18	0	36	0	54	0	72	0	18	0	36	0	54	0	72	0
10	0	15	0	30	0	45	0	60	0	15	0	30	0	45	0	60	0
20	0	12	0	24	0	36	0	48	0	12	0	24	0	36	0	48	0

Notes: Based on vehicle occupancy rate of 1.5 persons/vehicle.
Maximum possible increase in vehicle delay for early release versus standard timing occurs when the first vehicle turns right and the remaining vehicles go through the intersection. Minimum increase occurs when at least the first three vehicles and possibly all vehicles go through the intersection.

Source: Reference 1

Table 7. Increase in delay from late release timing over standard timing.

Pedestrian Volume per Cycle	Pedestrian Delay (person-s)	Vehicle Delay (person-s/cycle) 2 Veh/Cycle Max	Min	4 Veh/Cycle Max	Min	6 Veh/Cycle Max	Min	8 Veh/Cycle Max	Min	Total Delay (person-s/cycle) 2 Veh/Cycle Max	Min	4 Veh/Cycle Max	Min	6 Veh/Cycle Max	Min	8 Veh/Cycle Max	Min
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	9	0	-8	2	-20	6	-32	12	-44	9	1	11	-11	15	-23	21	-35
5	21	0	-15	3	-36	12	-57	21	-78	21	6	24	-15	33	-36	42	-57
10	41	0	-29	5	-68	21	-107	42	-146	41	12	46	-27	62	-66	83	-105
20	83	0	-53	8	-139	26	-185	165	-312	83	30	91	-56	109	-102	248	-229

Notes: Based on vehicle occupancy rate of 1.5 persons/vehicle.
Maximum possible increase in vehicle delay for late release versus standard timing occurs when the first three vehicles go through the intersection and the remainder turn right. Minimum increase (maximum decrease) occurs when the first three vehicles turn right and the remainder go through the intersection.
Negative sign indicates that vehicle delay decreased with late release.

Source: Reference 1

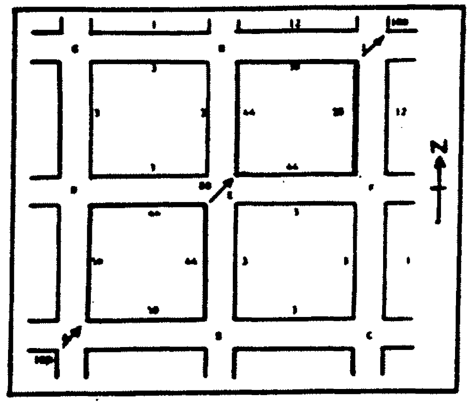

Figure 2. Network pedestrian paths with exclusive pedestrian phasing.

Source: Reference 7

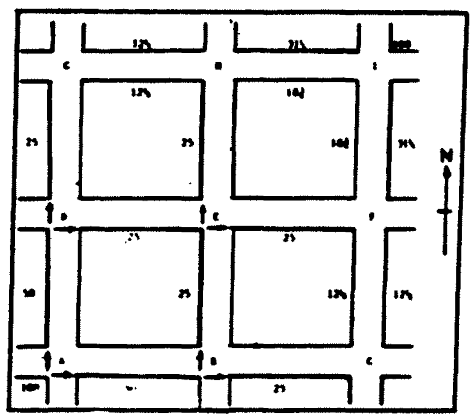

Figure 3. Network pedestrian paths with standard pedestrian phasing.

Source: Reference 7

Pretty used a deterministic numerical technique (developed by Miller[1]) that is commonly used in Australia to compute bicycle crossing intervals, signal settings and delays. He estimated pedestrian and vehicle delays for varying cycle lengths corresponding to two groups of signal controls (scramble timing, and shared phase with motor vehicles). Pretty's methods of computing delay (based upon an empirical relationship rather than observed data) represents a departure from techniques used by most other researchers. Studies conducted in Australia have primarily used recorded events to compute delays. Pretty also assumed that pedestrians arrive at a uniform rate throughout each cycle and that the number of pedestrians desiring to cross both streets is twice the number crossing one street. It should be noted here that his assumption of pedestrian arrivals contradicts assumptions made by researchers in the U.S.

The numerical examples presented by Pretty do not lend themselves to a direct comparison between the two types of control. It does appear, however, from the results presented that scramble timing significantly increases both pedestrian and vehicular delay, although the signal parameters (cycle length, etc.) analyzed in the two cases are somewhat different. The author does not address the question as to whether the differences in the total intersection delay is due to differences in the types of control, or the differences between the signal parameters. It is however, safe to assume that the differences are attributable to a combination of these two factors.

Pretty also shows that pedestrians are always likely to benefit from shorter cycle lengths which results in reduced pedestrian delay. The study also shows that increased pedestrian volume significantly increases pedestrian delay (a conclusion that appears quite obvious).

3. Smith in his ITE paper discusses problems associated with the lack of consistency in the timing of pedestrian clearance intervals as well as different phasing schemes [8]. He computed both the vehicle right-turn delays and pedestrian delays for two hypothesized timing schemes: (1) minimum clearance alternative; and (2) minimum WALK alternative as shown in Figure 4.

Vehicular right-turn delay was computed using a relationship that was developed from data collected for 68 hours of time-lapse photography at intersection approaches in Washington, D.C.; Phoenix, Arizona; Akron, Ohio; and Cambridge, Massachusetts (Figure 5). Pedestrian delay was calculated using a bi-level arrival rate with the assumption that such arrivals

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1 Miller, A.J., "Signalized Intersections - Capacity Guide", Australia Road Research Board, Research Report AAR, No. 79, 1972.

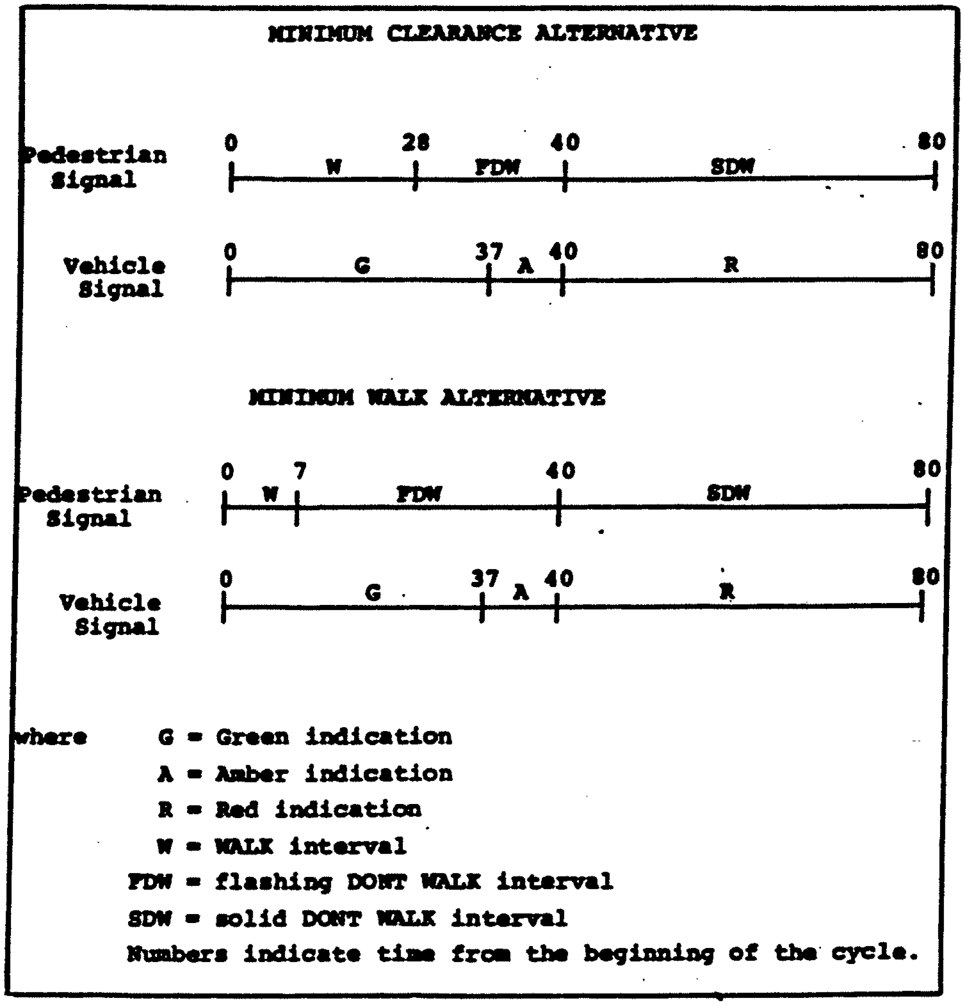

Figure 4. Vehicle and pedestrian phases tested in vehicle delay analysis.

Source: Reference 8.

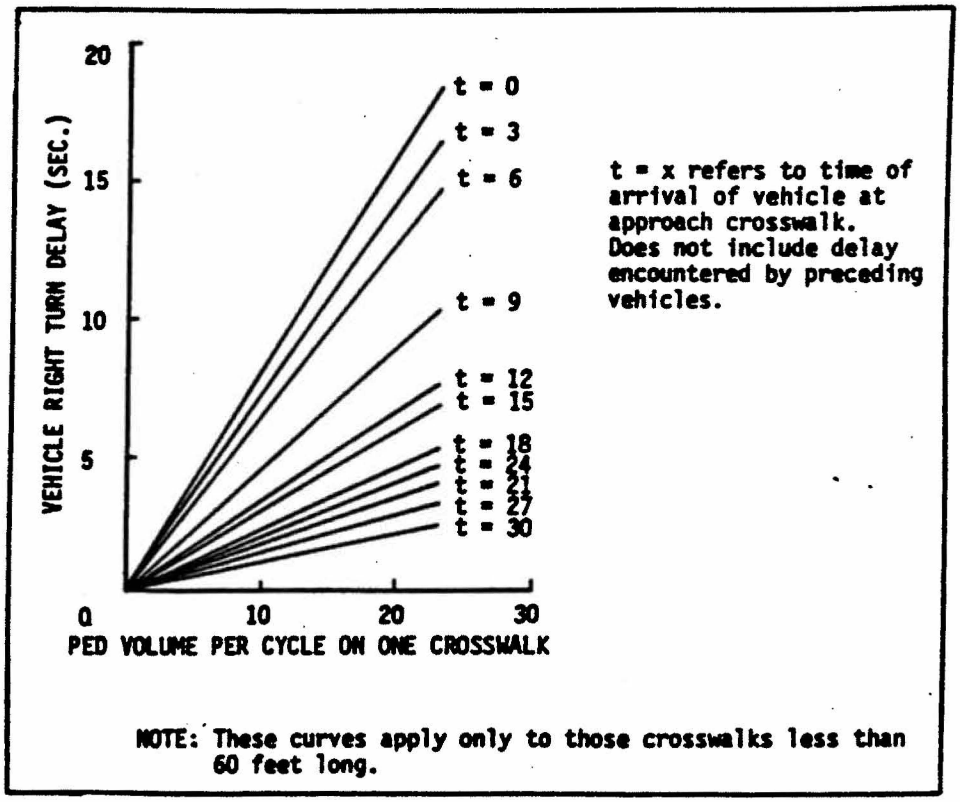

Figure 5. Relationship between pedestrian volume and vehicle right turn delay.

Source: Reference 8.

are highest during and just prior to the WALK interval and approximately half that rate following the WALK interval.

Smith's study showed that the minimum WALK alternative reduces vehicle right-turn delay because of no interference between pedestrians and vehicles after the initial platoon of vehicles has crossed the street (Table 8). Smith also concluded that the increase in pedestrian delay of the minimum WALK alternative over the others was significantly greater than the decrease in vehicle right-turn delay. He went on to conclude that clearance intervals longer than the minimum generally increase overall intersection delay.

4. Wilson, as a part of a study conducted at the Transport Research Road Laboratories, England assessed the operational and behavioral effects of installing an audible signal for pedestrians at a signal controlled intersection [9]. He used time lapse photgraphy to record pedestrian crossings at a signalized intersection for two separate time periods, before the installation of audible signal and one year after the audible signal was installed (Figure 6). The data was then analyzed to determine the effectiveness of the signal. Only adult pedestrians ages 15 to 59 were observed. Wilson's major conclusions can be summarized as follows:

- Pedestrian delay at the curb was not affected by the installation of the audible signal (Table 9).

- Time taken to cross the road by pedestrians crossing during the "Green Man" phase decreased by 5 percent (Table 9).

- For those pedestrians starting to cross during the "Green Man" phase, a significant reduction was obtained in the proportion failing to complete their crossing before the vehicle green signal began (Figure 7).

- Significant differences in pedestrian behavior and delay were observed during the analysis of "before" and "after" data. Further, these behavioral and delay characteristics indicate positive safety effects through installation of the audible signal.

5. The paper written by Williams and discussed earlier in connection with pedestrian safety also presented findings on the effect of Pelican crossings on traffic operation [6]. In the only known study (reported by Golden - 1977, conducted at a single Pelican crossing site in Dublin before and after its installation) it was found that there was no difference in delay/stopped vehicles as compared to Pelican and Zebra crossings. Compared to non-Pelican traffic signals, such delays were substantially lower in both cases. On the question of delays to pedestrians, in almost all studies reported by Goldschmidt (1977), Willet (1977), and the TRRL

Table 8. Delay effect of the minimum clearance alternative relative to the minimum WALK alternative.

Pedestrian Volume Per Cycle	Increase In Ped. Delay per cycle (person-sec.)	Decrease in vehicle delay per cycle for various veh. volumes (delay in person-sec.)*				Increase in total delay per cycle for various veh. volumes under min. WALK alternative			
		2 vpc	4 vpc	6 vpc	8 vpc	2 vpc	4 vpc	6 vpc	8 vpc
0	—	0	0	0	0	0	0	0	0
2	31	0	0	0	0	31	31	31	31
5	75	0	2	9	18	75	73	66	57
10	148	0	9	24	39	148	139	124	109
20	299	5	23	41	231**	294	276	258	68

* Note: Person delay assumes an average vehicle occupancy of 1.5 persons per vehicle.
** This significant jump in vehicle delay arises out of the inability of the 7th and 8th vehicles to make their turn during this cycle. They are assumed to make their turn during the following cycle.

Source: Reference 8

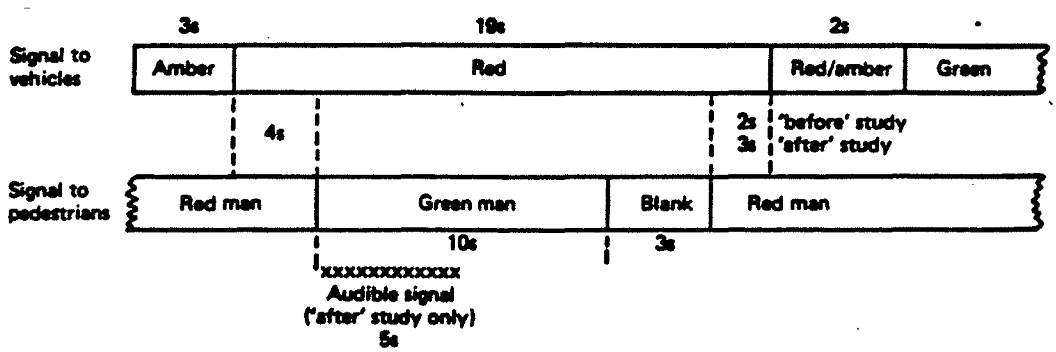

Figure 6. Signal phasing diagram used by Wilson.

Source: Reference 9

Table 9. Summary of adult pedestrian behavior before and after installation of an audible signal at a light controlled crossing (road width 11.6 m).

Light phase showing when pedestrian:— Arrives at kerb	Starts to cross	Study	Percentage of pedestrians who finish crossing in:— Green Man or blank phases	Red Man phase	Number of pedestrians observed	Mean kerb delay	Mean crossing time	Mean walking speed	Mean time after start of Green Man phase when pedestrian starts crossing
Blank or Red Man	Green Man	Before	78%	22%	436	29.1 sec	8.6 sec	1.34 m/sec	2.7 sec
		After	89%	11% *	485	30.9 sec	8.3 sec *	1.40 m/sec	2.1 sec *
Green Man	Green Man	Before	40%	60%	294	0.2 sec	8.1 sec	1.43 m/sec	5.7 sec
		After	51%	49% *	295	0.1 sec	7.5 sec *	1.54 m/sec	5.1 sec *
Blank	Blank	Before	–	100%	52	0 sec	6.7 sec	1.74 m/sec	11.3 sec
		After	–	100%	38	0 sec	6.8 sec	1.72 m/sec	10.7 sec *
Any phase	Red Man	Before	24%	76%	282 (Sample)	16.6 sec	7.8 sec	1.48 m/sec	Not applicable
		After	19%	81%	283 (Sample)	16.9 sec	7.6 sec	1.53 m/sec	

* Difference between before and after figures statistically significant at 5 per cent level (ie the probability of such a difference occurring by chance is less than one in twenty).

Source: Reference 9

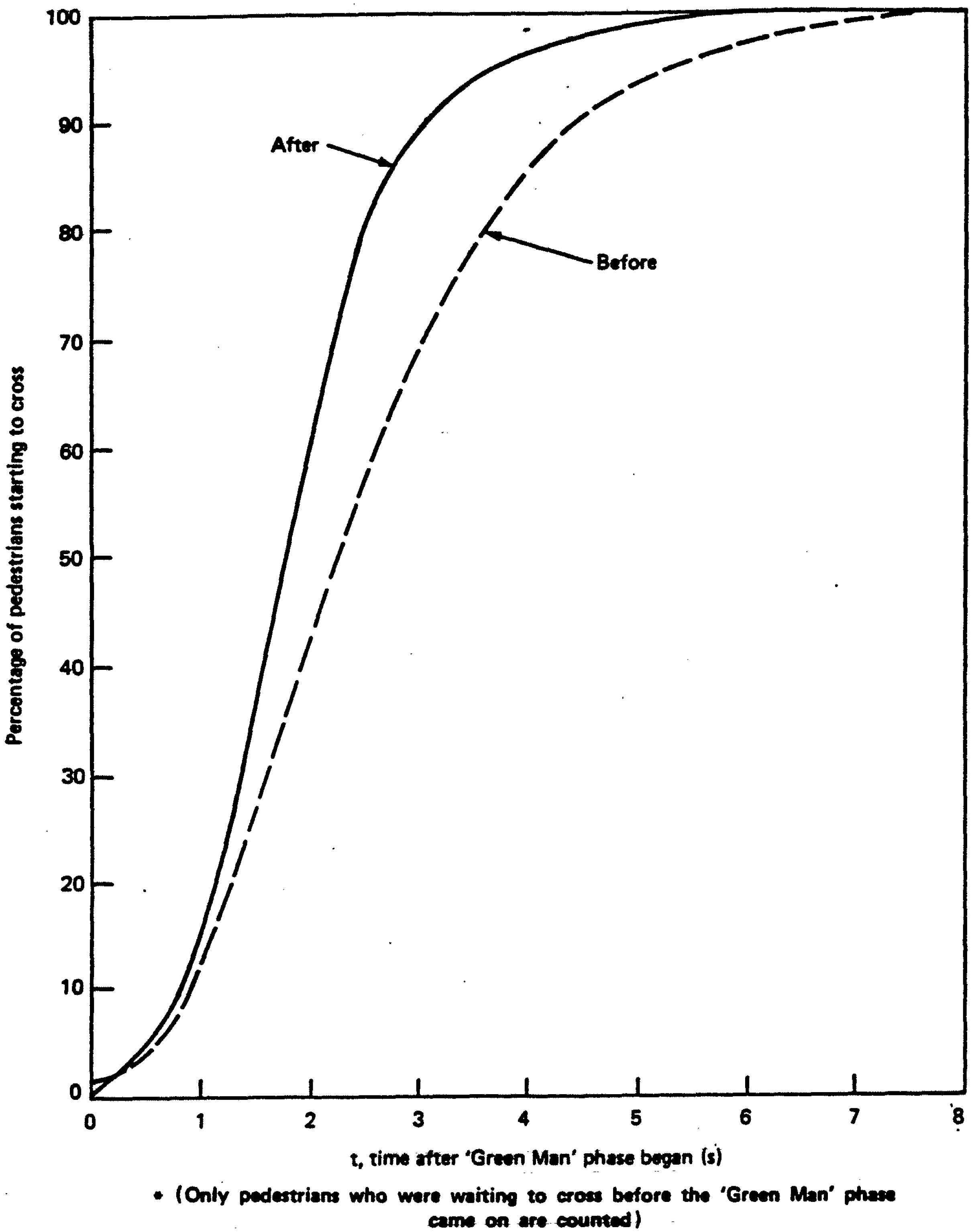

Figure 7. Cumulative percentages of pedestrians starting to cross within a given time (t) of "Green Man" phase commencing.

Source: Reference 9

(1976), Pelicans appeared to increase delays over Zebras. Also, compared to situations where no special crossing facility existed, Zebras significantly reduced pedestrian delays. Based upon these findings, Williams makes this general conclusion that "Pedestrian delays at Pelicans are similar to those at signal controlled crossings but are much higher than at Zebra crossings".

Pedestrian Signals and Behavior

The possible effects of pedestrian signals on the behavior of pedestrians and motorists has been a topic of research among traffic engineers and psychologists for a number of years. The aspect of such behavioral studies is of immense importance to safety analysts, since in the absence of sufficient accident data (which is often the case for pedestrian accidents), behavioral changes associated with pedestrians signals may often be regarded as indicative of safety improvements. With this in mind, a number of behavioral studies were reviewed, and are presented below:

1. Jennings et al., studied pedestrian behavior at a number of signalized locations that had experienced a large number of pedestrian accidents in the City of Portland [10]. The authors used video recording techniques to observe the behavior of 107 pedestrians crossing at signalized intersections. These data were collected for three broad purposes: (1) to determine if specific behavioral characteristics can be categorized; (2) to determine if the categories can be reliably used by independent observers; and (3) to determine if an analysis of the categories can describe or identify potential unsafe behavior. The authors found that pedestrian behavior could be described in terms of its unsafe aspects. To quote the authors:

> "Numerous pedestrians do not obey the DONT WALK signal. Numerous pedestrians do not look in the presence of either a WALK or DONT WALK signal before crossing the street. Moreover, the pedestrians who do not stop also do not look. In short, there are a reasonable number of pedestrians who do not appear to assess the traffic situation before crossing the street".

Based upon their findings, the authors concluded that:

- Pedestrian accident records can be used to assist in the selection of sites for collection of unsafe behavioral data.
- Certain types of behavioral data can be categorized.
- The behavior of some pedestrians at intersections is potentially unsafe and injury-producing.

- The proper development of a field observational methodology improves the opportunity to understand and reduce pedestrian accidents.

Jennings' study does not directly pertain to the question of behavioral changes associated with pedestrian signals, but it provides some useful information. The study indicates that unsafe behavior is associated with intersections experiencing higher frequencies of pedestrian accidents. However, the above inference can be seriously questioned, since the authors did not attempt to collect similar behavioral data at intersections with little or no pedestrian accident occurrences, and did not test how pedestrian behavior at these intersections compared with those at the original intersections studied. It is entirely possible that even at those "safer" intersections, the authors could find similar unsafe pedestrian behavior. If this were so, then the postulated association between unsafe behavior and accidents would not be true. In the absence of such an objective comparison of behavioral data between safe and hazardous intersections, the first three conclusions appear highly questionable. The last conclusion, on the other hand is quite obvious and does not require much elaboration.

The authors, further, did not develop any quantitative relationship between "unsafe behavior" and pedestrian accidents. Yet if such a relationship could be developed, it might be possible to evaluate the safety effects of pedestrian countermeasures through the observation of behavioral changes.

2. Smith discussed the importance of compliance of signal indications by pedestrians and suggests the purpose of a pedestrian clearance interval is likely to be defeated if such clearance intervals are longer than the minimum required intervals [8]. Compliance studies were performed at two intersections each in the cities of Washington, D.C., Phoenix, Arizona, and Buffalo, New York to determine the pedestrian compliance to a flashing DONT WALK interval which was longer than the minimum clearance. At each intersection several timing schemes were installed (ranging from the minimum clearance interval to long clearance intervals) and compliance data collected.

The data showed a trend of lower compliance (lowest percentage beginning to walk during the WALK interval) for those timing alternatives with the least amount of time allocated to the WALK interval (longer clearance intervals). Pedestrians appeared to show a higher degree of disregard for flashing DONT WALK (FDW) clearance intervals which are longer than the minimum (Figure 8). The author states the reason for decrease in compliance for clearance intervals larger than the minimum "appears to be that average pedestrians are not 'fooled' into thinking they have less time to cross the street before vehicles in the cross street are released".

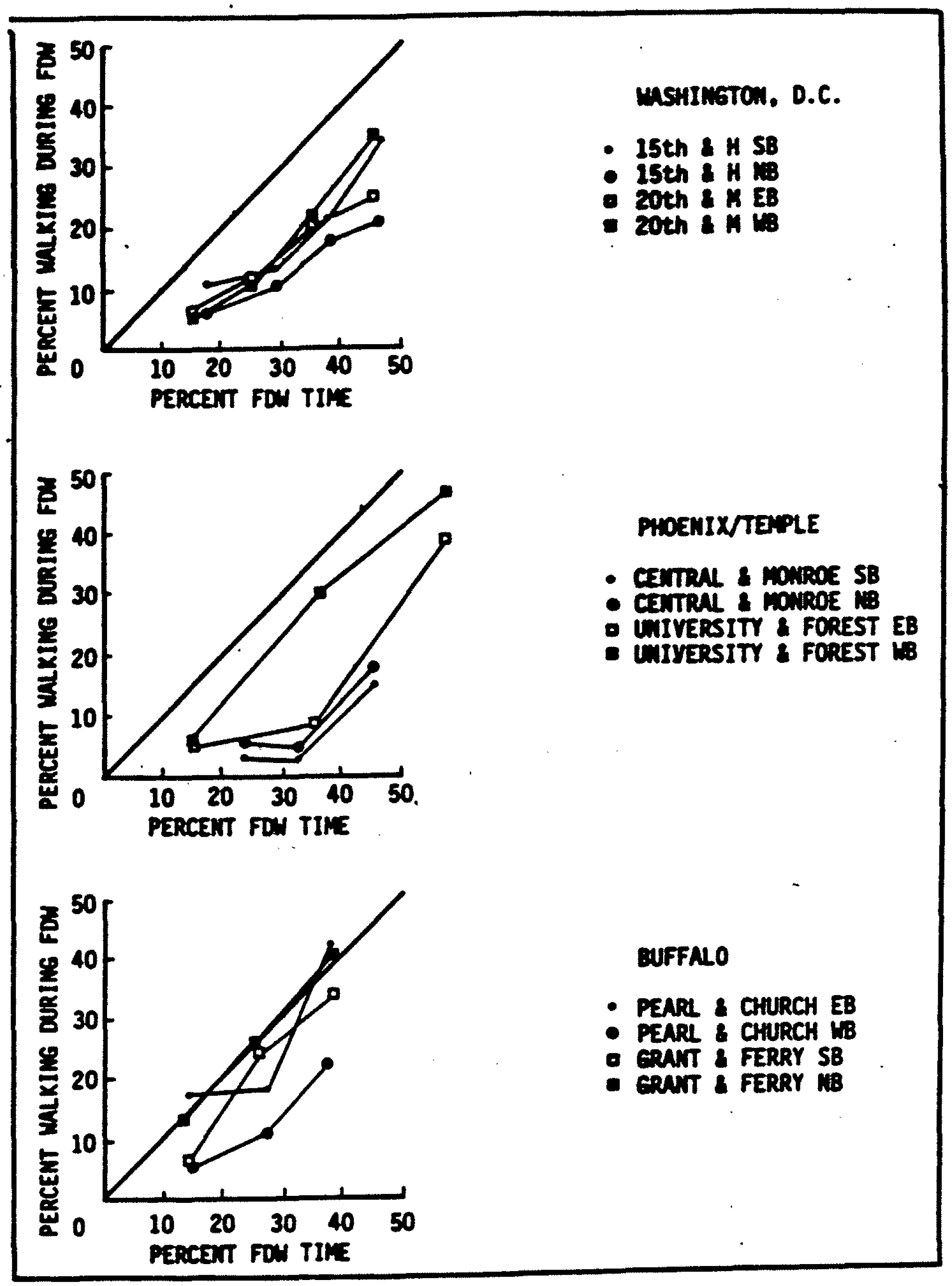

Figure 8. Relationship between compliance to the clearance interval and signal timing.

Source: Reference 8

3. Sterling in his ITE paper, that won the 1974 Past Presidents Award for Merit in Traffic Engineering, attempted to quantify pedestrian reaction to flashing WALK as well as the steady WALK indications [11]. He describes two measurable aspects of pedestrian attributes as reflective of pedestrian behavior: (1) observation rate being the percentage of legal crossings, and (2) conflict rate being the percentage of crossings with specifically defined interruptions. The quantification of these variables was used to develop conclusions with respect to pedestrian reaction regarding the two types WALK signals (flashing WALK and steady WALK). The author analyzed a number of crossings as follows:

- Decision legal crossing. An individual waits until the WALK interval before crossing.
- Nondecision legal crossing. An individual continues across the street without interruption during a WALK interval.
- Flashing DONT WALK crossing. An individual continues across the street illegally during flashing DONT WALK interval.
- Decision illegal crossing. An individual waits during the steady DONT WALK interval until an adequate gap appears in traffic and then crosses, usually without conflict.
- Arrival illegal crossing. An individual continues across the street during the steady DONT WALK interval, usually by weaving through the vehicular traffic.

Sterling collected pedestrian behavior data at a number of locations with a high concentration of pedestrian and vehicular volume in a total of twelve one-hour time intervals. In virtually all comparisons that were made with the data collected, it was found that the reaction to flashing WALK was less favorable than to steady WALK. The compliance rates for these steady and flashing signals were 51 percent and 29 percent, respectively, the corresponding conflict rates were 6 percent and 8 percent. Although the percentage difference in conflict rate is not so drastic as in the compliance rate, the effectiveness of flashing WALK signals appear questionable from these results. The specific conclusions of this study are:

- A significantly higher percentage of legal crossings and decision legal crossings occurred with the steady WALK as compared with the flashing WALK.
- A significantly higher percentage of illegal conflict crossings occurred with the flashing WALK than with the steady WALK.

4. Reiss, in a paper published by the ITE that was developed from a study conducted for the FHWA, discusses behavior of young pedestrians

(ages 5 to 14) during crossing of streets for typical school trips [12]. Students in the eastern United States were observed walking to school and were then surveyed regarding their behavior and the underlying knowledge associated with their habits as pedestrians. Using accident and age distribution data collected by the American Automobile Association[1] Reiss showed that there is a near-monotonic relationship between age and accident involvement rate for the 5 to 14 year old population. The youngest students are considerably overrepresented in the school trip accident data and the oldest students are under represented (Figure 9).

Selected portions of the survey data collected by Reiss are shown in Table 10, providing information on the age of the children, their mode of travel to school and the color of the traffic signal facing them when they would cross the street. The table shows that with increases in age, a greater proportion of the students will cross with the green signal. This increased knowledge of traffic control devices with student age closely matches the decreasing rate of student involvement in accidents. Further, students' propensity towards taking risk may increase with age. However, as the accident data indicates, this may be offset by improved knowledge and ability to interpret the signal indication with increasing age.

Reiss, in a paper published by the TRB, reemphasizes his earlier finding on the perceptions and knowledge of young pedestrians [13]. He found that although students' tendency towards risk taking increases with age, the situation is somewhat offset by their increased knowledge of when and how to take risks. A greater proportion of students (from a sample used in analyzing crossing behavior) were found to cross on the green signal. This relationship between the students increased knowledge of traffic control devices and age closely matches the decreasing rate of students involvement in accidents.

5. Robertson as a part of a FHWA study on pedestrian safety analyzed pedestrian behavior, compliance and understanding for different types of word messages [14]. The paper essentially addresses two problems:

- The question of providing enough WALK (W) time to complete their crossing, and

- The effectiveness of a flashing WALK (FW) indication to warn pedestrians that vehicles might be turning at the intersection.

The author reports on three experiments conducted in this study to address these questions.

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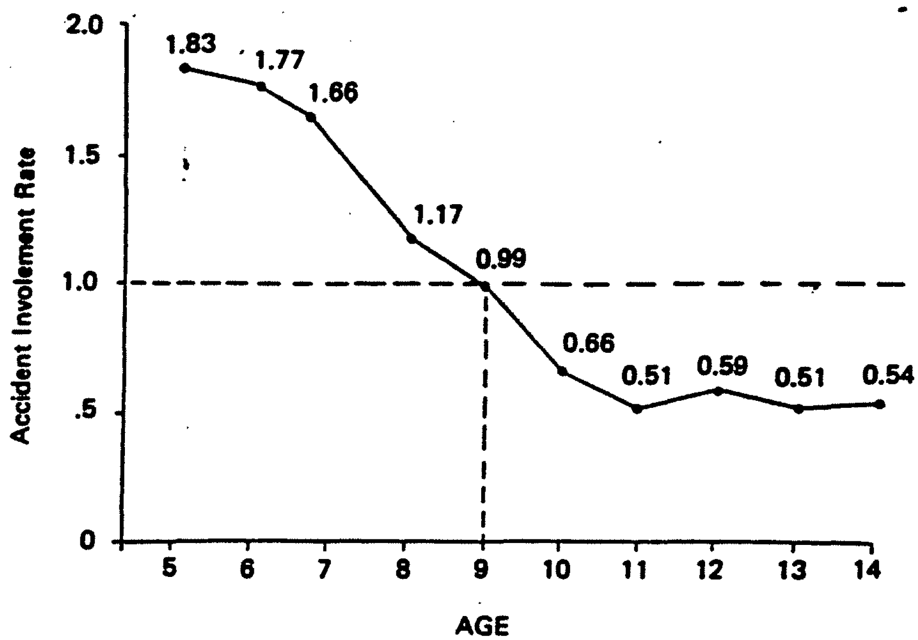
1 Pedestrian Safety Report, AAA special study of school child pedestrian accidents, Washington, D.C., 1968.



Based on 1,910 School Trip Accidents.

Figure 9. School trip pedestrian accident involvement rate of students by age.

Source: Reference 12

Table 10. Respondents' means of transport to school and indication of traffic signal color when crossing versus age.

Means of Transport	Walk			School Bus			City Bus	Train		Car		Bike		
Color of Traffic Signal When Student "Would" Cross	Red	Yellow	Green	Red	Yellow	Green	Red	Yellow	Green	Red	Green	Red	Green	Total
Age														
5	34	1	39	2	1	7				13	8			105
6	23	3	24	7		3	1			5	5			71
8	36		61	11	1	4				15	12			140
9	31	1	55	11	1	10	1		1	7	8	3	2	131
11	24		66	10		2				4	14	1	3	124
12	26	1	68	1				1		5	4	1	6	113
13	18	2	76							1	5	1	1	104
14	20		69			1				1	2	1		94
														882

Source: Reference 12

Experiment 1 - Comparing a steady DONT WALK (DW) clearance indication to the standard flashing DONT WALK (FDW) clearance indication.

Experiment 2 - Comparing a DONT START (DS) message with a DONT WALK (DW) message.

Experiment 3 - Comparing a steady WALK (W) to flashing WALK (FW).

All three experiments were conducted simultaneously in Buffalo, New York, and Phoenix, Arizona. A before and after study design was employed to conduct the experiments. The evaluation of each experimental signal display was based on the following criteria.

- A significant change in the occurrence of one or more of the observed pedestrian behaviors;
- A significant difference in the types of pedestrian violations and the distributions of those violations over time; and
- Responses from the user survey with respect to the meaning of the indications and perceived actions required by the indications.

The pedestrian signal displays for the three experiments are shown in Figure 10. The results of the three experiments are summarized in Tables 11, 12, and 13. Based upon these observations, the author concludes that:

- A steady DONT WALK clearance display appears to have the same effectiveness as a flashing DONT WALK clearance display. There is not sufficient evidence to conclude that a steady clearance is better than a flashing clearance.
- The DONT START message offers little or no improvement over the current DONT WALK messsage.
- The flashing WALK message is not an effective means of warning pedestrians about turning vehicles.

6. Williams in his paper presented at the Joint ARRB/DOT Pedestrian Conference discusses pedestrian behavior relative to Pelican crossings in England [6]. A 1976 TRRL study found that pedestrian non-compliance was quite typical, since most pedestrians crossed against the red signal. Skelton (1976) reported similar findings in his study of Pelican crossings in Newcastle-Upon-Tyne and found that a higher proportion of pedestrians crossed against a red light during low vehicular volumes. Interviews conducted among drivers and pedestrians revealed a lack of understanding

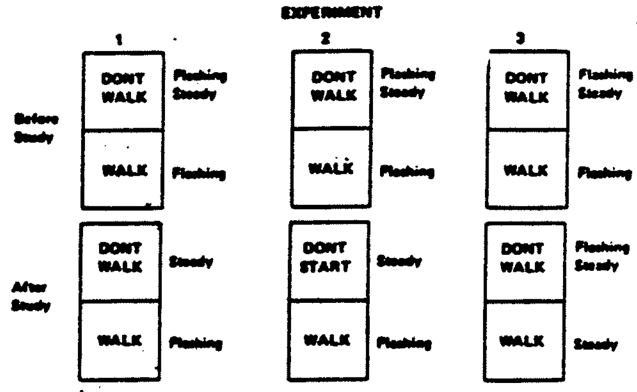


Figure 10. Displays for experiments 1, 2, and 3.

Source: Reference 14

Table 11. Summary of results for experiment 1: steady DONT WALK (after) versus flashing DONT WALK (before).

	Buffalo			Phoenix		
Item	Site 1	Site 2	Sites 1 and 2	Site 5	Site 6	Sites 5 and 6
Behavior						
B	nc	nc	nc	A*	nc	nc
RTV	nc	nc	nc	nc	nc	B*
MV	nc	nc	nc	nc	nc	nc
TV	nc	nc	nc	nc	nc	nc
RVH	nc	nc	nc	nc	nc	nc
VH	nc	nc	nc	nc	A*	nc
Compliance						
Leaving curb on walk	B**	nc	B*	A**	nc	A*
Leaving curb on clearance	nc	A*	nc	nc	nc	nc
Understanding						
Question 1[a]	nc	nc	nc	nc	nc	nc
Question 2[b]	nc	nc	B*	nc	A*	A*

Note: A = significant difference in favor of after (experimental) condition; B = significant difference in favor of before (MUTCD standard) condition; nc = no significant difference between before and after conditions; * = significant at the 0.05 level; and ** = significant at the 0.01 level.

[a] If you are at the curb, what should you do if you see the FDW or DW indication?
[b] If you had just started to cross the street and you saw the FDW or DW indication, what should you do?

Source: Reference 14

Table 12. Summary of results for experiment 2: steady DONT START (after) versus flashing DONT WALK (before).

Item	Buffalo			Phoenix		
	Site 3	Site 4	Sites 3 and 4	Site 1	Site 2	Sites 1 and 2
Behavior						
B	nc	nc	nc	nc	nc	nc
RTV	nc	nc	nc	nc	nc	nc
MV	nc	nc	nc	nc	nc	nc
TV	nc	nc	nc	nc	A**	A*
RVH	nc	nc	nc	nc	nc	nc
VH	nc	nc	nc	nc	nc	nc
Compliance						
Leaving curb on walk	nc	nc	nc	nc	A*	nc
Leaving curb on clearance	nc	nc	nc	nc	nc	nc
Understanding						
Question 1[a]	nc	A**	nc	nc	nc	A*
Question 2[b]	nc	nc	nc	nc	nc	nc

Note: A = significant difference in favor of after (experimental) condition; B = significant difference in favor of before (MUTCD standard) condition; nc = no significant difference between before and after conditions; * = significant at the 0.05 level; and ** = significant at the 0.01 level.

[a] If you are at the curb, what should you do if you see the FDW or DS indication?

[b] If you had just started to cross the street and you saw the FDW or DS indication, what should you do?

Source: Reference 14

Table 13. Summary of results for experiment 3: steady WALK (after) versus flashing WALK (before).

Item	Buffalo			Phoenix		
	Site 5	Site 6	Sites 5 and 6	Site 3	Site 4	Sites 3 and 4
Behavior						
B	B**	B**	B**	nc	nc	nc
RTV	B*	nc	B**	nc	nc	nc
MV	nc	nc	nc	nc	nc	nc
TV	nc	B*	B**	nc	nc	nc
RVH	nc	nc	nc	nc	nc	nc
VH	nc	B**	B**	nc	nc	nc
Compliance						
Leaving curb on walk	B**	nc	B**	A**	nc	A**
Leaving curb on clearance	nc	nc	nc	A*	nc	A*
Understanding						
Question 3[a]	nc	nc	nc	nc	nc	nc
Turn expectancy, percent[b]	49.5	41.4	45.5	35.0	44.0	39.5

Note: A = significant difference in favor of after (experimental) condition; B = significant difference in favor of before (MUTCD standard) condition; nc = no significant difference between before and after conditions; * = significant at the 0.05 level; and ** = significant at the 0.01 level.

[a] At some intersections, the W signal flashes, at some, it does not. What does the flashing (nonflashing) W signal mean at this intersection?

[b] The percentage of pedestrians that would expect vehicles to be turning into their crosswalk if they started their crossing on the W indication.

Source: Reference 14

of the way a Pelican is supposed to work. The pedestrian reaction time to green signals was also found to be quite long, generally exceeding 2 seconds. Willet (1977) and Golden (1977) also reported findings similar to those of Skelton and the TRRL. Goldschmidt (1977) found that Pelican signals have a delayed response to pedestrian actuation and that pedestrians are not given any advance warning of their priority phase with an amber signal. He cited the above reasons for pedestrian non-compliance, particularly at crossings with high vehicular volumes. He also found that the elderly people in particular were unable to respond quickly to the crossing indication and were sometimes left stranded midway during the crossing. Linton (1976) reported that installing a PUSH THE BUTTON sign above the pedestrian push button control at seven Pelican crossings in the Greater London area increased the usage of the push button control.

Based upon the above findings, Williams makes the general conclusion that pedestrians tend to accept natural gaps in traffic rather than wait for the signal to provide a protected crossing interval. This behavior may not be harmful if pedestrians accept only safe gaps. However, unnecessary motorist delays may be caused by pedestrians crossing on red signals after activating the Pelican signal.

7. Retzko and Androsch studied pedestrian behavior at signalized intersections in Dusseldorf and a few other cities in the Federal Republic of Germany [15]. The authors mention that a major difference between pedestrian signals and signals for vehicular traffic is the absence of the amber phase in pedestrian signals in most cities in Germany. To carry out a comparative evaluation of the two kinds of signalization, the authors investigated pedestrian behavior at a number of signalized intersections (with and without an amber phase). The authors identified four types of walking patterns depending primarily upon the the conditions at the start of the walking maneuver as follows:

- Early walkers
- Green walkers
- Late walkers
- Risk walkers

Data were collected on these walking patterns in 1972 and 1973 at 24 crosswalks of similar geometrics during a total of 5,000 cycles. The intersections were situated in central business districts in Dusseldorf, Dornstadt, Frankfurt and Manheim. The authors found that the presence of an amber phase generally results in better pedestrian compliance. Furthermore, in the absence of an amber phase (as is more common in Germany), pedestrians tend to walk against the red. Based upon this finding the authors recommend the installation of amber phase (clearance interval) for pedestrian signals.

8. Robertson in his ITE paper that was developed as a part of an FHWA study on pedestrian safety, reported on user preference and understanding of symbol displays (as opposed to word messsages) and on the field testing and evaluation of these displays [16]. A total of five preference surveys were conducted; two directed towards traffic engineers and safety experts, two at pedestrians in 12 cities, and one at school children.

The author discusses different conceptual forms of symbolic signal displays and presents the result of each preference survey with appropriate details. Selected sections of his results are shown in Tables 14, 15, 16 and 17. These tables show that there is a great deal of difference in opinion and response to symbols and colors between engineers, adult pedestrians and school children. The survey findings are summarized by the author as follows:

> "The first engineers survey indicated a preference for the hand and standing man displays and a three-section, three-color signal head. The second engineers survey favored the hand over the standing man with a preference for a two-section, three-color signal. Orange and white were the preferred colors, with red and green a respectable second. Yellow was the favored clearance indication color. Symbols were thought to be suitable replacements for words in pedestrian signal displays.
>
> The first pedestrian survey overwhelmingly attached the most intuitive meanings to the circle slash symbol and to red and green for pedestrian signal display colors. The second pedestrian survey indicated that symbols could be field tested without adverse safety effects. Preference for the hand and circle slash displays was evenly split between the four cities participating in the surveys. The school-age survey indicated that the symbols did have some degree of intuitive meaning, but that unless education was provided, the field test sites should not be located on elementary school walking routes."

9. Kyle, as a part of his Master's thesis at the University of Illinois, attempted to evaluate the effectiveness of dynamic pedestrian signals[1] in controlling pedestrian movements [17]. A dynamic pedestrian signal contains a special lens and reflector that makes it impossible for the pedestrian to see the WALK - DONT WALK indication unless the viewer is in a specified area on the roadway or sidewalk. This visual

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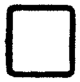
1 A major difference between a conventional signal and the new dynamic signal in the former type is likely to change to DONT WALK while the pedestrians are in the crosswalk and this is likely to frustrate the pedestrian. The latter type lets the pedestrian see the WALK indication the entire time he is crossing.

Table 14. Results of first user survey (number of responses).

City	Question 1					Question 2		Question 3		Sex	
						Orange	Red	White	Green	M	F
Alexandria, VA	2	1	11	0	16	2	28	5	25	18	12
Baltimore, MD	0	1	6	0	23	4	26	6	24	15	15
Daytona Beach, FL	1	1	12	0	16	17	13	8	22	15	15
Denver, CO	0	4	6	0	20	6	24	1	29	15	15
Tempe, AZ	1	2	3	0	24	4	26	3	27	15	15
Buffalo, NY	0	1	11	0	18	3	27	6	24	15	15
Greensboro, NC	0	2	8	0	50	6	54	6	54	30	30
San Diego, CA	0	2	7	0	21	2	28	0	30	15	15
Sioux City, IO	0	3	10	1	16	7	23	8	22	14	16
Washington, D.C.	0	1	2	0	27	0	30	3	27	20	10
Total	4	18	76	1	231	51	279	46	284	172	158
% of 330 responses	1.2	5.5	23.0	0.3	70.0	15.5	84.5	13.9	86.1	52.1	47.9

Question 1: Which one of these symbols most clearly means DONT WALK to you?
Question 2: For the symbol you just picked, which color most clearly means DONT WALK to you?
Question 3: Which one of these symbols most clearly means WALK to you?

Source: Reference 16

Table 15. Summary of results, questions 1 to 3 - second user survey.

Questions	Correct Responses							
	Baltimore		Buffalo		San Francisco		Phoenix/Tempe	
	Circle Slash	Hand	Circle Slash	Hand	Circle Slash	Hand	Circle Slash	Hand
1	93%	92%	85%	80%	99%	99%	97%	98%
2	91	95	91	92	97	99	98	97
3	98	98	85	82	88	87	99	99

Question 1: When is it safe to start your crossing? Answer: Walking man symbol.
Question 2: What should you do if you see (prohibited indication)? Answer: Don't start to cross.
Question 3: If you had just started to cross the street and you saw (prohibited indication), what should you do? Answer: Either continue or return to the curb.

Source: Reference 16

Table 16. Summary of results, question 4 ("Which of the two signals do you think is easiest to understand?") - second user survey.

Response	Baltimore	Buffalo	San Francisco	Phoenix/Tempe
Circle Slash	41%	40%	50%	59%
Hand	56	53	44	37
Neither	2	2	2	4
Same	1	5	4	0

Source: Reference 16

Table 17. Percentage of correct responses by grade and symbol.

Grade / Symbols	Green 	White 					WALK	DONT WALK	Average Percentage Correct
Kindergarten 33	60%	60%	36%	49%	55%	24%	82%	79%	56%
First Grade 39	72	67	77	77	85	44	75	69	71
Second Grade 48	75	79	56	90	77	60	100	77	77
Third Grade 55	62	46	60	89	69	33	89	95	68
Fifth Grade 56	55	71	63	68	79	71	96	98	75
All Grades Combined 231	65	65	59	76	74	48	90	83	70

Source: Reference 16

restriction is intended to cause more pedestrians to cross at the crosswalk, instead of entering the street elsewhere, which occurs with the conventional pedestrian signal.

Kyle used a before-after type of experimental design in which pedestrian observation data was collected at two experimental and two control intersections. Time-lapse photography and manual counting methods were used to record pedestrian movements of the candidate locations in the Champaign, Illinois, urban area.

Kyle's study showed that the dynamic pedestrian signal tended to reduce the number of reneging pedestrian movements in the intersection area. A greater percentage of pedestrians crossed during the clearance interval in the after period when the dynamic signal was in operation, than during the before period. However, better pedestrian compliance of the signals was obtained with the standard pedestrian signals in operation. The author, however, attributed this behavioral aspect to a mechanical problem associated with the dynamic signal, and noted that better compliance with the dynamic signal might be expected with the correction of the mechanical problem.

10. Stoddard, as a part of the Master's thesis at the University of Washington, conducted a study, similar to that of Kyle, to assess the effectiveness of dynamic pedestrian signals in controlling pedestrian traffic [18]. Two types of analyses were conducted. First, a comparison of before and after reactions was conducted using a pedestrian compliance count at a specified intersection. Second, pedestrians were interviewed to determine pedestrian reaction to the new type of signal. A total of 558 pedestrians interviews were conducted on four different days two months after the new signals were installed.

The study showed that a significant number of pedestrians were cleared from the crosswalk with the dynamic signal and the author recommended that this type of pedestrian control would be appropriate for intersections where the pedestrian interval is short and/or the crosswalk distances relatively long. The interviews showed that only a small percentage of the pedestrians are likely to be confused by the new signal. More pedestrians recognized the blue indication of the dynamic pedestrian signal than did pedestrians identifying the white WALK of the standard pedestrian signal [18].

11. McLean, discusses the effect of pedestrian signals in his paper abstract in the proceeding of the Joint ARRB/DOT Pedestrian Conference [19]. He concluded that "pedestrian-actuated traffic signals have the potential to reduce mid-block pedestrian accidents by as much as one

seventh". However, the above conclusion appears to be based more on intuitive judgment or on observation of pedestrian behavior than on a result of rigorous analytic procedures.

Summary

Research in the area of pedestrian safety has gained considerable prominence among traffic engineers and psychologists over the last decade. Pedestrians have historically accounted for a disproportionately large number of highway fatalities not only in the U.S. but also in England and a number of European countries. The incidence of most of these pedestrian fatalities at or near urban intersections has led traffic experts to believe that the use of pedestrian signals at these locations would have the desirable effect of improving pedestrian safety. A number of cities have experimented with this concept and have installed different types of pedestrian signals that have varied from simplistic word messages to more complex combinations of symbols; and often with different results.

The overall purpose of this literature survey was to ascertain what exactly is known regarding the effects of pedestrians signals upon: (1) safety, (2) operation, and (3) behavioral aspects of pedestrians. While the state-of-the-art review was conducted in these three areas separately, it must be noted that a number of the papers reviewed addressed more than one area, and in some instances do not lend themselves to distinct categorization in one given area. For example, the infrequency of pedestrian accident data lead many researchers to use compliance data for safety analysis, yet another researchers have considered compliance to be a part of pedestrian behavior.

Pedestrian Signals and Safety

A total of six papers were reviewed that have addressed the question of interrelationship between safety and pedestrian signals. Three of these six papers were related to experiences in the U.S. and the other three on the experience of Pelican crossings in England and Australia. Some of the critical features of these studies are summarized in Table 18. This table shows that only one study attempted to analyze accident data (Fleig et al., in New York), but the relative infrequency of pedestrian accidents prevented the researchers from making any conclusions that may be considered statistically sound. In the absence of accident data, if compliance is regarded as a measure of safety (as postulated by most researchers), the general consensus among researchers in this country is that pedestrian signals generally result in increased compliance rates and thus contribute to increased safety. It must be mentioned, however, that there are variations in opinion among researchers in this regard relative to the type of signal used.

Table 18. Summary of pedestrian signal studies in the safety area.

Authors	Location of Study	Use of Accident Data	Use of Compliance Data	General Conclusions
1. Abrams and Smith	Sioux City, Iowa	No	Yes	Improved compliance observed since installation of pedestrian signals.
2. Mortimer	Eastern Michigan University	No	Yes	Decrease in conflicts, illegal starts and hazard index values since the installation of pedestrian signals.
3. Fleig and Duffy	New York	Yes (Limited)	Yes	A small reduction in pedestrian accidents at 11 intersections does not provide statistically reliable conclusions. No significant reduction in unsafe acts noticed.
4. Inwood and Grayson	England	Yes	No	No significant difference in pedestrian accidents between non-signalized and pedestrian actuated signalized crossings.
5. Skelton and Trenchard	England	No	No	Opinion survey indicated a lack of understanding of operating characteristics of pedestrian actuated signals.
6. Williams	England & Australia	Yes	No	General reduction in pedestrian accidents observed with installation of pedestrian actuated signals. However, presence of other countermeasures makes it difficult to isolate the effect of pedestrian actuated signals.

To some extent, experiences with Pelicans in England and Australia reveal similar trends. Again, the nonavailability of accident data posed major problems to the researchers. There were no indications of major adverse safety effects of Pelicans in any of the studies reviewed. However, in cases where definite positive effects were felt (after the installation of Pelicans), it was difficult to isolate the singular effect of Pelicans from other countermeasures installed. The overall general conclusion that can be made from these studies are:

> It appears from compliance data and very limited accident data that the installation of pedestrian signals could possibly have an overall beneficial safety effect, although this has not been proven by any known past studies.

Pedestrian Signals and Traffic Operation

A total of five papers were reviewed that related to the effect of pedestrian signals on traffic operation, of which two were based upon studies conducted in the U.S., two in England, and one in Australia. The content and coverage of these papers were somewhat different from one another as evidenced from the review presented in the earlier section. For example, the paper by Wilson dealt with the effects of audible signals, which must be categorized as an extremely specialized control device. As such, it is difficult to develop any broad-based conclusions from these articles.

It was however quite apparent from these reviews that pedestrian signals are almost always likely to increase pedestrian delay, and in some instances (depending upon the vehicular volume and the signal parameters) overall vehicular delay is also likely to increase. Some of the authors indicate, that pedestrians may attempt to "jump the gun" by crossing against a red signal; a maneuver that is associated with higher risk. Thus, the general conclusion to be drawn is:

> Pedestrian delay is most likely to increase with the installation of pedestrian signals; and in many cases, vehicular delay is also likely to increase.

Pedestrian Signals and Behavior

The question of behavioral changes has constituted a topic of research to psychologists. Traffic experts have been interested in this topic primarily because of a possible relationship between pedestrian behavior and safety. A total of eleven papers were reviewed on this topic of which eight related to experiences in this country, one in England, one in Germany, and one in Autralia.

As in the case of traffic operations, the content of the papers on behavior varies widely. The following general conclusions were made:

- It appears (although not conclusively proven) that unsafe pedestrian behaviors are related to high hazard intersections.

- Under low vehicular volume conditions, pedestrians are likely to ignore signal indications, particularly when the clearance interval is longer than the minimum. Pedestrians have a general tendency to accept natural gaps in traffic.

- The compliance rate for steady WALK signals is higher than that for flashing WALK. Overall, the compliance rate for flashing signals appears to be lower than that for steady signals.

- Students propensity towards risk (in crossing streets) increases with age. However, their greater ability to interpret signal indications and to take protective measures in unsafe situations may offset the effect of risk resulting in lower accident experiences in older age groups.

- The presence of a clearance interval in a pedestrian signal tends to increase compliance rates.

- There is a great deal of difference in opinion and response to symbols and colors between traffic engineers, adult pedestrians and school age pedestrians.

References

1. Abrams, C.M. and Smith, S.A., "Selection of Pedestrian Signal Phasing", TRB Record 629, 1977.

2. Mortimer, R.G. "Behavioral Evaluation of Pedestrian Signals", Traffic Engineering, November, 1973.

3. Fleig, P. and Duffy, D.J., "A Study of Pedestrian Safety Behavior Using Activity Sampling", Traffic Safety, December, 1967.

4. Inwood, J. and Grayson, G.B., "The Comparative Safety of Pedestrian Crossings", TRRL Report 895, 1979, (England).

5. Skelton, N., Bruce, S., Trenchard, B., "Pedestrian-Vehicle Conflict and Operation of Pedestrian Light-Controlled (Pelican) Crossings", Proceedings of the International Conference on Pedestrian Safety, December, 1976 (Israel).

6. Williams, M., "Pelican Crossings, Myth or Miracle", Joint ARRB/DOT Pedestrian Conference, Sydney, Australia, November, 1978 (Australia).

7. Pretty, R.L., "The Delay to Vehicles and Pedestrians at Signalized Intersections", ITE Journal, May, 1978.

8. Smith, S.A., "A Plea for Consistency in Pedestrian Signal Timing", ITE Journal, November, 1978.

9. Wilson, D.G., "The Effects of Installing an Audible Signal for Pedestrians at a Light Controlled Junction", TRRL Report 917, 1980 (England).

10. Jennings, R.D., Burki, M.A., and Onstine, B.W., "Behavioral Observations and the Pedestrian Accident", Journal of Safety Research, March, 1977.

11. Sterling, C.F., "An Analysis of Pedestrian Reaction to the Flashing WALK indicator", Traffic Engineering, November, 1974.

12. Reiss, M.L., "Young Pedestrian Behavior", Transportation Engineering, October, 1977.

13. Reiss, M.L., "Knowledge and Perceptions of Young Pedestrians", TRB Record 629, 1977.

14. Robertson, H.D., "Pedestrian Signal Displays: An Evaluation of Word Message and Operation", TRB Record 629, 1977.

15. Retzko, H.G., Androsch, W., "Pedestrian Behavior at Signalized Intersections", Traffic Engineering & Control, Aug/Sept., 1974.

16. Robertson, H.D., "Pedestrian Preferences for Symbolic Signal Displays", Transportation Engineering, June, 1972.

17. Kyle, A.F., III, "A Preliminary Comparison of Standard Pedestrian Signals", prepared by the Highway Traffic Safety Center University of Illinois, Urbana, August, 1973.

18. Stoddard, R.G., "A Pedestrian Interview and Compliance Study of an Optically Programmed Signal", Master's Thesis, University of Washington, Seattle, Washington, 1974.

19. McLean, "Indepth Study of Pedestrian Accidents", Joint AARB/DOT Pedestrian Conference, Sydney, Australia, November, 1978 (Australia).

APPENDIX B - DATA ABSTRACT AND LAYOUT FOR THE FULL DATA BASE

DATA FILE LAYOUT DESCRIPTION

Location Descriptors

ITEM #	CARD TYPE	COL-UMN	FOR-MAT CODE	ITEM DESCRIPTION	NOTES
1	1	1-4	A4	City Code	Detroit = DET Columbus = COL New Haven = NHV Albany = ALB Chicago = CHI Washington = WSH Seattle = SEA Kansas City = KNS Richmond = RCH Toledo = TOL Denver = DEN Hartford = HRT W. Hartford = WHT Grand Rapids = GRR Tampa = TMP Waltham = WLT Miami = MIA
2	1	5-8	I4	Location Code	Intersection location number
3	1	9-10	I2	Card Number	Card type designation code = 1
4	1	11-30	5A4	Main Street Name	Main street name
5	1	31-50	5A4	Cross Street Name	Cross street name
6	1	51-54	I4	Direction Code	Main street direction code designation 1 = N-S 2 = E-W
7	1	55-56	I2	Operation Code	Intersection operations code designation 1 = One way - one way 2 = Main st. two way - cross st. one way 3 = Main st. one way - cross st. two way 4 = Two way - two way 5 = Mixed main or cross st.

DATA FILE LAYOUT DESCRIPTION

Location Descriptors - Continued

ITEM #	CARD TYPE	COLUMN	FORMAT CODE	ITEM DESCRIPTION	NOTES
8	1	57-60	I4	Land Use Code	Major land use designation **Code** / **Type** 1 Residential (SF, Multiple) 2 Commercial (Shops, Office) 3 Industrial 4 Institutional (Public, Church) 5 Educational 6 Recreational 7 Mixed residential/commercial 8 Mixed residential/non-commercial 9 Other
9	1	61-63	I3	Main St. Speed Limit	Posted or legal main street speed limit
10	1	64-66	I3	Cross St. Speed Limit	Posted or legal cross street speed limit
11	1	67-68	I2	Main St. Bus Code	Bus route on main street? if Yes = 1 No = 0
12	1	69-70	I2	Cross St. Bus Code	Bus route on cross street? if Yes = 1 No = 0
13	1	71-74	I4	Skewness Factor	Skewness angle subtended by intersection of main street & cross street center lines
14	1	75-76	I2	Area Type Factor	Area type designation code 1 = CBD (Central Business District) 2 = CBD Fringe 3 = Outlying Business District 4 = Residential Area

DATA FILE LAYOUT DESCRIPTION

Signal Parameters

ITEM #	CARD TYPE	COL-UMN	FOR-MAT CODE	ITEM DESCRIPTION	NOTES
15	2	1-4	A4	City Code	See Item 1
16	2	5-8	I4	Location Code	See Item 2
17	2	9-10	I2	Card Number	Card Type Designation = 2
18	2	11-14	I4	Signal Operation Code	Signal Operation Type Code 1 = Standard Pre-Timed 2 = Traffic Actuated 3 = Pedestrian Actuated 4 = Pedestrian Semi-Actuated 5 = Pedestrian/Traffic Actuated
19	2	15-16	I2	Pedestrian Signal Timing Code	Pedestrian Signal Timing Code Legend: 1 = No Pedestrian Signal 2 = Scramble (B) 3 = Standard (S) 4 = Early Release (E) 5 = Late Release (L) 6 = Combination (some sort of protected pedestrian movement)
20	2	17-18	I2	Pedestrian Signal Hardware Code	Pedestrian Signal Hardware Designations 0 = None 1 = 8"-Walk-Don't Walk Standard 2 = 12"-Walk-Don't Walk Standard 3 = Rectangular Walk-Don't Walk 4 = Non-Standard Circular Lens Walk 5 = Other 6 = Ped. Signals Installed but not Operating 8 = Standard Pedestrian Signal with Audible Indication 9 = Unknown
21	2	19-22	2I2	Signal Timing Implemented	Data when Signal Timing Strategy was Implemented Month-Year 9999 = Unknown
22	2	23-26	I4	PM Peak Period Cycle Length	PM Peak Hour Signal Cycle Length - in Seconds
23	2	27-28	I2	Number of Phases	Number of Total Signal Phases per Cycle
24	2	29-31	I3	Main Street Green Period	-Main Street PM Green Interval in Seconds for Auto

ITEM #	CARD TYPE	COL-UMN	FOR-MAT CODE	ITEM DESCRIPTION	NOTES
25	2	32-34	I3	Main Street Amber Period	-Main Street PM Amber Period in Seconds for Pedestrians
26	2	35-37	F3.1	Main Street Pedestrian Green Period	-Main Street PM Green Interval in Seconds for Pedestrians
27	2	38-40	F3.1	Main Street Pedestrian Amber Period	-Main Street PM Clearance Interval in Seconds for Pedestrians (flashing don't walk)
28	2	41-43	F3.1	Cross Street Green Interval	-Cross Street PM Green Period Interval in Seconds for Autos
29	2	44-46	F3.1	Cross Street Amber Period	-Cross Street PM Amber Period in Seconds for Autos
30	2	47-49	F3.1	Cross Street Pedestrian Green Period	-Cross Street PM Pedestrian Crossing Period in Seconds
31	2	50-53	F4.1	Cross Street Pedestrian Clearance Period	-Cross Street Pedestrian Clearance Interval (flashing don't walk indication) in Seconds
32	2	54-56	F3.1	Special Phase Main Street Green	Total Green Time for Main Street Special Phases for Autos
33	2	57-59	F3.1	Special Phase Main Street Amber	Total Amber Time for Main Street Special Phase for Autos
34	2	60-62	F3.1	Special Phase Green for Ped.	Total Special Phase Green Time for Pedestrians on Main Street
35	2	63-65	F3.1	Special Phase Amber for Ped.	Total Special Phase Amber Time for Pedestrians on Main Street
36	2	66-68	F3.1	Special Phase Cross Street Green	Total Green Time for Cross Street Special Phase for Autos
37	2	69-71	F3.1	Special Phase Cross Street Amber	Total Amber Time for Cross Street Special Phase for Autos
38	2	72-74	F3.1	Special Phase Cross Street Ped. Green	Special Phase Green Time for Pedestrians on Cross Street

DATA FILE LAYOUT DESCRIPTION

ITEM #	CARD TYPE	COL-UMN	FOR-MAT CODE	ITEM DESCRIPTION	NOTES
39	2	75-77	F3.1	Special Phase Cross Street Ped. Amber	Special Phase Amber Time for Pedestrians on Cross Street
39A	2	78-79	I2	Ped. Signal Location	0 = No Ped Signals 1 = Ped. Signals for North Crosswalk 2 = Ped. Signals for East Crosswalk 3 = Ped. Signals for South Crosswalk 4 = Ped. Signals for West Crosswalk 5 = Ped. Signals for North and South Crosswalks 6 = Ped. Signals for East and West Crosswalks 7 = Ped. Signals for All Crosswalks 8 = Ped. Signals for Other Combination of 2 Crosswalks 9 = Ped. Signals for Other Combination of 3 Crosswalks
39B	2	80	I1	Use of Flashing Walk Code	0 = Flashing Walk not Used 1 = Flashing Walk Used

ITEM #	CARD TYPE	COL-UMN	FOR-MAT CODE	ITEM DESCRIPTION	NOTES
40	3	1-4	A4	City Code	See Item 1
41	3	5-8	I4	Location Code	See Item 2
42	3	9-10	I2	Card Type Code	Card Type Code = 3
43	3	11-14	I4	Volume Data	Data of Auto Volume Counts Month-Year (i.e. 1280 implies December 1980) 9999 = Unknown
44	3	16-30	3I5	North Leg Volumes	North Leg (Raw Data) Auto Volumes for: 1. Total Approach Volume (columns 16-20) 2. Right Turns (columns 21-25) 3. Left Turns (columns 26-30)
45	3	32-46	3I5	East Leg Volumes	East Leg Auto Volumes (as in item 44)
46	3	48-62	3I5	South Leg Volumes	South Leg Auto Volumes (as in item 44)
47	3	64-78	3I5	West Leg Volumes	West Leg Auto Volumes (as in item 44)

DATA FILE LAYOUT DESCRIPTION

Peak Hour Volumes and Pedestrian Volume Totals

ITEM #	CARD TYPE	COLUMN	FORMAT CODE	ITEM DESCRIPTION	NOTES
48	4	1-4	A4	City Code	See Item 1
49	4	5-8	I4	Location Code	See Item 2
50	4	9-10	I2	Card Type Code	Card Type Code = 4
51	4	11-15	F5.2	Auto Volumes Expansion Factor	Expansion Factor for Converting Coded Volume Data to 24 Hour Counts
52	4	16-19	I4	Auto Volumes Collection Period	Collection Period Codes 1 = All Day (10 to 12 Hours) 2 = Am and PM Peak Periods 3 = AM Peak Period 4 = PM Peak Period 5 = AM, Midday and PM Peak Period 6 = Midday Period 7 = 6-8 Hours including AM or PM Peak Period 8 = 24 Hour 99 = Other
53	4	20-25	I5	Peak Hour Auto Traffic Volume	Highest Hourly Vehicular Volume
54	4	26-30	I5	Peak Hour Time	Hour of the Highest Auto Traffic Volume in Military Time (4 digits, code 2500 where peak data not available)
55	4	31-37	I6	Total North-South Peds	Raw Count Data for Peds Moving N-S Through the Intersection
56	4	38-43	I6	Total East-West Peds	Raw Count Data for Peds Moving E-W Through the Intersection
57	4	44-49	I6	Total Diagonal Peds	Raw Count Data for Peds Moving Diagonally Through the Intersection
58	4	50-54	F5.2	Ped. Volumes Expansion Factor	Expansion Factor to Convert Ped. Count Data into 16 Hour Counts
59	4	55-57	I3	Ped. Volumes Count Period	Collection Period Codes 1 = All Day (10 to 12 Hours) 2 = AM and PM Peak Periods 3 = AM Peak Period 4 = PM Peak Period 5 = AM, Midday and PM Peak Period 6 = Midday Period 7 = 6-8 Hours Including AM or PM Peak Period 8 = 24 Hour 99 = Other

DATA FILE LAYOUT DESCRIPTION

Peak Hour Volumes and Pedestrian Volume Totals PAGE 8 OF 16

ITEM #	CARD TYPE	COL-UMN	FOR-MAT CODE	ITEM DESCRIPTION	NOTES
60	4	58-62	I5	Peak Hour Ped Volumes	Highest Hourly Pedestrian Volume
61	4	63-67	I5	Peak Hour Time	Hour of the Highest Pedestrian Traffic Volume in Military Time (4 digits, code 2500 where peak data not available)

ITEM #	CARD TYPE	COL-UMN	FOR-MAT CODE	ITEM DESCRIPTION	NOTES
62	5	1-4	A4	City Code	(See Item 1)
63	5	5-8	I4	Location Code	(See Item 2)
64	5	9-10	I2	Card Type Code	Card Type Code = 5
65	5	11-13	I3	Width	North Leg Pavement Width in Feet
66	5	14-15	I2	Road Type	Functional Classification of North Leg 1 = Arterial 2 = Collector 3 = Local
67	5	16-17	I2	Left Turn Lanes	Number of Exclusive Left Turn Lanes on North Leg
68	5	18	I1	Left Turn Control	Turning Controls 0 = No Prohibitions 1 = Partial Prohibitions 2 = Full Prohibitions
69	5	19-21	I2	Through Lanes	Number of Lanes for North Leg from which a Through Movement can be made
70	5	22-23	I2	Right Turn Lane	Number of Exclusive Right Turn Lanes on North Leg
71	5	24	I1	Right Turn Control	Turning Controls 0 = No Prohibitions 1 = Partial Prohibitions 2 = Full Prohibitions
72	5	25-26	I2	RTOR Code	Is RTOR on North Leg is Permitted 1 = Yes 0 = No 2 = Partial Prohibition
73	5	27	I1	Parking Code	Is Parking is Permitted Near Intersection on North Leg 1 = Yes 0 = No
74-82	5	28-44			Same as Items 65-73 for East Leg
83-91	5	45-61			Same as Items 65-73 for South Leg
92-100	5	62-78			Same as Items 65-73 for West Leg

ITEM #	CARD TYPE	COLUMN	FORMAT CODE	ITEM DESCRIPTION	NOTES
101	6	1-4	A4	City Code	(See Item 1)
102	6	5-8	I4	Location Code	(See Item 2)
103	6	9-10	I2	Card Type Code	Card Type Code = 6
104	6	11-15	F5.0	Accident Experience Period	Number of Years of Accident Data
105	6	16-19	I4	First Year Total Accidents	Total Accidents at the Location in the First Year of Data*
106	6	20-22	I3	First Year Pedestrian Accidents	Number of Pedestrian Accidents Occuring in the First Year*
107	6	23-26	I4		Second Year*
108	6	27-29	I3		
109	6	30-33	I4		Third Year*
110	6	34-36	I3		
111	6	37-40	I4		Fourth Year*
112	6	41-43	I3		
113	6	44-47	I4		Fifth Year*
114	6	48-50	I3		
115	6	51-54	I4		Sixth Year*
116	6	55-57	I3		

* Note: Code 999 when the year was excluded from the analysis period due to changes at the location.

DATA FILE LAYOUT DESCRIPTION

Hourly Pedestrian Volume

ITEM #	CARD TYPE	COL-UMN	FOR-MAT CODE	ITEM DESCRIPTION	NOTES
117	7	1-4	A4	City Code	See Item 1
118	7	5-8	I4	Location Code	See Item 2
119	7	9-10	I2	Card Number	Card Type Designation Code = 7 (This card is optional)
120	7	13-16	I4	Pedestrian Volume	Total Pedestrian Crossing Volume on all Crosswalks at Intersection from 6 AM to 7 AM
121	7	17-20	I4		7 AM - 8 AM
122	7	21-24	I4		8 AM - 9 AM
123	7	25-28	I4		9 AM - 10 AM
124	7	29-32	I4		10 AM - 11 AM
125	7	33-36	I4		11 AM - 12 Noon
126	7	37-40	I4		12 Noon - 1 PM
127	7	41-44	I4		1 PM - 2 PM
128	7	45-48	I4		2 PM - 3 PM
129	7	49-52	I4		3 PM - 4 PM
130	7	53-56	I4		4 PM - 5 PM
131	7	57-60	I4		5 PM - 6 PM
132	7	61-64	I4		6 PM - 7 PM
133	7	65-68	I4		7 PM - 8 PM
134	7	69-72	I4		8 PM - 9 PM

ITEM #	CARD TYPE	COL-UMN	FOR-MAT CODE	ITEM DESCRIPTION	NOTES
135	7	73-76	I4		9 PM - 10 PM
136	7	77-80	I4		10 PM - 11 PM

ITEM #	CARD TYPE	COL-UMN	FOR-MAT CODE	ITEM DESCRIPTION	NOTES
137	8	1-4	A4	City Code	City Code
138	8	5-8	I4	Location Code	Location Number
139	8	10	I2	Card Type	Card Type Code = 8
140	8	12-17	I6	Date	Month/Day/Year 00 00 00 99 = Unknown
141	8	18	I1	Day of Week	Day of Week Code: 1 = Sunday 2 = Monday 3 = Tuesday 4 = Wednesday 5 = Thursday 6 = Friday 7 = Saturday 9 = Unknown
142	8	19-20	I2	Time of Day	Time of Day Code: 01 = Midnight to 1:00 a.m. 02 = 1:00 a.m. to 2:00 a.m. 03 = 2:00 a.m. to 3:00 a.m. 04 = 3:00 a.m. to 4:00 a.m. 05 = 4:00 a.m. to 5:00 a.m. 06 = 5:00 a.m. to 6:00 a.m. 07 = 6:00 a.m. to 7:00 a.m. 08 = 7:00 a.m. to 8:00 a.m. 09 = 8:00 a.m. to 9:00 a.m. 10 = 9:00 a.m. to 10:00 a.m. 11 = 10:00 a.m. to 11:00 a.m. 12 = 11:00 a.m. to Noon 13 = Noon to 1:00 p.m. 14 = 1:00 p.m. to 2:00 p.m. 15 = 2:00 p.m. to 3:00 p.m. 16 = 3:00 p.m. to 4:00 p.m. 17 = 4:00 p.m. to 5:00 p.m. 18 = 5:00 p.m. to 6:00 p.m. 19 = 6:00 p.m. to 7:00 p.m. 20 = 7:00 p.m. to 8:00 p.m. 21 = 8:00 p.m. to 9:00 p.m. 22 = 9:00 p.m. to 10:00 p.m. 23 = 10:00 p.m. to 11:00 p.m. 24 = 11:00 p.m. to Midnight 99 = Not Known

ITEM #	CARD TYPE	COL-UMN	FOR-MAT CODE	ITEM DESCRIPTION	NOTES
143	8	23	I1	Weather Code	Weather Code 1 = Clear or Cloudy 2 = Fog 3 = Raining 4 = Snowing 9 = Other or Not Known
144	8	24	I1	Light Code	Light Code: 1 = Daylight 2 = Dawn or Dusk 3 = Darkness - Street Lights 4 = Darkness - No Street Lights 9 = Not Known
145	8	25	I1	Road Suface Code	Road Surface Code: 1 = Dry 2 = Wet 3 = Snowy or Icy 9 = Other or Not Known
146	8	27	I1	No. of Pedestrians Injured	When more than one pedestrian is involved in collision, record the total number of pedestrians, otherwise leave blank.
147	8	28	I1	Accident Severity	Accident Severity Code: (Code highest injury if more than one pedestrian injured) 1 = Fatal 2 = A - Injury - Incapaciating Injury (bleeding wound, loss of counciousness) 3 = B - Injury - Visible Signs of Injury (bruises, swelling, etc. 4 = C - Injury - No Visible Sign of Injury but Complaint of Pain 5 = Injury - No Severity Specified 6 = No Injury 7 = Unknown
148	8	29-32	A1, I2	Distance from Intersection	Distance in Feet N, S, E, W of center of Intersection (Place a "C" in column 29 if measure is taken from curb line.) 998 = Within Crosswalk 999 = Exact Distance Unknown

ITEM #	CARD TYPE	COL-UMN	FOR-MAT CODE	ITEM DESCRIPTION	NOTES
149	8	33	I1	Direction from Intersection	Direction from Intersection 1 = North (Leg) 2 = South (Leg) 3 = East (Leg) 4 = West (Leg) 5 = At Intersection 9 = Unknown
150	8	36-37	I2	Age of Pedestrian	Age of Pedestrian 98 = 98 Years or Older 99 = Unknown
151	8	38	I1	Sex of Pedestrian	Sex of Pedestrian 1 = Male 2 - Female 3 = Unknown
152	8	39	I1	Pedestrian Action	Pedestrian Action 1 = Crossing with Signal 2 = Crossing Against Signal 3 = Crossing Diagonally 4 = Working in Road 5 = Playing in Road 6 = Pedestrian Running with Signal 7 = Pedestrian Running against Signal 8 = Unkown Pedestrian Violation 9 = Other/Unknown Pedestrian Action
153	8	40	I1	Pedestrian Drinking	Pedestrian Drinking 1 = Had been Drinking 2 = Had not been Drinking 3 = Unknown
154	8	43	I1	Driver Intent	Driver Intent 1 = Going Straight Ahead 2 = Right Turn 3 = Left Turn 9 = Other/Unknown
155	8	44	I1	Driver Hazardous Action	Driver Hazardous Action 1 = Speeding 2 = Fail to Yield on Turn 3 = Signal Violation 4 = Driver Inattention 5 = Avoiding Other (Vehicle or Pedestrian) Collision

ITEM #	CARD TYPE	COL-UMN	FOR-MAT CODE	ITEM DESCRIPTION	NOTES
155	8			Continued	Driver Hazardous Action (Continued) 6 = Hit & Run 7 = Other Driver Violation 8 = No Driver Violation 9 = Unknown if Driver made a Hazardous Action or Not
156	8	45	I1	Driver Drinking	Driver Drinking 1 = Had been Drinking 2 = Had not been Drinking 9 = Unknown
157	8	47	I1	Citation Issued	Citation Issued 0 = No Citation Issued 1 = Yes - Driver 2 = Yes - Pedestrian 3 = Yes - Both 9 = Unknown
158	8	49	I1	Vehicle Type	Vehicle Type 1 = Passenger Car 2 = Pick up Truck, Van 3 = Police/Emergency Vehicle 4 = Truck 5 = Bus 6 = Other 9 = Unknown Vehicle Type
159	8	51	I1	Other Factors.	Other Factors 1 = Driver Fatigue, Illness 2 = Sight Obstructions (i.e. Parked Vehicles) 3 = Glare/Sunlight in Eyes 4 = Vehicle Defects 5 = Walking from Around Bus 6 = Pedestrian did not see or Understand Signal 7 = Signal Malfunction 8 = Pedestrian Disability (Handicapped) 9 = No Contributing Factors Stated or Obvious
160	8	53-80	A28	Comments	Description of Unusual Accident Characteristics or Contributing Circumstances

APPENDIX C - DATA ABSTRACT AND LAYOUT FOR THE REDUCED DATA BASE

DATA FILE LAYOUT DESCRIPTION

PROJECT Reduced Data File - Pedestrian Signalization Study PAGE 1 OF 8

ITEM #	CARD TYPE	COLUMN	FORMAT CODE	ITEM DESCRIPTION	NOTES
1	1	1-4	A4	City Name	Alphanumeric Code for Cities Detroit = DET Columbus = COL New Haven = NHV Albany = ALB Chicago = CHI Washington = WSH Seattle = SEA Kansas City = KNS Richmond = RCH Toledo = TOL Denver = DEN W. Hartford = WHT Grand Rapids = GRR Tampa = TMP Miami = MIA Waltham = WLT
2	1	5-8	I4	Location Code	Intersection Number
3	1	9-10	I2	Card Type 1	Designation for dependent variables card
4	1	11-16	F6.3	Total Accidents	Total number of recorded accidents at the location over the analysis period
5	1	17-22	F6.3	Average Annual Accidents	Average number of all accidents per year at the location
6	1	23-28	F6.3	Total Pedestrian Accidents	Total number of recorded pedestrian accidents over the analysis period
7	1	29-34	F6.3	Average Annual Pedestrian Accidents	Average number of pedestrian accidents per year at the location
8	1	35-40	F6.3	Ped-Auto Accident Ratio	Ratio of pedestrian accidents to total intersection accidents
9	1	41-46	F6.3	Total Ped-Turn Accidents	Total pedestrian accidents involving turning vehicles
10	1	47-52	F6.3	Average Annual Ped-Turn Accidents	Average number of ped accidents involving turning vehicles per year at the location

DATA FILE LAYOUT DESCRIPTION

PROJECT Reduced Data File - Pedestrian Signalization Study PAGE 2 OF 8

ITEM #	CARD TYPE	COLUMN	FORMAT CODE	ITEM DESCRIPTION	NOTES
11	1	53-58	F6.3	Total Fatal & A-Type Injury Ped Accidents	Total pedestrian accidents resulting in fatal or A-type injuries
12	1	59-64	F6.3	Average Annual Fatal and A-type Injury Accidents	Average number of ped accidents resulting in fatal or A-type injuries per year at the location
13	1	65-70	F6.3	Average Annual Injury Accidents	Average number of ped accidents resulting in injuries per year at the location
14	1	71-72	I2	Daytime Ped Accidents	Total ped accidents occurring during daytime hours
15	1	73-74	I2	Dawn-Dusk Ped Accidents	Total ped accidents occurring during dawn or dusk periods
16	1	75-76	I2	Darkness W/Street Lights Ped Accidents	Total ped accidents occurring during periods of darkness at locations with street lighting
17	1	77-78	I2	Darkness W/O Street Lights Ped Accidents	Total ped accidents occurring during periods of darkness at locations without street lights
18	1	79-80	I2	Other Light Condition Ped Accidents	Total ped accidents for which the lighting conditions are not known
19	1	81-82	I2	Young Ped Accidents	Total accidents occurring during the study period involving peds younger than 16 yrs
20	1	83-84	I2	Elderly Ped Accidents	Total accidents occurring during the study period involving peds older than 59 years
21	1	85-86	I2	Other Ped Accidents	Total accidents occurring during the study period involving peds 16-59 years old
22	1	87-88	I2	Thru Ped Accidents	Total number of ped accidents occurring during the study period involving vehicles going straight

DATA FILE LAYOUT DESCRIPTION

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ITEM #	CARD TYPE	COLUMN	FORMAT CODE	ITEM DESCRIPTION	NOTES
23	1	89-90	I2	Right-Turn Ped Accidents	Total number of ped accidents occurring during the study period involving vehicles turning right
24	1	91-92	I2	Left-Turn Ped Accidents	Total number of ped accidents occurring during the study period involving vehicles turning left
25	1	93-94	I2	Other Ped Accidents	Total number of ped accidents occuring during the study period for which the driver intent was unknown

DATA FILE LAYOUT DESCRIPTION

PROJECT Reduced Data File - Pedestrian Signalization Study

ITEM #	CARD TYPE	COLUMN	FORMAT CODE	ITEM DESCRIPTION	NOTES
26	2	1-4	A4	City Name	Same as Item 1
27	2	5-8	I4	Location Code	Intersection number
28	2	9-10	I2	Card Type 2	Designation for independent variables card
29	2	11-16	I6	Total Intersection Volume	Sum of the auto traffic on all intersection legs
30	2	17-22	I6	Right-Turn Volume	Sum of the right turning autos on all intersection legs
31	2	23-28	I6	Left-Turn Volume	Sum of the left turning autos on all intersection legs
32	2	29-34	I6	Total Turn Volume	Sum of the left and right turning autos on all intersection legs
33	2	35-40	I6	Peak Hour Intersection Volume	Estimated intersection auto traffic volumes during the peak hour
34	2	41-46	I6	Peak Hour Turn Volumes	Estimated total turning volumes during the peak hour
35	2	47-52	I6	Total Ped Volume	Sum of the ped volumes for all crosswalks
36	2	53-59	F7.3	Ratio of Main Cross Street Volumes	Ratio of the main street volume to the cross street volume
37	2	60-66	F7.3	Ped Accident Rate	Ped accident rate based upon the total intersection traffic volume
38	2	67-73	F7.3	Ped Accident Rate	Ped accident rate based upon turning volumes
39	2	74-80	F7.3	Ped Accident Rate	Ped accident rate based upon ped volumes
40	2	81-87	F7.3	Ped Accident Rate	Ped accident rate based upon the number of potential ped-vehicle conflicts (i.e., ped and auto volumes)
41	2	88-94	F7.3	Ped Accident Rate	Ped turning accident rate based upon turning volumes

DATA FILE LAYOUT DESCRIPTION

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ITEM #	CARD TYPE	COLUMN	FORMAT CODE	ITEM DESCRIPTION	NOTES
42	3	1-4	A4	City Code	Alphanumeric City Code (as in Item #1)
43	3	5-8	I4	Location Code	Intersection location identification number
44	3	9-10	I2	Card Type	Classification data card - Type 3
45	3	11-12	I2	Operation Code	Intersection operations code designation 1 = One-way - one-way 2 = Main st. two-way - cross st. one-way 3 = Main st. one-way - cross st. two-way 4 = Two-way - two-way 5 = Mixed main or cross st.
46	3	13-14	I2	Land Use Code	Major land use designation Code Type 1 Residential (SF, Multiple) 2 Commercial (Shops, Office) 3 Industrial 4 Institutional (Public, Church) 5 Educational 6 Recreational 7 Mixed residential/commercial 8 Mixed residential/non-commercial 9 Other
47	3	15-16	I2	Approach Speed Code	Approach speeds code designations

Cross Street \ Main Street	$\leq$ 35 mph	> 35 mph
$\leq$ 35 mph	Code = 1	2
> 35 mph	2	3

ITEM #	CARD TYPE	COLUMN	FORMAT CODE	ITEM DESCRIPTION	NOTES
48	3	17-18	I2	Bus Operations Code	Bus operations code, such that

Cross Street \ Main Street	Buses	No Buses
Buses	1	2
No Buses	2	3

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ITEM #	CARD TYPE	COLUMN	FORMAT CODE	ITEM DESCRIPTION	NOTES
49	3	19-20	I2	Skewness Code	Skewness Code designations based on angle subtended by intersection of main and cross streets 1 = Orthogonal (90°) 2 = Non-Orthogonal (other than 90°)
50	3	21-22	I2	Area Type Factor	Area type designation code 1 = CBD (Central Business District) 2 = CBD Fringe 3 = Outlying Business District 4 = Residential Area
51	3	23-24	I2	Signal Operation Code	Signal operation type code 1 = Standard Pre-Timed 2 = Traffic Actuated 3 = Pedestrian Actuated 4 = Pedestrian Semi-Actuated 5 = Pedestrian/Traffic Actuated
52	3	25-26	I2	Pedestrian Signal Timing Code	Pedestrian signal timing code legend 1 = No Pedestrian Signal 2 = Scramble (B) 3 = Standard (S) 4 = Early Release (E) 5 = Late Release (L) 6 = Combination (some sort of protected pedestrian movement)
53	3	27-28	I2	Pedestrian Signal Hardware Code	Pedestrian signal hardware designations 0 = None 1 = 8" Walk-Don't Walk Standard 2 = 12" Walk-Don't Walk Standard 3 = Rectangular Walk-Don't Walk 4 = Non-Standard Circular Lens Walk 5 = Other 6 = Ped. Signals Installed but not Operating 8 = Standard Pedestrian Signal with Audible Indication 9 = Unknown

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<table>
<tr><th>ITEM #</th><th>CARD TYPE</th><th>COLUMN</th><th>FORMAT CODE</th><th>ITEM DESCRIPTION</th><th>NOTES</th></tr>
<tr><td>54</td><td>3</td><td>29-30</td><td>I2</td><td>Cycle Length Code</td><td>Signal cycle length code designation

1 = cycle less than 65 seconds
2 = cycle greater than 65 seconds</td></tr>
<tr><td>55</td><td>3</td><td>31-32</td><td>I2</td><td>Number of Phases Code</td><td>Number of signal phases code designation

1 = Standard 2 phase operation
2 = Multiphase operation</td></tr>
<tr><td>56</td><td>3</td><td>33-34</td><td>I2</td><td>Function Classification Code</td><td>Functional classification code designations
<table>
<tr><th>Cross Street \ Main Street</th><th>Arterial</th><th>Collector</th><th>Local</th></tr>
<tr><td>Arterial</td><td>1</td><td>2</td><td>2</td></tr>
<tr><td>Collector</td><td>2</td><td>3</td><td>3</td></tr>
<tr><td>Local</td><td>2</td><td>3</td><td>3</td></tr>
</table>
All other cases = 4
(Where roadway types are different for opposite intersection legs)</td></tr>
<tr><td>57</td><td>3</td><td>35-36</td><td>I2</td><td>Width Code (All Equal To 9)</td><td></td></tr>
<tr><td>58</td><td>3</td><td>37-38</td><td>I2</td><td>Number of Lanes Code</td><td>Number of lanes designations
<table>
<tr><th>Cross Street \ Main Street</th><th>0-2</th><th>3-5</th><th>6+</th><th>mix*</th></tr>
<tr><td>0-2</td><td>1</td><td>2</td><td>3</td><td>6</td></tr>
<tr><td>3-5</td><td>2</td><td>3</td><td>4</td><td>6</td></tr>
<tr><td>6+</td><td>3</td><td>4</td><td>5</td><td>6</td></tr>
<tr><td>mix*</td><td>6</td><td>6</td><td>6</td><td>6</td></tr>
</table>
*Mix indicates all situations where a significant change in the number of lanes between opposite legs exists.</td></tr>
</table>

DATA FILE LAYOUT DESCRIPTION

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ITEM #	CARD TYPE	COLUMN	FORMAT CODE	ITEM DESCRIPTION	NOTES
59	3	39-40	I2	RTOR Code	RTOR Option designations 1 = RTOR permitted on all intersection legs 2 = RTOR permitted on some intersection legs 3 = RTOR prohibited on all intersection legs
60	3	41-42	I2	Turn Restrictions Code	Turn restrictions code designations 1 = all turning movements are prohibited 2 = some turning movements are prohibited 3 = no turning movements are prohibited
61	3	43-44	I2	Location Hazardousness Code	Location hazardousness code designations 1 = Total accidents per year less than or equal to 10 2 = Total accidents per year greater than 10 but less than or equal to 20 3 = Total accidents per year greater than 20.

APPENDIX D - DISCUSSION OF THE MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES (MUTCD) WARRANTS RELATIVE TO PEDESTRIANS

1963 MUTCD Warrants Relating to Pedestrians

The 1963 MUTCD provides for signal warrants for pedestrians in 3 different sections. Section 3D is devoted to warrants for Pretimed Signals, Section 3E to Pedestrian Actuated Control and Section 3F to Pedestrian Signals. These are discussed below.

Section 3D - Pretimed Signals

As prescribed in the manual pretimed signals may be installed only when one or more of the following six warrants are met.

Warrant 1 - Minimum vehicular volume
Warrant 2 - Interruption of continuous traffic
Warrant 3 - Minimum pedestrian volume
Warrant 4 - Progressive movement
Warrant 5 - Accident experience
Warrant 6 - Combinations of warrants

Note that of the above 6 warrants, Warrant 3 is directly related to pedestrian movements. Warrant 5 also has some pedestrian accident implications. These two warrants are discussed below.

Warrant 3 - The manual specifies that the minimum pedestrian volume warrant is satisfied, when for each of any 8 hours of an average day the following traffic volume exists (pp. 186-187).

"1. On the major street 600 or more vehicles per hour enter the intersection (total of both approaches); or 1,000 or more vehicles per hour (total of both approaches) enter the intersection on the major street where there is a raised median island 4 feet or more in width; and

2. During the same 8 hours as in paragraph 1 there are 150 or more pedestrians per hour on the highest volume crosswalk crossing the major street.

When the 85th percentile speed of major street traffic exceeds 40 miles per hour, or when the intersection lies within the built-up area of an isolated community having a population of less than 10,000, the minimum pedestrian volume warrant is 70 percent of the requirements above, in recognition of differences in the nature and operational characteristics of traffic in urban and rural environments and smaller municipalities.

A signal installed under this warrant at an isolated intersection should be of the semi-traffic-actuated type with push buttons for pedestrians crossing the main street. If such a signal is installed at an intersection within a coordinated system, it should be equipped and operated with control devices which provide proper coordination."

The manual does not provide any information on the procedure used by the authors to derive the critical pedestrian volume of 150 per hour; or any rationale behind the procedure. In the absence of any such documentation, one might assume that these decisions were based upon engineering judgments, perhaps supplemented with empirical observations.

Warrant 5 - The manual mentions that signals should not be installed on the basis of a "single spectacular accident" and that contrary to common belief, more accidents are experienced in certain intersections after signal installation. The manual specifies four conditions under which the accident experience warrant is satisfied of which, the third condition is specifically related to pedestrians. The four conditions are:

"1. Adequate trial or less restrictive remedies with satisfactory observance and enforcement has failed to reduce the accident frequency; and

2. Five or more reported accidents of types susceptible of correction by a traffic control signal have occurred within a 12-month period, each accident involving personal injury or property damage to an apparent extent of $100 or more; and

3. There exists a volume of vehicular and pedestrian traffic not less than 80 percent of the requirements specified in the minimum vehicular-volume warrant, the interruption of continuous traffic warrant, or the minimum pedestrian-volume warrant; and

4. The signal installation will not seriously disrupt progressive traffic flow.

Any signal installed solely on the accident experience warrant should be semi-traffic-actuated with control devices which provide proper coordination if installed at an intersection within a coordinated system, and normally should be fully traffic-actuated if installed at an isolation intersection."

The manual also suggests that if none of the remaining five warrants except the accident experience warrant described above is fulfilled, the initial presumption should be against signalization. In other words, accident experience alone, should not be used as the sole determining factor for a pre-timed signal.

Section 3E - Traffic Actuated Signals

Traffic actuated signals are designed to be responsive to fluctuations in traffic conditions. The manual suggests that consideration of a traffic actuated signal should be given when the installation of pre-timed signal is warranted. A number of factors is mentioned in this context that should be considered and weighed before an actuated signal is installed. As shown below, pedestrian traffic is one of these functions:

> "Pedestrian Traffic - When only the minimum pedestrian volume warrants (sec. 3D-6) for pre-timed signals are met, traffic actuated signals should be considered. They will delay vehicular movements only when the streets are in use by pedestrians."

The manual prescribes a number of ways in which a determination of the need of pedestrian actuated signals can be accomplished (pp. 205-206).

"1. When pedestrian signals are not warranted in conjunction with a traffic-actuated signal installation (sec. 3F-2) but where occasional pedestrian movement exists and there is inadequate opportunity to cross without undue delay, pedestrian detectors shall be installed. The pedestrian actuations may be handled on the same basis as vehicle actuations, provided that the minimum green interval is adequate to serve pedestrians. In this case, no separate pedestrian signal indications are shown.

2. When pedestrian signals are not otherwise warranted but a pedestrian movement exists which would not have adequate crossing time with the above operation (sec. 3F-2 paragraph 7), pedestrian signals and detectors shall be installed and operated as prescribed in section 3F-7.

3. When pedestrian signals are warranted and installed in conjunction with a traffic-actuated signal, the operation should follow the patterns described in section 3F-7."

Section 3F - Pedestrian Signals

The manual provides for the installation of pedestrian signals for the exclusive purpose of directing pedestrian traffic at signalized intersections as follows (p. 218).

> "Pedestrian signals shall be installed in conjunction with vehicular traffic signals already meeting one or more of the

minimum warrants previously set forth for pretimed or traffic-actuated signals (sec. 3D).

1. When a traffic signal is installed under the pedestrian volume warrant (sec. 3D-6).

2. When pedestrians and vehicles move during the same phase and properly adjusted pedestrian clearance intervals are needed to minimize vehicle-pedestrian conflicts.

3. When an exclusive phase is provided or made available for pedestrian movement in one or more directions, all vehicles being stopped.

4. When heavy vehicular turning movements require a semi-exclusive pedestrian phase for the protection and convenience of the pedestrian.

5. When pedestrian movement on one side of an intersection is permissible while through vehicular traffic is stopped to protect a vehicular turning movement on the other side of the intersection.

6. When an intersection is so large and complicated or a street so wide that vehicular signals would not adequately serve pedestrians.

7. When the minimum green intervals for vehicles at intersections with traffic-actuated controls is less than the minimum crossing time for pedestrians and equipment is provided which extends the vehicular green time upon pedestrian actuation.

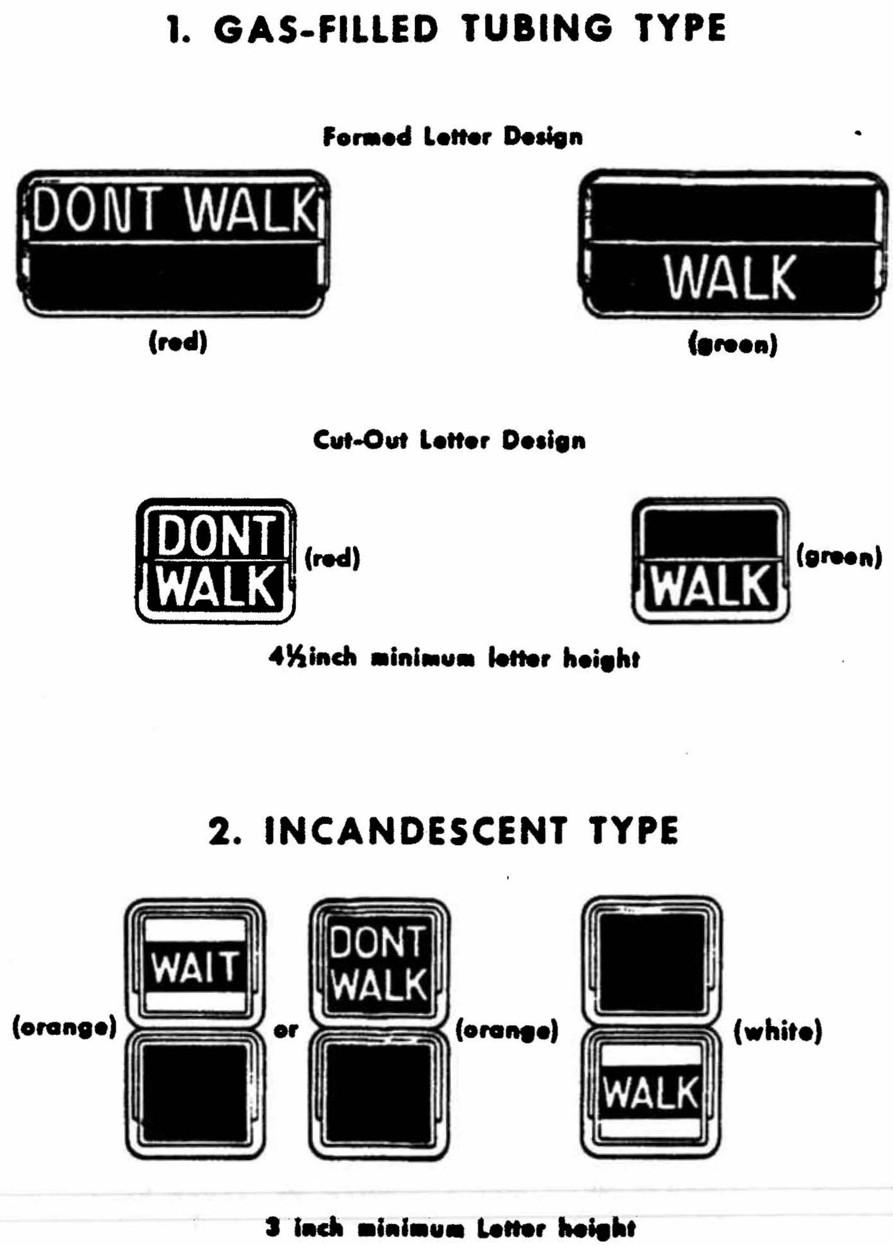
8. When multiphase or split-phase timing would tend to confuse pedestrians guided only by vehicle signal indications.

9. When pedestrians cross only part of the street, to or from an island, during a particular phase."

Pedestrian Signal Indication

The manual provides general design guidelines for pedestrian signals and suggests that pedestrian signals should be rectangular in shape and should contain the lettered messages WALK and DONT WALK (Figure 11 reproduced from Figure 3-4 of MUTCD). The meaning of the two indications are as follows: (p. 221).

"WALK - While the WALK indication is illuminated, pedestrians facing the signal may proceed across the roadway in the direction of the



Note: 1 inch = 2.5 cm

Figure 11. Pedestrian signal design standards from the 1963 MUTCD.

signal and shall be given the right of way by the drivers of all vehicles.

DONT WALK - While the DONT WALK indication is illuminated, either steady or flashing, no pedestrian shall start to cross the roadway in the direction of the signal, but any pedestrian who has partly completed his crossing during the WALK indication shall proceed to a sidewalk, or to a safety island if one is provided."

The pedestrian clearance interval has been defined in the manual as the time interval to "allow a pedestrian crossing in the crosswalk to leave the curb and travel to the center of the farthest traveled lane before opposing vehicles receive a green indication." A flashing DONT WALK during the pedestrian clearance interval is recommended in the manual. Four basic ways are suggested in which pedestrian signal intervals can be combined with vehicular signal intervals. (p. 222):

"Combined pedestrian-vehicular phase. Signal phasing wherein pedestrians may proceed to use certain crosswalks parallel to the through vehicular movement and wherein vehicles are permitted to turn across the said crosswalks.

Semi-exclusive pedestrian vehicular phase. Signal phasing wherein pedestrians may proceed to use certain crosswalks with parallel or other vehicular movements, but wherein vehicles are not permitted to turn across these crosswalks during the pedestrian movement.

Leading pedestrian phase. Signal phasing wherein an exclusive pedestrian phase, in advance of the minor-street vehicular phase, is provided for pedestrians crossing the main street only.

Exclusive pedestrian phase. Signal phasing wherein pedestrians may proceed to cross the intersection in any direction during an exclusive phase while all vehicles are stopped".

Pedestrial Signals at School Crossings

The 1963 manual does not have a separate formal warrant for school crossings and generally discourages the installation of signals at school crossings "where schoolboy patrols or adult crossing guards can be used effectively, where students can be directed to cross at locations which are controlled by traffic control signals or police officers where pedestrian refuge islands provide adequate protection". (p. 187)

The manual specifies that the decision on signals at school crossings should be based on sound engineering judgements and suggests that such a signal may be warranted if: (p. 187)

"1. Pedestrian crossing volumes at a designated school crossing on the major street exceed 250 pedestrians in each of 2 hours; and

2. During each of the same 2 hours vehicular traffic through the designated school crossing exceeds 800 vehicles; and

3. There is no traffic signal within 1,000 feet of the crossing".

When the 85-percentile speed of major-street traffic exceeds 40 miles per hour (67 km per hour) or when the intersection lies within the built-up area of an isolated community having a population less than 10,000, the warrant is 70 percent of the requirements above. This reduction in requirements is made in recognition of differences in the nature and operational characteristics of traffic in urban and rural environments and smaller municipalities.

Note the above provision is made as a part of Warrant 3 in the manual, i.e. the Pedestrian Volume Warrant. The manual also recommends that signals installed under this warrant should be of the pedestrian actuated type and equipped with pedestrian indications. The manual further suggests that as a general rule, "the installation of pedestrian signals at non-intersectional locations is to be avoided".

1971 MUTCD Warrants Relating to Pedestrians

The 1971 MUTCD represents a number of major additions to the 1963 document, of which one relates directly to pedestrians. These additions are discussed essentially in the same order as in the previous section.

Section 4C - Warrants for Traffic Signal

The manual suggests that as a part of determining the need for traffic signals, an analysis of the factors contained in the following warrants should be made:

Warrant 1 - Minimum vehicular volume.
Warrant 2 - Interruption of continuous traffic.
Warrant 3 - Minimum pedestrian volume.
Warrant 4 - School crossings.
Warrant 5 - Progressive movement.
Warrant 6 - Accident experience.
Warrant 7 - Systems.
Warrant 8 - Combination of warrants.

Warrant 4 (School Crossings) and Warrant 7 (Systems) are additions to the signal warrants in the 1963 MUTCD, and Warrant 4 is directly related to pedestrian movements. Further, Warrants 3 and 6 (i.e. Minimum

Pedestrian Volume and Accident Experience) are essentially similar to Warrants 3 and 5 of the earlier document with little or no change.

Warrant 3 (Minimum Pedestrian Volume) - There is no change in the volume criteria in this edition over the 1963 document. However, there is some important information in the 1971 MUTCD relating to signal indications and mid-block crossings. These are stated below: (p. 238)

> "Signals installed according to this warrant shall be equipped with pedestrian indications conforming to requirements set forth in other sections of this Manual.
>
> Signals may be installed at nonintersection locations (mid-block) provided the requirements of this warrant are met, and provided that the related crosswalk is not closer than 150 feet to another established crosswalk. Curbside parking should be prohibited for 100 feet in advance of and 20 feet beyond the crosswalk. Phasing, coordination, and installation must conform to standards set forth in this Manual. Special attention should be given to the signal head placement and the signs and markings used at nonintersection locations to be sure drivers are aware of this special application."

Warrant 4 (School Crossings) - The intent of Warrant 4 is to provide for additional protection at school crossings in situations where there may not be a sufficient number of gaps (of adequate size) to enable safe crossing in groups. The previous version of the MUTCD did have some provision for school crossings as a part of Warrant 3. However, the development of a separate warrant as a part of the 1971 manual is to be considered as a major improvement, considering the overall safety implications of children at street crossings, where the availability of gaps may pose safety hazards. The warrant includes the following provisions.

> "When traffic control signals are installed entirely under this warrant:
>
> 1. Pedestrian indications shall be provided at least for each crosswalk established as a school crossing.
>
> 2. At an intersection, the signal normally should be trafficactuated. As a minimum, it should be semi-traffic-actuated, but full actuation with detectors on all approaches may be desirable. Intersection installations that can be fitted into progressive signal systems may have pretimed control.
>
> 3. At non-intersection crossings, the signal should be pedestrian-actuated, parking and other obstructions to view should be prohibited for at least 100 feet in advance of and 20 feet beyond the crosswalk, and the

> installation should include suitable standard signs and pavement markings. Special police supervision and/or enforcement should be provided for a new non-intersection installation."

Warrant 6 (Accident Experience) - No change in this warrant was made over the 1963 document. As such, the information is not repeated here.

Section 4C-12 - Pedestrian Actuated Control

The manual states that the operation of a traffic actuated signal must take into consideration the needs of pedestrians as well as vehicular traffic. The following specific situations are mentioned where pedestrian actuated signals may be justified (pp. 240-241):

"1. When pedestrian signals are not warranted in conjunction with a traffic actuated signal installation (sec. 4D-3) but where occasional pedestrian movement exists and there is inadequate opportunity to cross without undue delay, pedestrian detectors shall be installed and operated as prescribed in sections 4D-6 and 7.

2. When pedestrian signals are not otherwise warranted but a pedestrian movement exists which would not have adequate crossing time during the green interval, pedestrian signals and detectors shall be installed and operated as prescribed in sections 4D-6 and 7.

3. When pedestrian signals are warranted and installed in conjuction with a traffic-acutated signal, the operation should follow the patterns described in sections 4D-6 and 7".

The manual suggests that in case of actuated signals, pedestrians should be assured of sufficient time to cross the roadway. The following guidelines are provided in this context (p. 245).

> "Where traffic signals are of the actuated type, control equipment should provide sufficient pedestrian crossing time when there has been a pedestrian actuation and the minimum vehicular time is less than that needed by the pedestrians. Where traffic signals are not of the vehicle-actuated type, pedestrian actuation may be used to provide sufficient pedestrian crossing time, or the vehicular time should be adjusted to provide the crossing time needed by pedestrians".

Section D - Pedestrian Signals

According to the 1971 MUTCD, pedestrian signals are to be installed in conjunction with vehicular traffic signals (as set forth according to the warrants described earlier) when any of seven conditions exist (pp. 241-242). It should be noted that the conditions are somewhat different from their 1963 counterparts as previously specified in this document. These seven conditions are:

"1. When a traffic signal is installed under the pedestrian volume or school crossing warrant.

2. When an exclusive interval or phase is provided or made available for pedestrian movement in one or more directions, with all conflicting vehicular movements being stopped.

3. When vehicular indications are not visible to pedestrians such as on one-way streets, at "T" intersections; or when the vehicular indications are in a position which would not adequately serve pedestrians.

4. At established school crossings at intersections signalized under any warrant.

5. When any volume of pedestrian activity requires use of a pedestrian clearance interval to minimize vehicle-pedestrian conflicts or when it is necessary to assist pedestrians in making a safe crossing.

6. When multi-phase indications (as with split-phase timing) would tend to confuse pedestrians guided only by vehicle signal indications.

7. When pedestrians cross part of the street, to or from an island, during a particular interval (where they should not be permitted to cross another part of that street during any part of the same interval)".

A careful comparison of the condition specified in the 1963 manual with those of the 1971 version reveal interesting findings.

1. Conditions numbered as 1,2,3,8 and 9 in the 1963 version have been retained in principle in the later version in a different order, as outlined in conditions 1,5,2,6 or 7 respectively.

2. Conditions numbered 4,5,6 and 7 in the 1963 version have essentially been eliminated from the 1971 version. The 1971 version does not provide any reasons for this elimination. Most of these conditions eliminated, (4,5, and 6 in particular) are of a general nature, so that the application of the conditions in actual practice would have required the use of judgemental factors.

3. The new version provides two additional conditions, numbered 3 and 4, that call for special treatment of T-intersections and school crossings.

Pedestrian Signal Indication

According to the manual, all pedestrian indications are to be rectangular in shape and should consist of the lettered messages WALK-DONT WALK that are supposed to carry the following meaning (p. 241).

"1. The DONT WALK indication, steadily illuminated, means that a pedestrian shall not enter the roadway in the direction of the indication.

2. The DONT WALK indication, while flashing, means that a pedestrian shall not start to cross the roadway in the direction of the indication, but that any pedestrian who has partly completed his crossing during the steady WALK indication shall proceed to a sidewalk, or to a safety island.

3. The WALK indication, steadily illuminated, means that pedestrians facing the signal indication may proceed across the roadway in the direction of the indication.

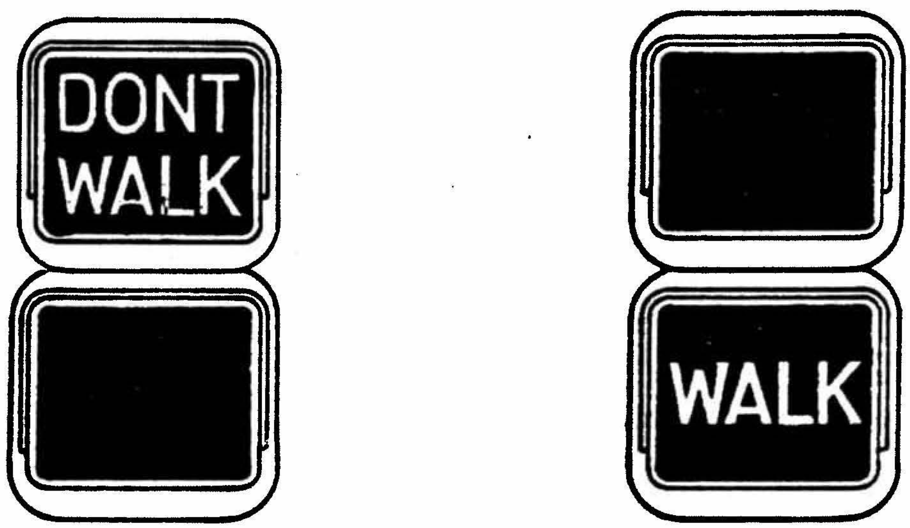
4. The WALK indication, while flashing, means that there is a possible conflict of pedestrians with vehicles."

A comparison of the interpretations of WALK and DONT WALK indications between 1963 and 1971 reveal no changes, excepting that the meaning of flashing DONT WALK is more clearly explained in the later version. Also, it appears that the concept of flashing WALK, signifying possible pedestrian-vehicular conflict was presented for the first time in the 1971 edition.

Figure 12 is an illustration of the recommended signal face designs. The manual specifies that the DONT WALK indication shall be mounted directly above or integral with the WALK indication, and that when not illuminated, the messages shall not be distinguishable by pedestrians at the far end of the crosswalk they control.

As in the 1963 manual, the 1971 manual also suggests four basic combinations of pedestrian signal intervals with vehicular signal operation as follows (pp. 244-245). It should, however, be noted that these combinations are somewhat different from those suggested in the earlier manual. The four signal intervals are described as:

Single Section with Cut-out Letters



Two Section Type

Figure 12. Pedestrian signal face designs from the 1971 MUTCD.

"1. Combined Pedestrian-Vehicular Interval - a signal phasing wherein pedestrians may use certain crosswalks and vehicles are permitted to turn across these crosswalks (the pedestrian indication shall be WALK).

2. Exclusive Crosswalk Interval - a signal phasing wherein pedestrians may use certain crosswalks but vehicles are not permitted to move across these crosswalks during the pedestrian movement (the pedestrian indication shall be steady WALK).

3. Leading Pedestrian Interval - a signal phasing wherein an exclusive pedestrian interval, in advance of the vehicular indication shall be steady WALK. When the leading pedestrian interval is terminated, and a combined pedestrian-vehicular interval begins, the WALK indication may begin to flash.

4. Exclusive Pedestrian Phase - a signal phasing wherein pedestrians may proceed to cross the intersection in any direction during an exclusive phase while all vehicles are stopped (the pedestrian indication shall be steady WALK)."

The manual also mentions that a pedestrian clearance interval shall always be provided with pedestrian signals. Regarding the duration of the clearance interval, the manual provides the following guidelines: (p.245)

> "The duration should be sufficient to allow a pedestrian crossing in the crosswalk to leave the curb and travel to the center of the farthest traveled lane before opposing vehicles receive a green indication (normal walking speed is assumed to be 4 feet per second). On a street with a median at least 6 feet in width, it may be desirable to allow only enough pedestrian clearance time on a given phase to clear the crossing from the curb to the median. In the latter case, if the signals are pedestrian-actuated, an additional detector shall be provided on the island".

It should be noted that the definition of clearance interval has essentially remained unchanged from that provided in the 1963 version. The 1971 version however provides more information on the treatment of the clearance interval for streets with a median.

The manual suggests that a minimum WALK interval of seven seconds should be provided so that pedestrians have adequate time to leave the curb before the clearance interval is shown. However, it is not necessary for the WALK interval to equal or exceed the total crossing time calculated for the particular street width. Pedestrians are likely to complete the crossing during the flashing DONT WALK clearance interval.

1978 MUTCD Warrants Relating to Pedestrians

The 1978 manual, that is currently in force, does not represent any significant changes in the provisions for signal warrants over those specified in the 1971 manual.

Section 4C - Warrants for Traffic Signal

The same set of eight warrants as specified in the 1971 manual have been retained in the latest manual; as such no separate mention of these are made in the document.

Section 4C-12 - Pedestrian-Actuated Signal

No change was made in this manual on the conditions governing the need for pedestrian-actuated control.

Section D - Pedestrian Signals

The seven conditions governing the possible installation of pedestrian signals in conjunction with vehicular traffic signals are the same as specified in the 1971 manual.

Pedestrian Signal Indication

As in the 1971 document, the 1978 manual also recommend that pedestrian indications are to be rectangular in shape and should consist of the lettered messages WALK - DONT WALK. While there is no significant difference in the meaning of DONT WALK indication, the WALK indication is given a slightly different interpretation as follows: (p. 4D-1)

"1. The DONT WALK indication, steadily illuminated, means that a pedestrian shall not enter the roadway in the direction of the indication.

2. The DONT WALK indication, while flashing, means that a pedestrian shall not start to cross the roadway in the direction of the indication, but that any pedestrian who has partly completed his crossing during the steady WALK indication shall proceed to a sidewalk, or to a safety island.

3. A WALK indication, whether steady or flashing, means that pedestrians facing the signal indication may proceed across the roadway in the direction of the indication. In addition a WALK indication indicates one of the following:

   (a) A steady WALK indication, when used in an area where the optional flashing WALK (see 3b below) is not used, indicates that there may or may not be possible conflicts of pedestrians with vehicles turning on a CIRCULAR GREEN indication.

(b) A flashing WALK (use optional) indication means that there is a possible conflict of pedestrians with vehicles turning on a CIRCULAR GREEN indication.

(c) A steady WALK indication when used in an area where the optional flashing WALK is used indicates the absence of conflicts of pedestrians with vehicles turning on a CIRCULAR GREEN indication."

Note again that there is no significant difference in 1 and 2 (DONT WALK) from the 1971 document, but the WALK indication has a slightly different meaning as specified in 3 above. According to the 1978 version, the exact interpretation of the steady WALK indication would require the pedestrian to know whether an optional flashing WALK is also used in the same signal head. In actuality the average pedestrian is not likely to know or remember about the particular signal. Thus, the purpose of the distinction between 3(a) and 3(b) is likely to be defeated.

Figure 13 is a copy of the recommended signal face designs. Note, under the two-section type, the symbol showing a pedestrian, is an addition to the 1971 predecessor. The manual also specifies dimensions of the letters to be used and calls for a precautionary measure in case of electrical or mechanical failure of the word DONT as follows:

"6. For crossings where the distance from the near curb to the pedestrian signal indication is 60 feet or less, the letters, if used, shall be at least 3 inches high or the symbols, if used, shall be at least 6 inches high. For distances over 60 feet, the letters, if used, should be at least 4 1/2 inches high and the symbols, if used, should be at least 9 inches high.

7. The light source shall be designed and constructed so that in case of an electrical or mechanical failure of the word DONT, the word WALK of the DONT WALK message will also remain dark."

No major change has been made in the 1978 manual over the 1971 manual on the four basic combinations of pedestrian signal intervals with vehicular signal operator. The following four combinations remain unchanged.

1. Combined pedestrian-vehicular interval
2. Exclusive crosswalk interval
3. Leading pedestrian interval
4. Exclusive pedestrian phase

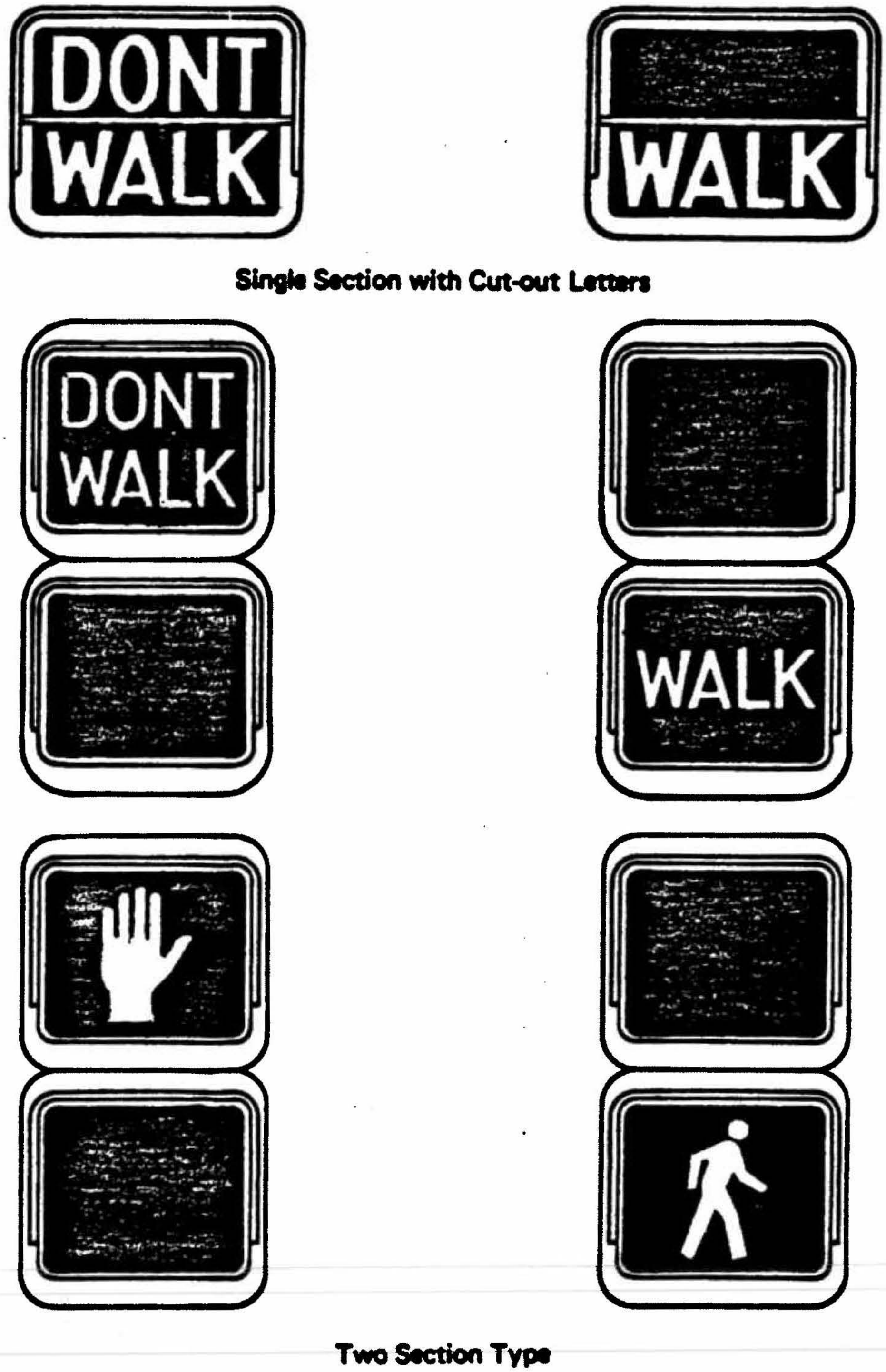


Figure 13. Pedestrian signal face designs from the 1978 MUTCD.

The 1978 document does not indicate any major change in the pedestrian clearance interval over its predecessor. However, for the WALK interval, a range of 4 to 7 seconds is suggested as a minimum value, as opposed to the 7 seconds specified in the 1971 document. The manual suggests the reasons for using the lower value as follows:

> "The lower values may be appropriate where it is desired to favor the length of an opposing phase and if pedestrian volumes and characteristics do not require the longer interval. The WALK interval itself need not equal or exceed the total crossing time calculated for the street width, as many pedestrians will complete their crossing during the flashing DONT WALK clearance interval."

APPENDIX E - LITERATURE REVIEW RELATIVE TO PEDESTRIAN SIGNAL WARRANTS

Introduction

The 1978 version of the Manual on Uniform Traffic Control Devices (MUTCD) specifies eight warrants for the installation of a traffic signal. These include [1]:

Warrant 1 - Minimum Vehicular Volume
Warrant 2 - Interruption of Continuous Traffic
Warrant 3 - Minimum Pedestrian Volume
Warrant 4 - School Crossing
Warrant 5 - Progressive Movement
Warrant 6 - Accident Experience
Warrant 7 - Systems Warrant
Warrant 8 - Combination of Warrants

Of the eight warrants, Warrant 3 (Minimum Pedestrian Volume) and Warrant 4 (School Crossing) are most related to pedestrians. According to the MUTCD, pedestrian signal indications (i.e., WALK/DONT WALK signals) shall be provided when a traffic signal is installed under the Pedestrian Volume or School Crossing Warrant [1]. Warrants 6 (Accident Experience) and 8 (Combination of Warrants) also allow for some consideration to pedestrians.

The MUTCD specifies other conditions for which a pedestrian signal indication shall be installed, including the following [1]:

- When an exclusive interval or phase is provided for pedestrian movements.
- When the vehicular signal indications are not visible to pedestrians.
- At school crossings at intersections with signals justified from any warrant.

In addition to those situations listed above where pedestrian signals are required, there are situations where pedestrian signal indications may be installed, according to the MUTCD [1]:

- When a pedestrian signal is needed to "minimize vehicle-pedestrian conflicts" or assist pedestrians in making a safe crossing.
- When multi-phase indications may confuse pedestrians.
- Where a divided roadway exists and the signal timing only allows pedestrians to cross to the island during one interval.

The latest (1978) edition of the MUTCD specifies that the minimum pedestrian volume (Warrant 3) is satisfied when in each of any eight hours of an average day, the traffic volume exceeds 600 vehicles per hour (both approaches of the major street) and 150 pedestrians per hour crossing the highest volume crosswalk. Where a raised median island of 4 feet (1.2 m) or more exists, the required traffic volume is 1,000 vehicles per hour. Only 70 percent of these requirements are needed when the 85th percentile speed exceeds 40 miles per hour (64 km per hour), or the intersection lies in a community of less than 10,000 population. In midblock locations, the related crosswalk should be not closer than 150 feet (45 m) to another established crosswalk and a pedestrian pushbutton device should be installed at midblock locations [1].

The School Crossing Warrant (Warrant 4) in the MUTCD is based on having an adequate number of gaps in the traffic stream when children are using the crossing. This is based on the premise that when pedestrian delay between adequate gaps becomes excessive, children may become impatient and attempt to cross the street during an inadequate gap. The specific practice used for determining the adequacy of gaps in the traffic stream is the one published by the Institute of Transportation Engineers entitled "A Program for School Crossing Protection" [2].

The Minimum Pedestrian Volume Warrant and School Crossing Warrant are intended to create artificial gaps in traffic by the addition of traffic signals, where corresponding pedestrian signals must also be installed. At locations with traffic signals already in place, the installation of pedestrian signals are somewhat open to engineering judgement (i.e., vehicular indications are not visible, the use of a clearance indication is needed to minimize pedestrian-vehicular conflicts, etc.), as mentioned earlier. While these subjective guidelines all appear reasonable, there may be a need to better quantify the warrants for adding a pedestrian signal at traffic signalized intersections.

Many traffic engineers and researchers have argued that the current MUTCD pedestrian volume warrant is inappropriate. The requirements of the pedestrian volume warrant are so strict that many cities report that it is not practical for their conditions. In order to provide pedestrian signalization, many traffic engineers must rely almost exclusively on their own engineering judgment when selecting locations for such pedestrian signal installations. This has created inconsistencies between regions of the country and often between state and local agencies concerning the conditions under which pedestrian signals are installed.

To investigate the inconsistencies in the application of pedestrian signal and actuation devices, the existing warrants and operational practices documented in the literature were examined. In addition, new warrants developed to better serve the interests of pedestrian safety and operations, as proposed by various researchers, were also examined.

Background

The concept of electrical traffic control (traffic signals) started receiving widespread application in this country in the early 1920's to replace or supplement police traffic control. With sharp increases in auto traffic volumes on the nation's highways, there was a need for a decision mechanism to develop priorities for the installation of traffic signals. It is believed that the first such signal warrant based primarily upon the criteria of volume, was developed for the City of Chicago around 1924 for the purpose of assigning priorities to signal requests [3].

The first formal MUTCD was developed in 1948 by the National Joint Committee (NJC) that included a total of six separate warrants for fixed-time signal control, with appropriate numerical figures representing the average volumes over the eight highest hours. Warrants were also developed for actuated signals, based primarily upon qualitative factors.

In the 1954 MUTCD, the required volumes to warrant a signal were 250 pedestrians per hour (all crosswalks combined) which oppose 600 vehicles per hour. The mean traffic speed had to exceed 15 mph (24 kph), and no difference was specified for divided highways. In rural areas, these required volumes were only 50 percent of those listed above if the average approach speeds exceeded 30 mph (48 kph). Also, the 1954 warrants provided pedestrians to be added on a one to one basis to the cross street volume. Thus, a traffic signal was warranted at urban intersections with approach speeds of 20 mph (32 kph) and at least 75 traffic entities (pedestrians and automobiles) crossing the main street with an hourly volume of 750 vehicles. The minimum values for rural intersections with approach speeds over 35 mph (56 kph) were 50 traffic units crossing a street with 500 vehicles per hour. The 1948 MUTCD was similar, except that the values were based on an average volume over any 8-hour period, instead of based on each hour of an 8-hour period.

In 1963, a modified version of the MUTCD was published. In this version, the minimum vehicular volumes required to warrant a fixed-time signal were prescribed as a function of the approach width (number of lanes). Again, no major changes in the warrants for actuated signals were made.

The 1971 edition of the MUTCD represents a major modification to its predecessor. Two additional warrants were added to the six originally established in 1948. These are the warrants for: (1) school crossing; and (2) a systems warrant. Of these, the former one is directly related to pedestrians. The 1971 version did not incorporate any major change in the warrants of actuated signals. The MUTCD that is currently in force was published in 1978 and does not represent any major change in the provisions for signal warrants over the 1971 document. However, a number of changes in other areas were made in this new version. A discussion of the specific warrants related to pedestrians in the 1963, 1971 and 1978 MUTCD is given in Appendix D.

Since the early editions of the MUTCD, the volumes required to meet the pedestrian signal warrant have increased. This requirement for higher pedestrian volumes has, for obvious reasons, reduced the actual implementation of signals for pedestrians. For example, a survey of current practices conducted among different highway agencies (as a part of NCHRP Project 3-20) indicated that out of a total of 12,780 traffic signal installations, only 171 (1.3 percent) were installed due to Pedestrian Volume Warrant as shown in Table 19 [3]. Further, in 1,243 cases (9.7 percent), some consideration of pedestrians might have contributed to the installation decision under the Combination Warrant. The School Crossing Warrant has been used to justify only approximately 4.0 percent of existing traffic signals [3]. This information indicates that pedestrian conditions by themselves have not generally dictated the installation of traffic signals.

Over the past 20 years, several studies have been conducted in an attempt to develop or modify the signal warrants related to pedestrians. These studies have generally based their warrants on either minimum pedestrian volumes or on a measure of pedestrian delay (or both). For example, a study by Box in 1967 [4] recommended a minimum of 60 pedestrians per hour for one hour (or two 30-minute periods) as a warrant, which is comparable to the Canadian warrant [5] of 60 pedestrians per hour over a 4-hour period. A study by Massey in 1962 resulted in a recommended warrant of 500 pedestrians per hour for two 30-minute periods [6].

Extensive work was conducted for NCHRP Project 3-20 in 1976 which involved recommending modifications to existing traffic signal warrants [3]. The recommended pedestrian signal warrant was developed based primarily on pedestrian delay. Under that recommended warrant, a minimum of 100 pedestrians per hour would be required for any 4 hours on an average day, along with other considerations [3].

From a review of existing and recommended warrants, Neudorff recommended a pedestrian warrant based on a minimum of 100 pedestrians per hour crossing the major street and also at least 60 adequate gaps per hour on major street, using a specific computation of adequate gaps [7]. Robertson has recently developed a methodology for warranting pedestrian signals based on numerous traffic and roadway factors [8]. The following sections provide more discussion on some of these previously recommended warrants along with other analyses used to develop recommended warrants for pedestrian signals.

Table 19. Installation of traffic signals based on the current traffic signal warrants.

Warrant Number	Description	Percent Utilization
1	Minimum Vehicular Volume	51.2
2	Interruption of Continuous Traffic	20.3
3	Minimum Pedestrian Volume	1.3
4	School Crossings	4.0
5	Progressive Movement	2.8
6	Accident Experience	6.2
7	Systems	2.4
8	Combination of Warrants	9.7
	None of These	2.1

Source: Reference 3

Methodology

In order to adequately investigate the warrants for pedestrian signals, three basic activities were undertaken. These included:

- Discussions with many city traffic engineers regarding existing pedestrian signal warrants.
- A thorough review of the literature related to pedestrian signal warrants.
- An in-depth analysis of data at 1,297 intersections to determine the conditions under which the use of pedestrian signal indications could result in fewer pedestrian accidents at existing traffic signalized locations.

Separate reviews were made for the following categories of pedestrian signal warrants: (1) Minimum Pedestrian Volume Warrant; (2) School Crossing Warrant; (3) Pedestrian Signal Indications; (4) Accident and Combination Warrants; and (5) Warrants for Elderly and Handicapped Pedestrians.

Discussions with the city traffic engineers provided valuable insight into the use of the MUTCD warrant(s) and their practicality. No formal survey or questionnaire was conducted, but discussions were held while data were being collected for this project. Informal discussions were held with approximately 70 city traffic engineers regarding their feelings relative to the MUTCD pedestrian signal warrants.

The next step involved a detailed review of all available literature which has addressed the subject of pedestrian signal warrants. Several of these studies involved the development or recommendation of pedestrian signal warrants based on pedestrian delay calculations, safety considerations, and pedestrian and traffic volumes for a variety of highway conditions. A review of each of those articles was conducted to determine whether any of the proposed warrants had merit. The warrants in the current version of the MUTCD were evaluated in terms of five criteria:

- Appropriateness and reasonableness of the warrant to real-world conditions.
- Complexity in applying the warrant.
- Data requirements for using the warrant.
- Flexibility of warrant to be adaptable to all types of highway situations.
- Expected acceptability of the warrant to practicing traffic engineers in the U.S.

Based on these five criteria, an overall rating (excellent, good, fair, or poor) was given to the existing MUTCD warrant.

The third type of analysis involved a detailed analysis of 1,297 signalized intersections for use in determining whether guidelines could be developed for pedestrian signal indications based on pedestrian accidents. Geometric data, signal information, volume data, and accident data at each of the 1,297 locations were analyzed in an attempt to determine which highway and traffic variables explained the most variation in pedestrian accident experience for a variety of conditions. These variables were thought to be important for use in a pedestrian signal warrant for a variety of conditions. In particular, comparisons of pedestrian accidents were made between signalized intersections with and without pedestrian indications and a variety of volume and geometric conditions.

The following sections of the report provide an analysis of pedestrian signal warrants. The information is presented under the following headings:

- Current use of pedestrian signal warrants.
- Pedestrian volume warrant.
- School crossing warrant.

Current Use of Pedestrian Signal Warrants

As stated previously, informal discussions were conducted with city traffic engineers throughout the country as the basis for determining the adherence to and use of the pedestrian signal warrants. Other information related to the use of pedestrian signals was also obtained with regards to types of pedestrian signals in use, signal timing schemes, types of word messages on pedestrian signals, and related issues. The following is a summary of some of the general findings:

- Most city engineers stated that the warrants or guidelines for utilizing pedestrian signals are inadequate. Many stated that the pedestrian volume warrant, as prescribed in the MUTCD, is too restrictive and that they could rarely, if ever, justify the installation of signals based on the pedestrian volume warrant, because of the high pedestrian volumes required (150 per hour for 8 hours on the highest volume crosswalk).

- Many traffic engineers also stated that they do not conduct 8-hour pedestrian volume counts, so the pedestrian volume warrant cannot even be considered. A majority of the cities reported that they collect at most one-hour to three-hour pedestrian volume counts at a few locations, such as at school zone locations. Many of the cities had virtually no recent pedestrian volume information. Most pedestrian volume counts which were taken were for the peak volume periods. Exceptions to this included the cities of Chicago and Detroit, which each had 12-hour pedestrian volume counts for several hundred intersections. Washington, D.C. conducts and maintains current 10-hour pedestrian volume counts by approach at a large number of intersections citywide and Toledo, Ohio conducts manual counts (for a.m., midday, and p.m. peak periods) at a large number of intersections citywide. In Seattle, mechanical traffic counters were converted to automated pedestrian counters and hundreds of mechanical pedestrian volume counts were made several years ago to supplement their manual pedestrian volume counts. A pedestrian traffic volume flow map was also produced for the Seattle central business district area. Vehicular traffic volume data and turning movement counts were generally available for most cities, at least on major arterial streets and in the central business district.

- Many cities routinely install pedestrian signals at downtown locations where other major improvement projects are being implemented as a standard policy. Other cities install pedestrian signals at nearly all school zone locations and/or wherever a pedestrian accident occurs. At school zone locations, community and political pressures often force the cities to provide the maximum possible amount of protection, regardless of whether a site meets the School Crossing Warrant.

- In many cities, pedestrian signals are being installed at locations with existing traffic signals wherever pedestrian activity is known to exist. Traffic engineers in these cities state that they adopted this policy either because they believe that pedestrian signals increase pedestrian safety, or that this is one way of protecting them in the case of litigation against the city resulting from a pedestrian accident. The justification given for such widespread installation of pedestrian signal displays in some cities is the statement on page 4D-2 of the MUTCD, paragraph 1 which states:

  "Pedestrian signal indications also may be installed under any of the following conditions.

  1. When any volume of pedestrian activity requires use of a pedestrian clearance interval to minimize vehicle-pedestrian conflicts or when it is necessary to assist pedestrians in making a safe crossing."

  That statement in the MUTCD is a catch-all that allows for the justification of a pedestrian signal display at almost any traffic signalized location with any pedestrian activity at all, at the discretion of the responsible traffic engineer.

- A few city engineers have expressed their reluctance to use pedestrian signals unless forced to do so, either because of their expense to install and operate, or because they doubt that pedestrian signals are effective in improving pedestrian safety.

- A high percentage of pedestrian signals in use are the type which provides concurrent pedestrian movements. Most cities which have used early or late release signal timing have either converted them to concurrent timing or will do so in the near future. The lack of pedestrian and/or vehicle compliance to their respective signal displays with early or late release have resulted in safety problems, according to several city engineers, (i.e., Cincinnati, and Seattle). Subsequently, the timing was changed to concurrent timing at these locations.

- Of about 70 cities contacted, only a few use exclusive intervals for pedestrian movements, due to the added pedestrian and vehicle delay which results from such timing patterns. Scramble timing, which involves the use of an exclusive pedestrian interval with diagonal crossings, is not commonly used. Denver, Colorado, still has about 70 scramble-timed intersections in their downtown area, and other cities having a few scramble-timed intersections include Richmond, Virginia, New Haven, Connecticut, and Washington, D.C. A few cities, such as Tampa and Miami, Florida, and W. Hartford, Connecticut, use exclusive pedestrian intervals (but do not generally provide for diagonal crossings) at locations such as in school zones, or in locations where moderate to low pedestrian volumes exist.

- Some cities, in an effort to save on the operational costs of pedestrian signals turn off the signal at night to lower their electrical costs (i.e., New Haven turns off their pedestrian signal displays at 10:00 p.m. each night).

- A great disparity was found in the application of signal message types and operations among the cities. Although the flashing WALK is allowed by the National MUTCD to indicate a potential for turning vehicles, many states have not adopted the flashing WALK concept in their state manuals. Cities which use the flashing WALK were found to use it inconsistently. Some cities report that their signal hardware is not flexible enough to easily convert to the flashing WALK mode. Virtually all cities which use it report that pedestrians basically do not understand either the flashing WALK or the flashing DONT WALK concept.

- Most cities have expressed a need to develop a more realistic pedestrian volume warrant. The City of Seattle, for example, has proposed the adoption of a pedestrian volume warrant which is comparable to the warrants proposed by Lieberman in the NCHRP Project 3-20. Seattle has adopted the MUTCD School Crossing Warrant.

- In Boston, a unique approach is used with traffic signal phasing relative to pedestrians. Prior to a pedestrian WALK interval, a flashing green ball is displayed to motorists, followed by an amber period. Then, the vehicle signal display is a solid yellow ball simultaneous with a solid red ball during the pedestrian crossing interval as an added caution to motorists that pedestrians are crossing.

Pedestrian Volume Warrant

Summary of Existing and Proposed Warrants

A review of the pedestrian volume warrant included conducting a comprehensive literature review to find other studies which have been conducted relative to this warrant. In particular, studies which provided other recommended warrants to replace the current MUTCD were analyzed to determine their validity. A critical analysis of the MUTCD warrant and the other proposed pedestrian volume warrants was helpful in the development of recommended warrants. The articles or publications which were reviewed relative to the pedestrian volume warrant include:

1. Current (1978) MUTCD warrant [1]

2. Research Studies and Reports

   - Box [4]
   - NCHRP 3-20 [3]
   - King [9]
   - Massey [6]
   - Neudorff [7]

3. Other Agency Warrants

   - Pennsylvania [3]
   - Canada [5]
   - New Zealand [3,4,10]
   - Victoria, Australia [3]
   - Great Britain [3]
   - Ireland [3]

The following is a brief description of each warrant or study.

The 1978 MUTCD warrant for Minimum Pedestrian Volume (Warrant 3) is satisfied when 600 or more vehicles per hour enter an intersection (both approaches of the major street) for each of any 8 hours of an average day along with 150 or more pedestrians per hour during the same period crossing the highest volume crosswalk crossing the major street. For a divided highway, 1,000 vehicles or more per hour are required. Where the traffic speed exceeds 40 mph (64 kph) or in isolated communities (less than 10,000 population), the requirements are only 70 percent of those stated above. At midblock locations, the warrants are the same, provided that the crosswalk is not closer than 150 (45 m) feet to another established crosswalk. The complete warrant, as taken from the MUTCD, is given in Figure 14 [1].

In 1967, a study by Box was conducted for the signal committee of the National Joint Committee on Uniform Traffic Control Devices [4]. The purpose of the study was to review warrants for traffic signals and suggest considerations and numerical values for warrants. Of the 264 references that he reviewed in-depth, approximately 30 were found which contributed to pedestrian warrant information. Their recommended warrant is as follows [4]:

> "Pedestrian signal control is warranted when the peak 30 minute pedestrian delay, for at least two periods of an average weekday, or eight periods of a Saturday or Sunday, equals or exceeds 0.5 hours each, and when the peak hour pedestrian crossing volume is at least 60 persons, including one of the 30 minute periods."

4C-5 Warrant 3, Minimum Pedestrian Volume

The Minimum Pedestrian Volume warrant is satisfied when, for each of any 8 hours of an average day, the following traffic volumes exist:

1. On the major street, 600 or more vehicles per hour enter the intersection (total of both approaches); or where there is a raised median island 4 feet or more in width, 1,000 or more vehicles per hour (total of both approaches) enter the intersection on the major street; and
2. During the same 8 hours as in paragraph (1) there are 150 or more pedestrians per hour on the highest volume crosswalk crossing the major street.

When the 85-percentile speed of major-street traffic exceeds 40 mph in either an urban or a rural area, or when the intersection lies within the built-up area of an isolated community having a population of less than 10,000, the Minimum Pedestrian Volume warrant is 70 percent of the requirements above.

A signal installed under this warrant at an isolated intersection should be of the traffic-actuated type with push buttons for pedestrians crossing the main street. If such a signal is installed at an intersection within a signal system, it should be equipped and operated with control devices which provide proper coordination.

Signals installed according to this warrant shall be equipped with pedestrian indications conforming to requirements set forth in other sections of this Manual.

Signals may be installed at nonintersection locations (mid-block) provided the requirements of this warrant are met, and provided that the related crosswalk is not closer than 150 feet to another established crosswalk. Curbside parking should be prohibited for 100 feet in advance of and 20 feet beyond the crosswalk. Phasing, coordination, and installation must conform to standards set forth in this Manual. Special attention should be given to the signal head placement and the signs and markings used at nonintersection locations to be sure drivers are aware of this special application.

Figure 14. MUTCD - Minimum Pedestrian Volume Warrant.

Source: Reference 1.

Simply stated, the warrant requires a minimum of 60 pedestrians per hour for one hour (or for two 30-minute periods) and also an average of 60 seconds of mean delay per pedestrian for one of the two 30-minute periods. According to the authors, drivers are subjected to longer waiting times from their delay warrant, than pedestrians are subjected to under their proposed warrant. They justified this based on the added protection of motorists from inclement weather and the added danger of injury to pedestrians which are struck by motor vehicles [4].

A study was conducted for NCHRP Project 3-20 entitled "Traffic Signal Warrants" in 1976 by Lieberman, King, and Goldblatt [3]. The warrant is based primarily on pedestrian delay considerations and is presented in graphical form for undivided streets (Figure 15) and divided streets (Figure 16). The procedure involves considering the total major street volume (TMSV), the pedestrian volume (Qp), vehicle approach speed, pedestrian walking speed, and effective street width. A signal is warranted if four plotted points (i.e., four one-hour periods of data) lie to right of the curve corresponding to the effective street width. A procedure is given in the report for computing the effective street width. Note that a minimum of 100 pedestrians per hour are required for meeting the warrants in both figures. Minimum required traffic volumes for undivided and divided streets are 500 vehicles per hour and 1,000 vehicles per hour respectively [3].

A study was completed by King in 1977 in which he prepared warrants based on pedestrian delay [9]. The delay model was based on an exponential arrival distribution model, as developed by Tanner in 1951 [11], which was developed as a means to estimate pedestrian delay. Based on a 30-second assumed acceptable level of pedestrian delay and a 60-second level of maximum tolerable pedestrian delay, pedestrian signal warrants were prepared graphically for undivided highways (Figure 17) and divided highways (Figure 18). The warrant is satisfied if the measured hourly pedestrian volume lies above the appropriate Q_p curve for the given street width and vehicle flow rate. These curves apply to both intersections and midblocks and should be exceeded for 4 hours on an average weekday. The proposed warrant could also be met or exceeded for 10 hours on any weekend providing that at least 3 hours are met on the day with the lighter volumes [9].

It should be noted that Tanner's delay model is based on the assumption of random arrival of vehicles, whereas vehicular arrivals in most urban intersections are not likely to be random in nature. Thus, the validity of using the Tanner model for analyzing pedestrian delay at urban intersections and developing warrants based on those values may be questioned.

The study by Massey in Australia was conducted in 1962 in which warrants were developed for pedestrian crossings and also for pedestrian actuated signalized crossings [6]. The acceptable level of pedestrian

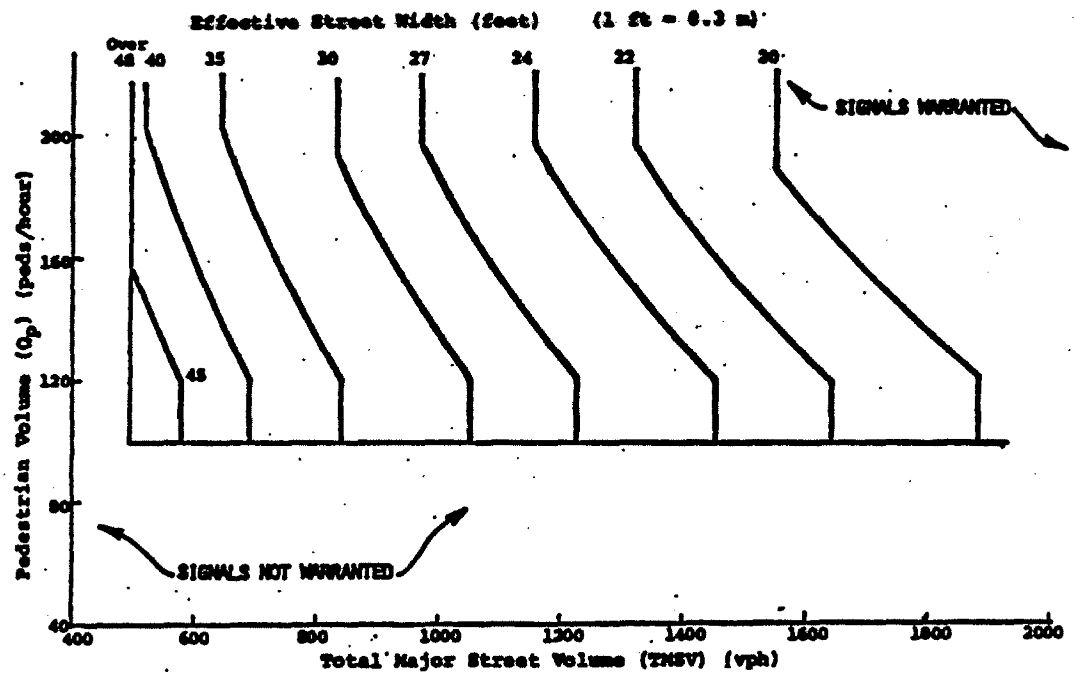


Figure 15. Proposed pedestrian signal warrant, undivided streets.

Source: Reference 3

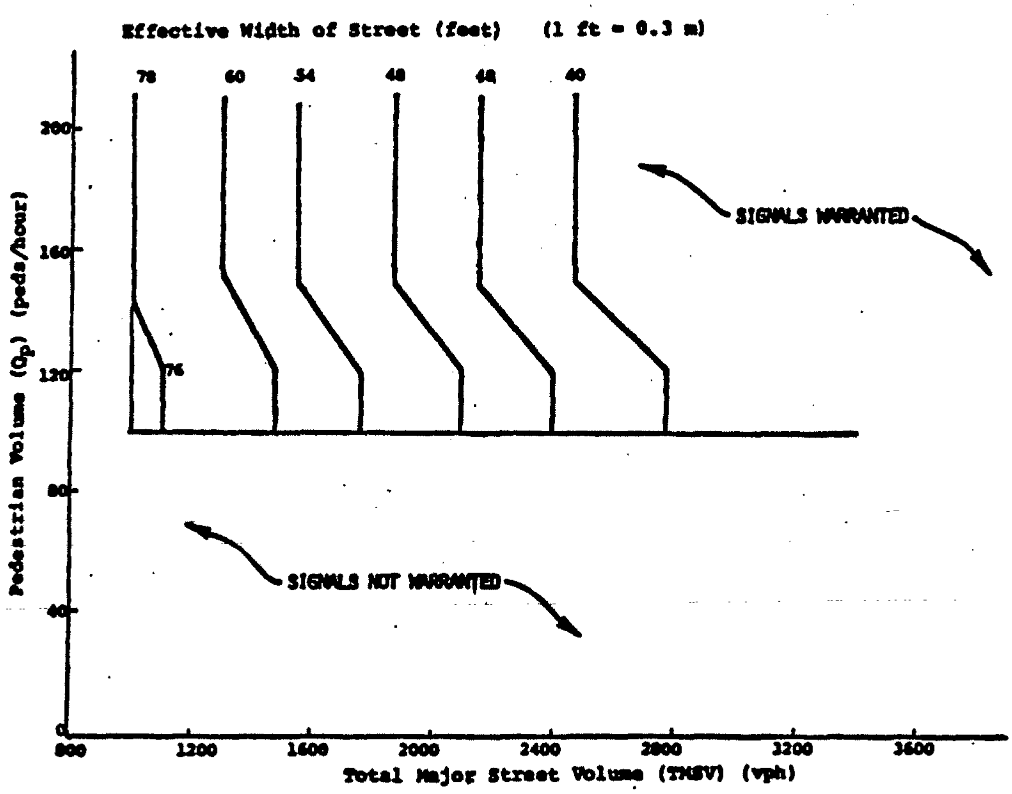


Figure 16. Proposed pedestrian signal warrant, divided streets.

Source: Reference 3

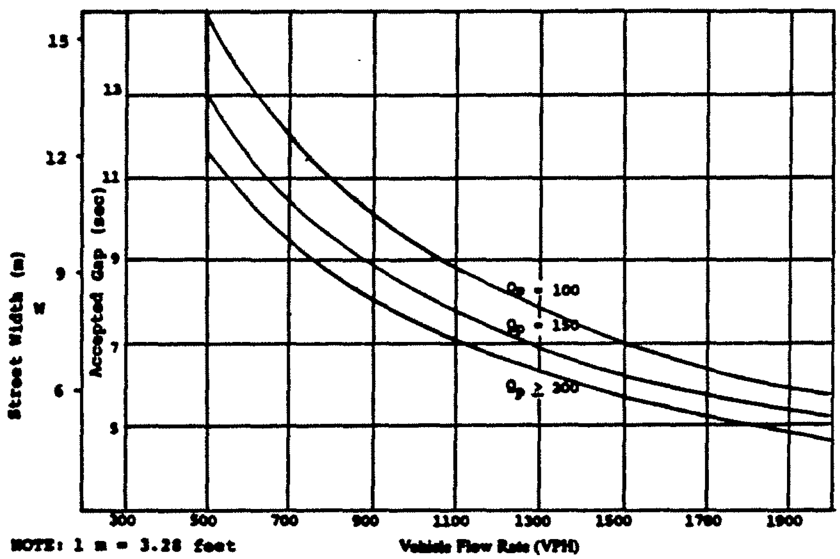


Figure 17. Proposed pedestrian signal warrant for an undivided highway.

Source: Reference 9.

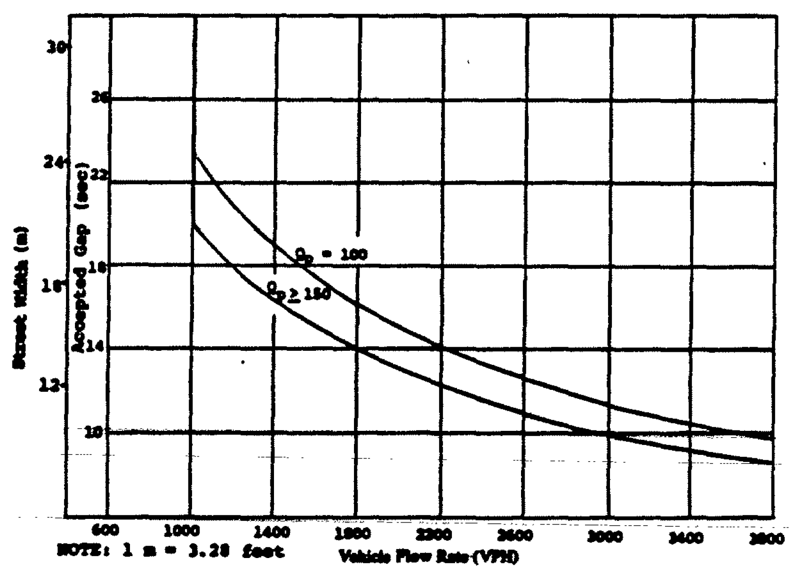


Figure 18. Proposed pedestrian signal warrant for a divided highway.

Source: Reference 9.

delay utilized was 30 seconds. For roadways with any number of lanes, a minimum volume of 500 pedestrians per hour is required for two 30-minute periods. A corresponding traffic volume of 400 per hour is also required. A legal pedestrian crossing (without a signal) is warranted for locations with 100 pedestrians per hour, and the law in Australia requires vehicles to yield to pedestrians at legal pedestrian crossings [6].

In 1981, an unpublished report was prepared by Neudorff for the FHWA project "Traffic Signal Warrants from Gap Detector Data", which involved recommending a pedestrian signal warrant [7]. The study was based on a review of other studies and resulted in the following recommended warrant:

> "The installation of a traffic signal is justified when, during each of any four (4) hours of an average weekday, the major street gap distribution and pedestrian volume satisfy the following criteria:
>
> 1. The number of major street gaps which are equal to or greater than an "adequate size" is less than sixty (60) per hour, [NOTE - The size of an adequate gap is determined from Table (20)] and
>
> 2. The pedestrian volume crossing the major street is equal to or exceeds one hundred (100) pedestrians per hour."

The warrant stated above was for both intersections and midblocks and for the installation of pedestrian signal heads and push buttons for pedestrian actuation.

Table 20. Adequate gap sizes.

Major Street Width (ft)	Adequate Gap (sec)	Major Street Width (ft)	Adequate Gap (sec)
13 - 16	7	37 - 40	13
17 - 20	8	41 - 44	14
21 - 24	9	45 - 48	15
25 - 28	10	49 - 52	16
29 - 32	11	53 - 56	17
33 - 36	12	57 - 60	18

Note: Gap sizes have been rounded up to next highest whole number.

1 foot = 0.3 m

Source: Reference 7

Numerous state highway agencies have developed their own modified warrants for use in installation of traffic and pedestrian signals. For example, Pennsylvania developed a peak hour pedestrian warrant for installing actuated equipment (not within 1,000 feet of a signalized location). The warrant is met when the following volumes are met or exceeded for each of any two hours of an average day [3]:

	Vehicles	Pedestrians
Urban Areas	800	250
Rural Areas	560	175

The Canadian Traffic Signal Installation Warrant includes a specific pedestrian volume warrant which is contained in a 1966 publication and is based on pedestrian volumes and delays. The specific warrant is as follows [5]:

"a. Pedestrians on an average must wait in excess of 60 seconds before being able to cross the main street in safety;

b. The number of pedestrians wishing to cross is at least 60 per hour;

c. The conditions specified in (a) and (b) exist for any four not necessarily continuous hours of a normal day;

d. The intersection or other location is suitable for signalization;

e. The nearest existing or proposed signal installation is more than 1,000 feet away.

The existing delay occasioned to pedestrians should be determined by a study at the location in question."

The Canadian warrants are similar to the warrants recommended by Box in terms of the minimum required pedestrian volumes (60 per hour) and mean delay per pedestrian (60 seconds). However, the Canadian warrant requires those conditions for 4 hours, compared to 2 30-minute periods in the Box recommended warrants.

The New Zealand Traffic Signal Warrant is based on assigning a vehicular equivalent to pedestrian volume and then treating pedestrians and vehicles together. The warrant is as follows [3,4,10]:

"Pedestrian and traffic volume: For the purpose of this warrant, pedestrians are considered to be equivalent to one-third of a vehicle up to 600 pedestrians per hour and as equivalent to one-sixth of a vehicle thereafter.

Signals are justified if the total hourly traffic volume on a normal weekday averaged over the following hours:

a. One morning peak hour (between 7:00 a.m. and 9:00 a.m.);

b. One morning off peak hour (between 9:00 a.m. and noon);

c. One mid-day hour (between noon and 2:00 p.m.);

d. One afternoon off peak hour (between 2:00 p.m. and 4:00 p.m.); and

e. One evening peak hour (between 4:00 p.m. and 8:00 p.m.);

reaches or exceeds both the volumes in the following table:"

Table 21. New Zealand minimum pedestrian volume warrant.

Intersection	Total No. of Traffic lanes for traffic approaching intersection (available for storage)	Warrant	
		Entering traffic from side roads*	Total traffic through intersection*
3 legs	3 or 4 lanes	240 v.p.h.	1,200 v.p.h.
	5 or 6 lanes	280 v.p.h.	1,400 v.p.h.
4 legs or more	4 lanes	200 v.p.h.	1,000 v.p.h.
	6 lanes	240 v.p.h.	1,200 v.p.h.
	8 lanes or more	280 v.p.h.	1,400 v.p.h.

* This includes the vehicular equivalent of the pedestrian traffic.

Source: Reference 3

For example, if 900 pedestrians cross a street, it would be converted to the equivalent of (600)/3 + (900 - 600)/6 = 200 + 50 = 250 "vehicles". The 250 would then be added in with the vehicle volume (either side street or through traffic) and checked against the warrant table (Table 21).

In Victoria, Australia, pedestrian-actuated signals are warranted if "the pedestrian volume exceeds 350 per hour in each of three hours for an average day in addition to 600 vehicles per hour (both directions) in the same three hours. An alternate warrant requires 175 pedestrians per hour and 600 vehicles per hour for each of 8 hours. The necessary volumes are reduced to 70 percent of the requirements above for locations with speeds above 40 mph (64 kph) or in isolated cities of less than 10,000 [3]. Note that the pedestrian volume requirements do not stipulate the highest volume leg as with the U.S. MUTCD, so the warrant would actually be lower than the U.S. warrant in most cases. Also, an alternate three-hour warrant exists, which would allow many locations to meet the warrant which would not meet an eight-hour warrant.

In Great Britain, a total of 1,450 vehicles plus pedestrians per hour is the suggested criteria for installing pedestrian signals, or 1,650 if a median refuge exists [3]. A special provision is made for actuated pedestrian crossings where vehicle speeds exceed 40 mph (64 kph) [3]. One major difference between this warrant and the New Zealand warrant is the weighting placed on pedestrians. The Great Britain warrant adds pedestrians to vehicles on a one-to-one basis, while the New Zealand counts a vehicle as equivalent to 3 pedestrians (or equivalent to 6 pedestrians where pedestrian volumes exceed 600 per hour).

The advisory pedestrian warrant in Ireland is based on only one peak hour period and requires different combinations of vehicles and pedestrian volumes for different street widths, speed limits, and street operation (one-way or two-way). For example, for a 44-foot (13 m) street width on a twoway street of 30 mph (50 kph), 90 pedestrians and 650 vehicles are required during the peak hour. The required pedestrian and traffic volumes for the Ireland advisory warrant are given in Table 22 [3].

Table 22. Excerpts from advisory warrants, Ireland: minimum pedestrian and vehicular volumes (peak hour volumes).

Carriageway Width (feet)	Pedestrian Volume	Speed Limit (mph)	Vehicular Volume	
			One-Way St.	Two-Way St.
20	80	30	1,175	1,000
		40	1,075	900
24	420	30	1,100	975
		40	1,000	810
30	330	30	975	800
		40	875	680
36	240	30	850	650
		40	750	550
44	90	30	650	450
		40	550	350

Note: 1 mph = 1.6 kph
1 foot = 0.3 m

Source: Reference 3

School Crossing Warrant

The establishment of warrants for the installation of traffic signals in school zones is intended to provide uniformity of traffic control in school areas. The MUTCD did not contain a formal warrant for installing traffic signals (with pedestrian indications) until the 1971 version. The 1963 MUTCD generally discouraged the installation of signals at school crossings "whereby schoolboy patrols or adult crossing guards can be used effectively, where students can be directed to cross at locations which are controlled by traffic control signals or police officers where pedestrian refuge islands provide adequate protection." However, the 1963 manual specified (as a part of Warrant 3 - Minimum Pedestrian Volume) that the decision to add signals at school crossings should be based on sound engineering judgment, and suggested that a signal <u>may</u> be warranted if:

"1. Pedestrian crossing volumes at a designated school crossing on the major street exceed 250 pedestrians in each of 2 hours; and

2. During each of the same 2 hours vehicular traffic through the designated school crossing exceeds 800 vehicles; and

3. There is no traffic signal within 1,000 feet of the crossing."

The criteria listed above should be reduced to 70 percent when the 85th percentile traffic speeds exceed 40 mph (64 kph) or in built-up areas of isolated communities of less than 10,000 population. Signals meeting these criteria should be pedestrian actuated with pedestrian indications. The 1963 manual also suggested that "the installation of pedestrian signals at non-intersection locations is to be avoided".

The 1971 MUTCD for the first time provided a separate and formalized warrant (Warrant 4) for providing additional protection at school crossings in situations where there are not a sufficient number of gaps. The 1978 MUTCD is similar to the 1971 version of the School Crossing Warrant, which states the following:

> "A traffic control signal may be warranted at an established school crossing when a traffic engineering study of the frequency and adequacy of gaps in the vehicular traffic stream

as related to the number and size of groups of school children at the school crossing shows that the number of adequate gaps in the traffic stream during the period when children are using the crossing is less than the number of minutes in the same period (sec. 7A-3)".

The reference to section 7A-3 (School Crossing Control Criteria) was made to provide additional details related to adequate gaps. The manual refers to the ITE publication "A Program for School Crossing Protection" [2] for use in determining the frequency and adequacy of gaps in the traffic stream. The 1978 versions of the MUTCD also provide three provisions for locations where traffic signals are installed entirely under the School Crossing Warrant [1]:

"1. Pedestrian indications shall be provided at least for each crosswalk established as a school crossing.

2. At an intersection, the signal normally should be traffic actuated. As a minimum, it should be semi-traffic-actuated, but full actuation with detectors on all approaches may be desirable. Intersection installations that can be fitted into progressive signal systems may have pretimed control.

3. At non-intersection crossings, the signal should be pedestrian actuated, parking and other obstructions to view should be prohibited for at least 100 feet in advance of and 20 feet beyond the crosswalk, and the installation should include suitable standard signs and pavement markings. Special police supervision and/or enforcement should be provided for a new non-intersection installation."

Several previous studies have addressed the School Crossing Warr
In the study by Box, a review of the School Crossing Warrant resultedant.
the following statement [4]: in

"In summary, the ITE recommended school practice using delay to pedestrians, accounts for all variables of vehicular volume and headway distribution."

The authors then applied that same delay concept to a recommende
adult crossing warrant based on pedestrian volume and delay. The autd
later suggest that the ITE school crossing delay warrant could be reshors
as follows [4]: tated

"Control is warranted when the number of adequate gaps in the traffic stream, during the peak pedestrian crossing period of 30 minutes, is less than 30 provided that a minimum volume of

60 pedestrians is found during the peak hour, and that the peak 30 minute gap deficiency occurs at least twice per normal weekday."

That suggested warrant for school crossing has many similarities to their recommended warrant for adult pedestrian crossing locations. The school crossing warrant was also reviewed in the 1976 NCHRP 3-20 draft report "Traffic Signal Warrants" [3]. Their recommended warrant "essentially replicates the existing MUTCD warrant, but presents it in graphical format." It applies to both intersection and midblock locations and is satisfied if the minimum requirements are met for the normal morning and afternoon crossing periods. The curves are given for situations on undivided highways with a crossing guard (Figure 19) and without a crossing guard (Figure 20), and also for divided highways with no crossing guard (Figure 21). One change from the ITE warrant is that the number of adequate gaps required for the heavier travelled roadway should be at an average of 100 per hour (instead of 60 per hour). Also, an alternative procedure is provided in the NCHRP report to apply a part-time traffic control device to locations with random vehicle arrivals on the major street [3].

Numerous studies and publications in past years have recommended the use of other signal warrants in school crossing locations. A 1977 study by the Michigan Department of Transportation recommended a minimum use of available gaps in traffic as with the ITE procedure, providing that a "minimum of 50 children should be utilizing the crossing before applying this warrant" [12]. A 1971 study by the California Division of Highways specified warrants for school area traffic signals separately for urban and rural areas. In urban areas, the required conditions are [13]:

> "500 vehicles and 100 school-age pedestrians for each of any two hours daily while children are crossing to or from school; <u>or</u>
>
> 500 vehicles per hour for each of any two hours while children are crossing to or from school, and a minimum total of 500 school-age pedestrians during the entire day."

In rural areas, the warrants are 70 percent of those stated for urban conditions.

Based on discussions with city traffic engineers around the country concerning the existing school crossing warrant, there are four basic conclusions that can be reached:

- Although not all city traffic engineers agree with the appropriateness of the MUTCD school crossing warrant, most cities seem to have accepted it and find it to be reasonable. For example, a recent draft resolution by the Seattle City Council stated that the current MUTCD school crossing criteria will be used to war-

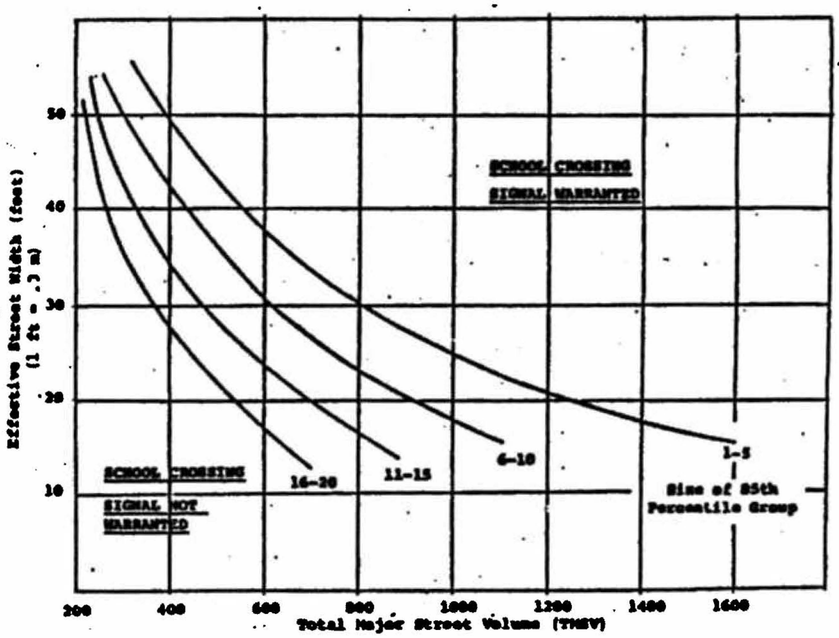


Figure 19. Proposed school crossing warrant - undivided highway with a school crossing guard.

Source: Reference 3

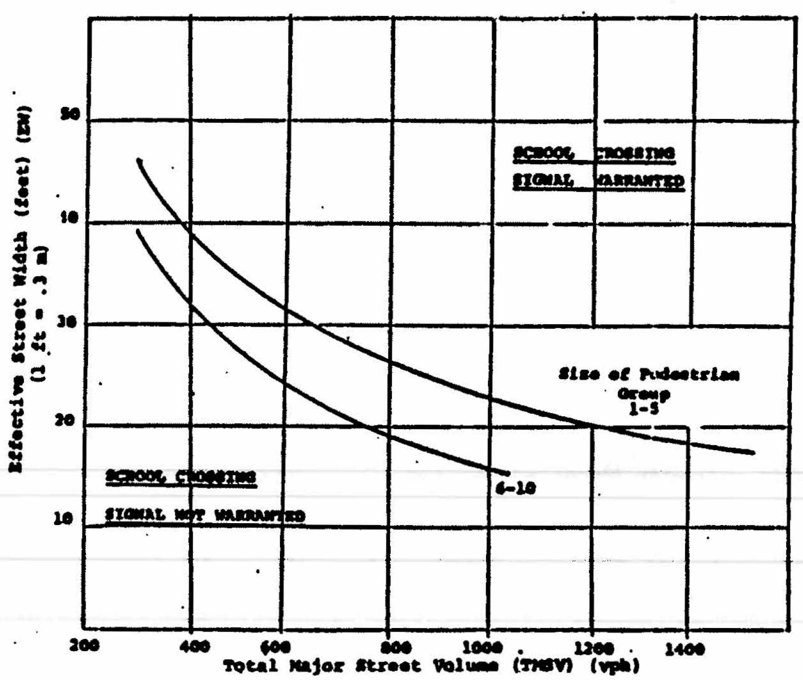


Figure 20. Proposed school crossing warrant - undivided highway with no crossing guard.

Source: Reference 3

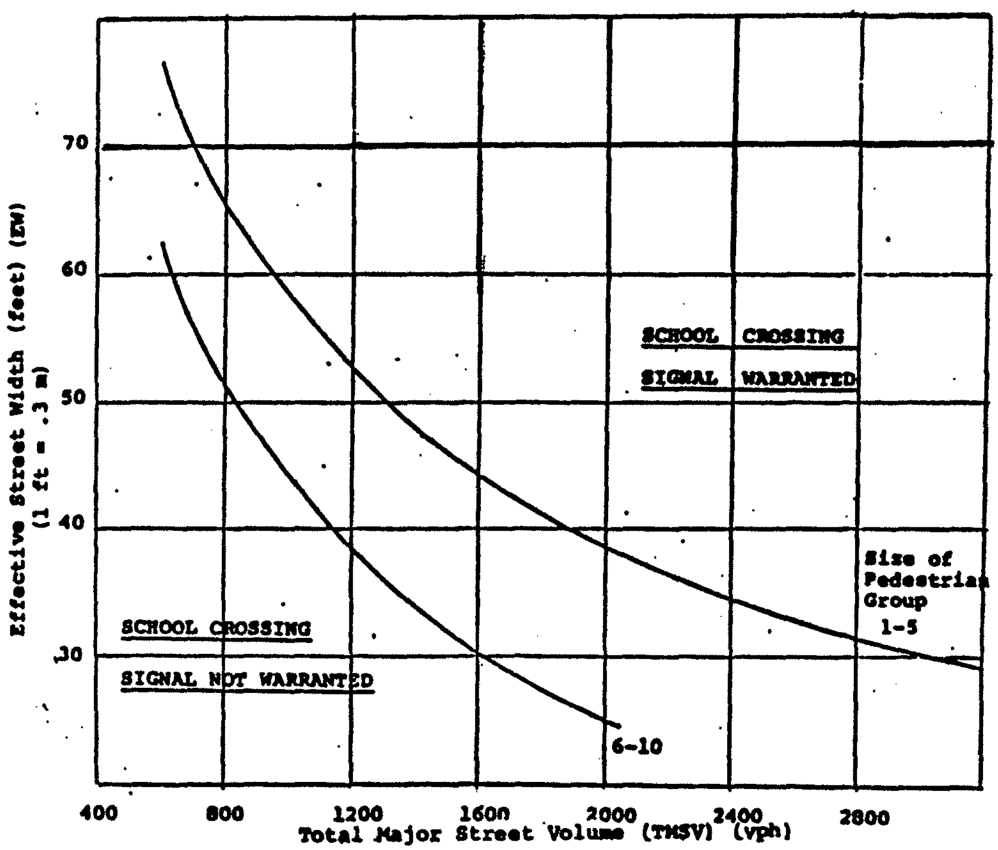


Figure 21. Proposed school crossing warrant - divided highway with no crossing guard.

Source: Reference 3

rant a signal at a school crossing location "contingent upon funds being available through the City Capital Improvement Program and upon whether or not the need for a traffic signal can be mitigated by some alternative traffic/pedestrian improvement" [14]. It should also be mentioned that the City of Seattle did not recommend the MUTCD Minimum Pedestrian Volume Warrant, but instead recommended the use of a pedestrian delay-based warrant [14].

2. Many traffic engineers utilize the MUTCD School Crossing Warrant to justify several signal installations each year. However, the warrant is high enough to prevent the installation of signals at a large number of locations where signals "aren't really needed."

3. In many (if not all) jurisdictions, the safety of school children in school zones is a very emotional and political issue. As a result, traffic engineers in many cities are forced to install traffic signals at virtually all school crossing locations, regardless of whether they meet any warrants. At signalized intersections, some cities also provide exclusive protected pedestrian intervals, where traffic is stopped in all directions and pedestrians have a "protected" crossing interval during certain hours of the day.

4. Generally speaking, adult school crossing guards have been found to be quite effective in increasing pedestrian safety in school crossings. However, the notion that an adult school crossing guard provides all the needed protection at a school crossing is not always true. Pedestrians or vehicles which do not respect or adhere to the crossing guard can create a hazardous situation.

The use of a traffic signal at a school crossing location may not always insure crossing safety. A certain percentage of motorists can be expected to violate the traffic signal, particularly during rush hour times. Also, studies have shown that a high percentage of pedestrians disregard the DONT WALK indication, particularly in cities where little or no police enforcement of pedestrian violations exists.

The five criteria discussed earlier were applied to the MUTCD School Crossing Warrant. In terms of appropriateness, the warrant is based on the number of adequate gaps in traffic which in itself is more likely to be appropriate for a variety of roadway conditions (i.e., street width, traffic speeds and volumes, etc.) compared to strictly a volume based warrant. The maximum number of gaps (one per minute) required to warrant a signal is quite reasonable, since many past research studies have found or supported the assumption of 60 seconds as a maximum amount of delay which a person should be expected to endure. The literature and many city engineers tend to support the basic concept of the MUTCD School Crossing Warrant, even though other modifications have been used in a few cases. The School Crossing Warrant was rated as "good" in terms of reasonableness and appropriateness (Criterion 1).

In terms of complexity (Criterion 2), the procedure outlined by ITE for determining gaps frequency and adequacy is relatively straight-forward and not unduly complicated. The practicality of the data collection (Criterion 3) is good, since data are collected only during the periods when children are using the crossing. At many school locations, this represents morning and afternoon periods of 15 to 45 minutes.

The flexibility of the School Crossing Warrant (Criterion 4) was found to be excellent, since the procedure for measuring adequate gaps accounts for various combinations of street width and traffic volume. Although a walking speed of 3.5 ft/sec (1.2 m/sec) is normally assumed, that can be changed in the mathematical calculation of adequate gap time in the ITE procedure.

The acceptability of the School Crossing Warrant by traffic engineers (Criterion 5) was rated as good, particularly when compared to the acceptability of the Minimum Pedestrian Volume Warrant. This does not imply that traffic engineers only install signals when this warrant is met. There will always be situations where traffic signals are installed for safety or other (i.e., political) reasons, even though the School Crossing Warrant is not met. No warrant is perfect for all situations, and good engineering judgment must enter into the decision of whether to install traffic signals. However, the School Crossing Warrant appears to have at least gained a reasonable degree of acceptance in the traffic engineering community.

Overall, the MUTCD School Crossing Warrant was rated as "good". It is recommended that the current MUTCD School Crossing Warrant continue to be used as presently stated.

References

1. Manual on Uniform Traffic Control Devices, U.S. Department of Transportation, Federal Highway Administration, Washington, D.C., 1978.

2. "A Program for School Crossing Protection," Institute of Transportation Engineers, 1971.

3. Lieberman, E.B., et al., "Traffic Signal Warrants," National Cooperative Highway Research Project 3-20, KLD Associates, Huntington, N.Y., December, 1976. Draft Unpublished Report.

4. Box, P.C. and Associates, "Assembly, Analysis and Application of Data Warrants for Traffic Control Signals," National Joint Committee on Uniform Traffic Control Devices, March, 1967.

5. Canadian Good Roads Association, "Installation Warrants for Traffic Control Signals," Part B, Division 2, May, 1966.

6. Massey, S.A., "Mathematical Determination of Warrants for Pedestrian Crossings," Traffic Engineering, Vol. 32, No. 12, September, 1962, pp. 19-21.

7. Neudorff, L.G., "Pedestrian Warrant Concept," unpublished report for Federal Highway Administration, 1981.

8. Robertson, H.D., "Signalized Intersection Controls for Pedestrians," unpublished document, 1981.

9. King, G.F., "Pedestrian Delay and Pedestrian Signal Warrants," Transportation Research Record No. 629, Transportation Research Board, Washington, D.C., 1977.

10. Clissald, C.M., and Palmer, M.R., Intersection Traffic Signal Warrants (Section A). "A discussion of the Draft New Zealand Standard Recommendation, Traffic Signals, D 7928", New Zealand Standards Institute, Wellington, New Zealand.

11. Tanner, J.C., "The Delay to Pedestrian Crossing a Road," Biometrika, Vol. 38, 1951, pp. 382-383.

12. "Guidelines for Traffic Control in School Areas," Michigan Department of State Highways and Transportation, December, 1977.

13. California Division of Highways, "School Crossing Protection Signs, Signals and Devices", California Busness and Transportation, 1971.

14. Memorandum from Paul Wiatrak to Councilmember Jeanette Williams, City of Seattle, August 15, 1979.

APPENDIX F - LITERATURE REVIEW AND CURRENT PRACTICE ON PEDESTRIAN SIGNAL ALTERNATIVES

Pedestrian Clearance Alternatives

Past Research

Numerous research studies have been conducted in recent years relative to signal displays for the clearance interval. A study was conducted in 1968 by the ITE, in which the steady DONT WALK message was compared with the flashing DONT WALK message [1]. The behavior of 177,000 Pedestrians was observed at 15 intersections where the flashing and steady DONT WALK signals were used. At eight locations, the steady DONT WALK message was used in the before condition and the flashing DONT WALK was used in the after and 30-days after periods. The sequence was reversed at the other 7 locations. The results are summarized in Table 23.

Table 23 - Summary of results in a study comparing the steady and flashing DONT WALK indications on pedestrian behavior.

Conditions		Percent Proper Crossings		
Before	After	Before	After	30 Days After
Steady	Flashing	92	95	88
Flashing	Steady	93	92	95

Source: Reference 1.

The results showed that the steady DONT WALK message resulted in a higher long-term benefit in terms of proper crossings compared to the flashing DONT WALK message.

In a 1977 study for the Federal Highway Administration, Robertson evaluated the effectiveness of the steady DONT WALK compared to the flashing DONT WALK and the steady DONT START message. Before/after studies were used to test devices at four intersections (two sites in each of two cities) for each of the experiments. The measures of effectiveness (MOE's) used were pedestrian behavior, pedestrian compliance, and user understanding. Robertson noted the following conclusions [2]:

- A steady DONT WALK clearance display appears to have the same effectiveness as a flashing DONT WALK clearance display.

- The DONT START indication offers little or no improvement over the current DONT WALK indication.

The author also stated that additional research is needed to determine the optimal clearance indication.

It should be mentioned that the experiment involved the use of the steady DONT START indication to replace both the clearance (flashing DONT WALK) and the prohibited (steady DONT WALK) indications. With this option, pedestrians see no difference between the clearance and prohibited periods and could be confused as a result. Another possible option could have been to test a three-head pedestrian signal, using a WALK interval, a steady DONT START for the clearance interval, and a steady DONT WALK for the prohibition period.

In that same FHWA study, symbolic pedestrian displays were developed and tested as an alternative to existing word messages. A variety of symbols and colors were tested (Figure 22) using preference surveys directed at 45 traffic engineers and safety experts, 300 pedestrians, and a number of elementary school children.

Three symbolic displays (with red-green and orange-white colors) were compared with the WALK/DONT WALK messages using pedestrian behavior, pedestrian compliance and user understanding as MOE's (Figure 23). Before-after studies were conducted in two cities for each display, and a validation study was repeated in two additional cities. The following conclusions were revealed [2]:

- The hand/walking man symbol display is a significant improvement over the standard DONT WALK/WALK display.
- The standing man/walking man symbol appears to be as effective as the DONT WALK/WALK display.
- The circle slash/walking man symbol is not as effective as the DONT WALK/WALK display.
- Even though pedestrians indicated a preference for red and green signal indication colors, compliance with orange and white was significantly higher.
- If symbolic pedestrian signals come into use, an educational program will be necessary for elementary school pedestrians.

The findings from that study and other research efforts led to the inclusion of the hand symbol (orange) and walking man symbol (white) as optional pedestrian signal displays in the 1978 version of the MUTCD.

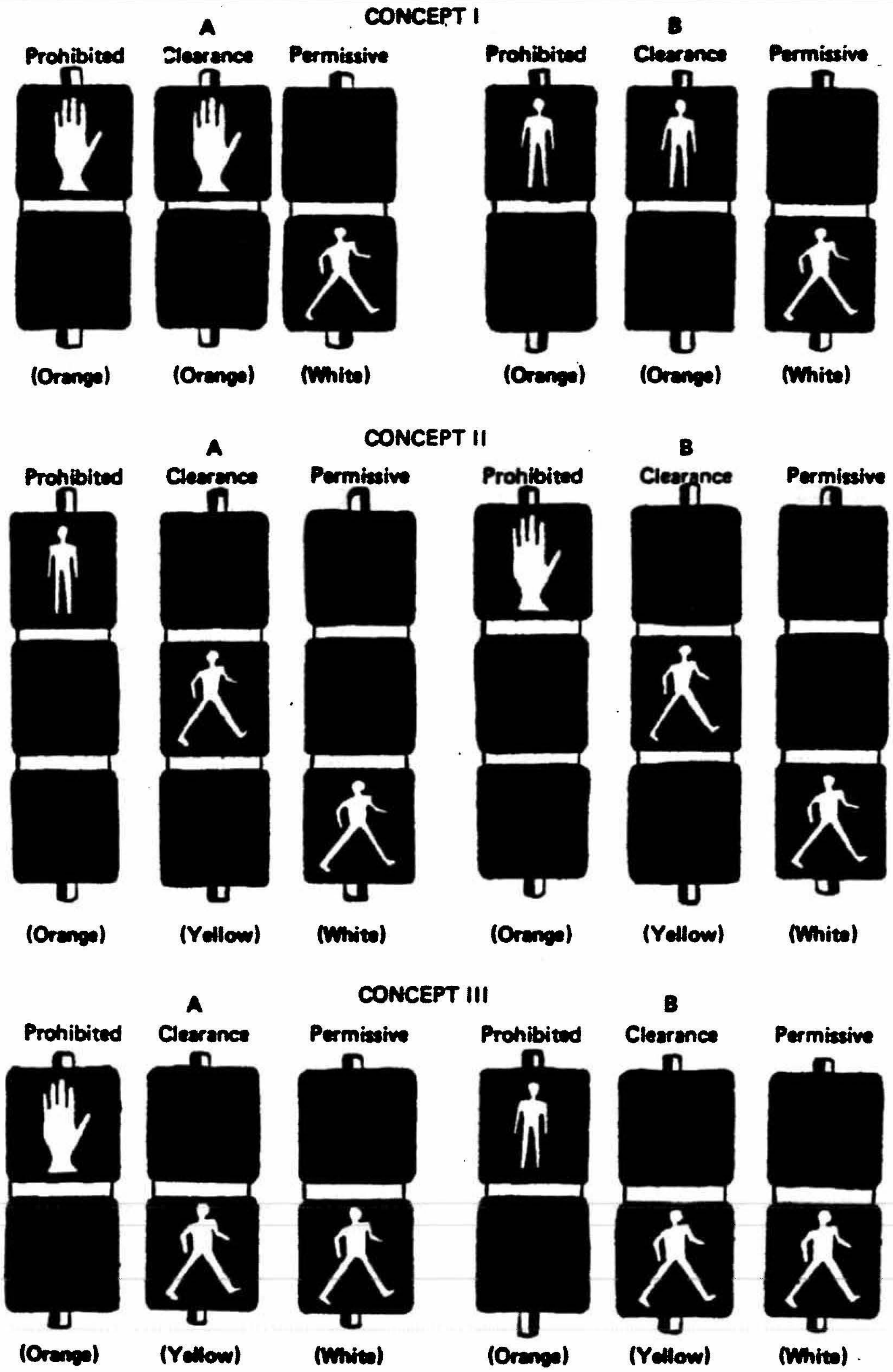


Figure 22. Symbolic pedestrian indications evaluated using reference systems.

Source: Reference 2

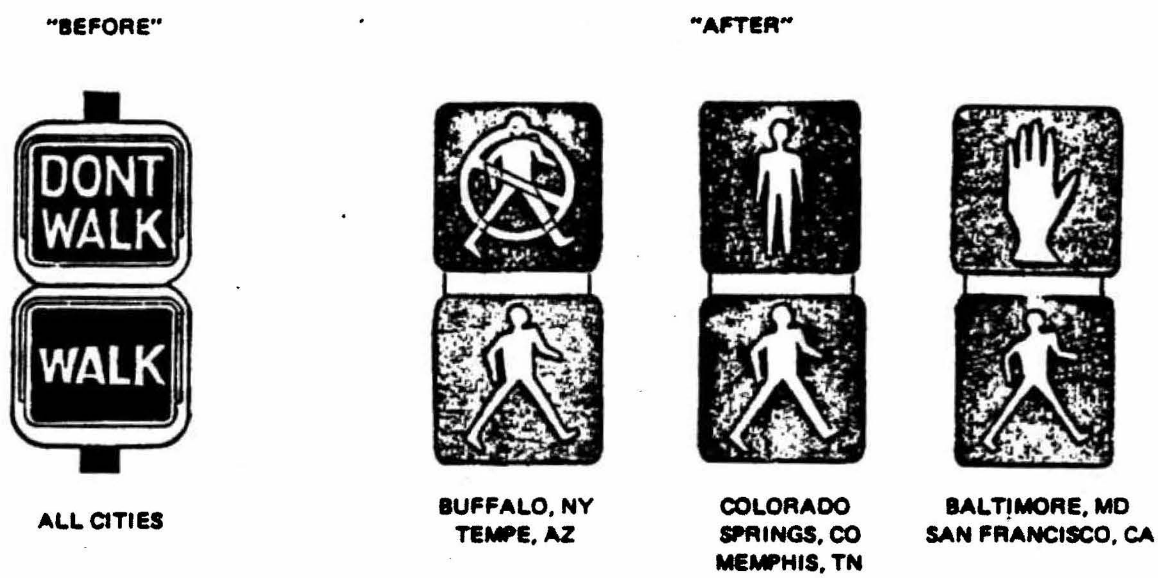


Figure 23. Symbolic pedestrian displays evaluated using before and after observations of pedestrian behavior.

Source: Reference 2

One source of confusion associated with the pedestrian clearance indication occurs when a pedestrian begins crossing on the WALK indication and the signal changes to a steady or flashing DONT WALK (or hand symbol). Some pedestrians believe that traffic will be released immediately, and they attempt to retrace their path back to the sidewalk from which they started. One possible cause of this confusion is that the clearance message is not totally consistent with its intended meaning, since the message flashes DONT WALK, when the intended meaning is "finish crossing" or "don't step off curb".

In an effort to minimize this confusion during the clearance interval, the 3M Dynamic Pedestrian Signal was developed. The dynamic pedestrian signal displays the WALK indication during the permissive interval and DONT WALK indication during the prohibited interval, as with conventional signals. During the pedestrian clearance interval, however, the WALK indication is optically projected in a moving pattern to be visible to pedestrians who have begun their crossings during the WALK phase until they have completed their crossing. Pedestrians on the curb, during the clearance interval, see the DONT WALK display.

The dynamic pedestrian signal was evaluated in separate studies by Kyle in 1973, Stoddard in 1974, and in another independent study for 3M Corporation in 1974 [3,4,5]. The three studies analyzed pedestrian understanding, compliance, and behavior (i.e., aborted crossings during the clearance display) and found that the dynamic pedestrian signal was equivalent to or better than the conventional pedestrian signal display. The dynamic pedestrian signal was recommended for long crosswalks, divided roadways, and intersections with a high percentage of elderly, young, or handicapped pedestrians [3,4,5]. In spite of some of the favorable aspects of the dynamic pedestrian signal, several potential problems were noted. These included:

- Pedestrian height and walking speed affects the indication which is displayed.
- Problems may exist with roadway grade, position of signal pole, curb height, etc. on the visual field of the projected WALK or DONT WALK message.
- Pedestrians on the curb at the onset of the clearance (who see the DONT WALK) observe pedestrians slightly ahead of them (who see the WALK) who are walking. This could encourage non-compliance of the signal (i.e., the feeling that those pedestrians are crossing now, so why shouldn't I cross also.)
- Some pedestrians see both indications at once when they arrive at the curb at the onset of the clearance interval.

- Electro-mechanical problems have caused the signal to stick on WALK, when the traffic signal was red [6].

Although the dynamic pedestrian signal concept is theoretically appealing, these problems have discouraged its use to date.

Current Practice

As a part of this study, phone conversations were held with representatives of more than seventy city traffic engineering departments and personal visits were made to about 25 of those cities. Observations were made relative to the types of pedestrian signal hardware and the mode of operation of the signals (i.e., flashing or steady) during different intervals. By far, the most common clearance indication in use today is the flashing DONT WALK word message. A few cities, such as Washington, D.C., Saginaw, Michigan and Denver, Colorado, have recently converted to the symbolic flashing hand indication at a portion of their signalized intersections.

Several cities still utilize the solid DONT WALK display to indicate both the clearance interval and the prohibited crossing interval. While not prevalent, a few cities still use the orange WAIT display (steady or flashing) to indicate clearance. The WAIT signal displays were generally the incandescent signal types which were an optional design given in the 1963 MUTCD. A few of the gas-filled tubing signals were also found with the DONT WALK indication, as shown by Figure 11 in Appendix D [7].

Information from several sources was used to identify the pedestrian clearance indications used in other countries. One of the more prominent sources on this subject was a 1975 FHWA report entitled "European Experience in Pedestrian and Bicycle Facilities", [8] which included findings based on visits in May 1974 to several cities in Germany, the Netherlands, Denmark, Sweden, and Great Britain. The City of Delft (in the Netherlands) was the only European city visited which used a flashing device for the clearance interval. A flashing green pedestrian symbol is used to designate the clearance interval. The steady symbolic red display which remains activated during the DONT WALK interval, is commonly used for the clearance interval in other cities in the Netherlands, as well as in Denmark and Sweden. A summary is provided in Table 24 of the current practice in various countries relative to indications for the clearance interval and pedestrian-vehicle conflicts. Most of the information was taken from one FHWA report by Fee [8].

The absence of a pedestrian signal indication is used in Great Britain as the pedestrian clearance interval. The British limit the use of pedestrian signals primarily to intersections with exclusive, protected pedestrian intervals. Pedestrians at these locations generally were found

Table 24. Pedestrian signal indications as they are used in different countries.

Country	Pedestrian Signal Indication				Special Notes	Observed Pedestrian Compliance Rate
	For The Walk Interval	Walk Interval To Indicate Potential Conflicts	Don't Walk Interval	Pedestrian Clearance Interval		
Great Britain(12)	White "Walk" message (switching to symbolic messages)	None mentioned.	Red "Wait" message (switching to symbolic message)	Pedestrian signal heads go blank during this interval.	Pedestrian signals are used primarily when the pedestrian is fully protected.	Poor (vehicle signals are placed so pedestrains cannot see them, so pedestrians cross when acceptable gaps in traffic. Where pedestrian signals exist, waiting times are too high. For an exclusive pedestrian phase, so signals are often violated).
United States (1,3,5,6)	Lunar White solid "Walk" or symbolic walking man	Solid or flashing mode for "Walk" or symbolic walking man.	Portland orange "Don't Walk" or symbolic hand (some cities still use the "Wait" message)	Flashing Don't Walk or hand (some cities still use a solid "Don't Walk" or "Wait")	The flashing walk concept was first introduced in the 1971 edition of the MUTCD. The optional symbolic man (Walk interval) and symbolic hand (Don't Walk interval) were introduced in the 1978 version of the MUTCD.	Poor to good, depending on the city and somewhat on part of the country since police enforcement levels vary widely.
Mexico	Symbolic Green Walking Man	None mentioned.	Symbolic Red Standing Man	Symbolic Red Standing Man	None	Unknown
Canada	Symbolic White Outline of Walking Man	None mentioned.	Symbolic Orange Outline of Hand	Unknown	None	Unknown

Source: Reference 8

Table 24. Pedestrian signal indications as they are used in different countries (Continued).

Country	Pedestrian Signal Indication: For The Walk Interval	Walk Interval To Indicate Potential Conflicts	Don't Walk Interval	Pedestrian Clearance Interval	Special Notes	Observed Pedestrian Compliance Rate
Germany(12)	Symbolic Green Walking Man	Yellow flashing symbol of a walking man, which is set on an angle aimed at the driver.	Symbolic Red Man (some signals have double red signal heads).	Symbolic Red Standing Man (same as for Don't Walk interval)	1971 Highway Code requires the use of symbolic traffic signals. Most large cities have already converted to symbolic. Some small cities have not as yet.	High (possibly due to high vehicle speeds and the concern of the pedestrians for their own safety.
Netherlands(12)	Symbolic Green Walking Man	None mentioned.	Symbolic Red Man	Symbolic Red Standing Man (same as for Don't Walk). Some use of flashing green man.	Very short clearance interval is used at many locations. In the City of Delft, a flashing green pedestrian symbol is sometimes used to designate the clearance interval.	"Very Weak" in Amsterdam and the Hague.
Denmark (12)	Symbolic Green Walking Man	None mentioned.	Symbolic Red Standing Man	Symbolic Red Standing Man	The words Wait and Walk used to be the Danish standard, but symbolic messages are now used throughout Denmark. Some pedestrian push buttons are used.	Adequate (better than the Netherlands, bub not as high as in Germany).
Sweden(12)	Symbolic Green Walking Man	None mentioned.	Symbolic Red Standing Man	Symbolic Red Standing Man	More consideration has been given in recent years to minimize pedestrian delay. Signals are timed to allow pedestrians to cross both portions of a divided street at once, instead of waiting in the refuge island.	Not given.

Source: Reference 8

to violate the WAIT indication due to the long waiting times that are associated with pedestrian signals in Great Britian [8].

An attempt was made in the FHWA report to subjectively assess the observed levels of pedestrian compliance to the signals among the various countries. Observed compliance appeared to vary widely from high compliance in Germany to poor compliance in Great Britain and some cities in the Netherlands [8]. A wide range of pedestrian compliance rates have also been found in the U.S. among various cities and parts of the country as discussed earlier [9]. There is little or no evidence that attributes the level of pedestrian compliance to the type of pedestrian signal message. For example, several of the European countries (i.e., Denmark, Sweden, and Germany, and some cities in the Netherlands) utilize the symbolic pedestrian signal messages with no special flashing mode for the clearance interval. Yet, observed pedestrian compliance rates were found to vary widely among these countries.

The symbolic red standing man and green walking man are also used in Mexico and Israel, as reported by Robertson [9]. In Canada, the outline of the symbolic hand (orange) and walking man (white) are used for the DONT WALK and WALK intervals, respectively. These messages were found to be preferable to the European standing-man/walking-man displays in a 1967 study [14].

In addition to the traditional pedestrian clearance indications discussed earlier (i.e., flashing DONT WALK, steady DONT WALK) there were also numerous other devices which are currently being used as supplements to or in place of the clearance indications discussed previously. For example, Washington, D.C. has recently equipped several intersections with audible pedestrian signals, which were intended to aid visually impaired pedestrians. The devices emit various frequencies of noise at the beginning of each walk interval and change pitch, tone, or pattern at the onset of the clearance interval.

Another type of clearance indication was observed in Detroit, which was a three-section signal device with a WAIT, yellow ball (clearance interval), and WALK, as illustrated in Figure 24. A three-section signal with a DONT START message for the clearance interval was also installed and tested in Miami, Florida. Although observations indicated that no significant difference exists in pedestrian behavior between the DONT START and flashing DONT WALK, pedestrians interviewed after crossing the intersection stated they preferred the DONT START message as being less confusing [15]. In Houston, Texas, a two-headed WALK/WAIT message is used at many locations, where the WAIT is steady or flashes during the clearance interval.

In Broward County, Florida, experimental stickers were developed and placed on the pedestrian signal poles to give the meaning of the flashing

DONT WALK, as well as the steady WALK and steady DONT WALK indications. These stickers were an attempt to educate the public, reduce confusion and thereby improve compliance to pedestrian signals. A sign with similar information is currently used in Albany, New York, at virtually all pedestrian signal locations. The sign (in black and orange on white background) is shown in Figure 25.

Various types of educational programs are also underway in several cities to help teach pedestrians the meaning of the pedestrian signal indications. For example, the city of Seattle has printed and distributed brochures which explain the meaning of the steady WALK, the flashing DONT WALK, and the steady DONT WALK. A copy of the brochure is shown as Figure 26. Baltimore has printed and distributed various types of literature aimed primarily at the pedestrian for safety in street crossings. Many cities throughout the U.S. have utilized radio and/or television commercials to encourage greater pedestrian safety. In many areas, educational programs related to crossing safety are presented to school age children to initiate good pedestrian behavior.

Alternatives to Indicate Potential Conflicts With Turning Vehicles

Past Research

Several articles and publications were found related to alternatives to indicate potential conflicts with turning vehicles, where researchers have examined the flashing WALK versus the steady WALK indications. A 1968 study by Welke [16] was performed in Washington, D.C. which evaluated the effect of the flashing WALK indication on turning vehicle delay, compared to: (1) blank-out DONT WALK units; and (2) green-yellow-red vehicular traffic signals (no pedestrian signals). The blank-out units are those which provide no message (i.e., the signal head is blank) during a particular interval. A time-lapse, 16 mm camera was used to collect before and after data during hours of 11:30 a.m. to 1:30 p.m. on weekdays. The flashing WALK did not result in any significant change in turning vehicle delay compared with the blank-out DONT WALK. However, a significant reduction in right-turn vehicle delay was found with the flashing WALK compared to the use of traffic signals alone. The author did not compare the flashing WALK display to the steady WALK display, but recommended the use of the flashing WALK for non-vehicle-free crosswalks with two or more turning vehicles per cycle for any eight hours of a given day. At locations with one or fewer turning vehicles per cycle, the standard green-yellow-red vehicle signals (i.e., no pedestrian signals) were recommended.

A quite different finding regarding the flashing WALK was reported in a study by Sterling in 1974 [17]. A study of pedestrian observation rate (percentage of legal crossings) and conflict rate (percentage of crossing with specifically defined interruptions) was made at two intersections in

Figure 24. Three-section signal using the yellow ball as the clearance indication.

Figure 25. Sign to explain the meaning of the pedestrian signal indications - Albany, New York.

Don't Walk

Do not start to cross the street if the DON'T WALK signal is on.

Shortly after the flashing DON'T WALK changes to a steady DON'T WALK, opposing vehicles will get a green light and may begin to go.

Many older pedestrians signals have no flashing intervals, but the DON'T WALK warns you for a longer period, allowing you enough time to finish crossing the street if you have already begun.

The DON'T WALK signals last throughout the green and yellow lights for opposing vehicles.

When the DON'T WALK sign is on and you want to cross, check for a pedestrian button and wait for the next WALK sign. Generally, your wait will be less than one minute.

REMEMBER – ALWAYS look both ways before crossing. And STAY ALERT!

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Engineering Department

Room 910, Seattle Municipal Bldg
600 Fourth Avenue
Seattle, Washington 98104

This brochure was prepared for your information by the City of Seattle Department of Engineering. If you have questions, call the Traffic Signal Operations Section at

625-2347

Pedestrian Signals

Your
Seattle
Engineering Department

Figure 26. Pedestrian safety brochure used in Seattle, Washington.

"Why doesn't the WALK light stay on long enough for me to cross the street?"

"Why do some of the DON'T WALK signs flash and others don't?"

"Who has right of way in a crosswalk--me or an automobile?"

To answer questions most frequently asked by pedestrians, your Seattle Traffic Engineer explains

Pedestrian Signals

Begin Crossing | **Complete Crossing** | **Do Not Start**

Just as motor vehicles must obey traffic lights and signs, three indicators tell pedestrians what to do.

WALK

This indicator only means "Begin!"

After looking both ways, start across the street.

You might not reach the opposite curb before the DON'T WALK signal flashes, but if you enter a crosswalk during the WALK signal, you will have the legal right and enough time to complete crossing.

If you need the maximum crossing time, cross at the START of the WALK signal.

BUT –

The WALK signal does not guarantee safety.

At signalized intersections, you have right of way over vehicles stopped or turning at the light – but careless drivers might not yield.

In both 1976 and 1977, 116 pedestrians were struck by cars while "protected" by the WALK signal.

ALWAYS LOOK BOTH WAYS BEFORE CROSSING A STREET – THEN STAY ALERT.

Flashing DON'T WALK

Like the yellow traffic light, flashing DON'T WALK signs mean CAUTION!

Before changing to a steady DON'T WALK, these newer signals warn you that traffic will soon be released.

If you are already in the street, continue across.

The flashing DON'T WALK combined with the WALK gives the average pedestrian time to cross from curb to curb.

If you are on the sidewalk when the DON'T WALK sign comes on or begins to flash, wait for the next WALK signal. Otherwise, you may not have enough time to cross.

DONT WALK IS A WARNING.

Figure 26. Pedestrian safety brochure used in Seattle, Washington (Continued).

a comparison between the flashing WALK and the steady WALK. The two major conclusions from the study were as follows:

1. A significantly higher percentage of both legal crossings and decision legal crossings occurred with the steady WALK than with the flashing WALK.[1]

2. A significantly higher percentage of illegal conflict crossings occurred with the flashing WALK than with the steady WALK.

A compliance rate of only 29 percent was observed with the flashing WALK, compared to 51 percent compliance with the steady WALK. The conflict rate was 8 percent for the flashing WALK, compared to 6 percent for the steady WALK, and this difference was found to be statistically significant. The author cited the unclear meaning of the flashing WALK as the primary reason for its ineffectiveness.

In the 1977 FHWA study by Robertson, 400 pedestrians were surveyed in two cities regarding the meaning of traffic signals [2]. Only 2.5 percent of the pedestrians understood the meanings of the flashing and steady WALK, and less than half of the pedestrians expected vehicles to turn into the crosswalk (even though about one-fourth of the total traffic in these two cities were turning vehicles). In that study, Robertson compared the flashing WALK and the steady WALK in terms of pedestrian behavior, pedestrian compliance, and user understanding at a total of four intersections in two cities. The major conclusion was: "flashing WALK is not an effective means of warning pedestrians about turning vehicles". The author also recommended that further research be conducted to determine the best means of alerting pedestrians and motorists about turning vehicle conflicts.

Current Practice

The flashing WALK indication is used in a number of cities throughout the country, such as Washington, D.C. However, many states (e.g., Michigan and Washington state) have not yet adopted the flashing WALK concept either because of reservations about the effectiveness of the flashing WALK or because of problems with converting existing signal hardware to allow the flashing mode.

According to the FHWA report mentioned earlier, no special signal messages are routinely used in Great Britain, Sweden, Denmark, or the

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1 A decision legal crossing is one in which a pedestrian arrives during the DONT WALK interval and waits until the WALK message is displayed before crossing.

Netherlands to alert pedestrians of potential conflicts [8]. In these countries the same display (usually a steady symbolic green man) is used for the WALK interval, regardless of whether or not the interval provides exclusive protection to the pedestrian.

Various types of sign and signal devices have been tested and used by state and local highway agencies to indicate the potential for pedestrian-vehicle conflicts. These messages have been directed at the motorist, as well as the pedestrian. For example, in Ann Arbor, Michigan, a blue, black, yellow, and white RIGHT TURN MUST YIELD TO PEDESTRIAN sign has been placed at several locations near the campus of the University of Michigan (Figure 27). In Detroit, a black, and yellow rectangular sign WATCH FOR PEDESTRIANS WHILE TURNING (Figure 28) has been placed at several downtown locations. In Washington, D.C., a black on red diamond shaped sign was observed which says YIELD TO PEDESTRIANS WHILE TURNING. In Manchester, New Hampshire, 36 inch by 36 inch (90 by 90 cm) white signs with a yield symbol in red and black lettering (Figure 29) have been installed at fourteen intersections [6]. Other than the flashing WALK pedestrian indication, there is no provision in the MUTCD for standard traffic control devices to provide this warning message.

Some displays have also been aimed at pedestrians relative to watching for turning vehicles. For example, in Seattle, a two-headed pavement marking which says LOOK BOTH WAYS is painted on many sidewalks at intersections where no pedestrian signals exist (Figure 30). In addition, brochures are used in Seattle to help teach the public the meaning of the steady WALK (Figure 26). The brochure reminds the pedestrian to look both ways before crossing the street even when a steady WALK is displayed (the flashing WALK is not used in that state). The sign placed on signal poles in Albany, New York (Figure 25), and the stickers in Broward County, Florida, also alert pedestrians of the meaning of the WALK and flashing WALK indication, as discussed earlier.

References

1. ITE Committee 3L(65), "Meaning of Flashing DONT WALK and Steady DONT WALK Signal Indication", Institute of Traffic Engineers, Department 3, Traffic Control MEasures, Washington, D.C., June, 1968.

2. "Urban Intersection Improvements for Pedestrian Safety, Volume IV, Pedestrian Signals Displays and Operations", Biotechnology, Inc., prepared for the FHWA, December, 1977.

3. Kyle, A.F., III, "A Preliminary Comparison of Standard and Dynamic Pedestrian Signals", prepared by the Highway Traffic Safety Center, University of Illinois - Urbana, August, 1973.

4. Stoddard, R.G., "A Pedestrian Interview and Compliance Study of an Optically Programmed Signal", Master's Thesis, University of Washington, Seattle, Washington, 1974.

Figure 27. Pedestrian yield sign (for motorists) used in Ann Arbor, Michigan

Figure 28. Warning sign used in Detroit, Michigan.

Figure 29. Pedestrian yield sign (for motorists) used in Manchester, New Hampshire.

Source: Reference 6

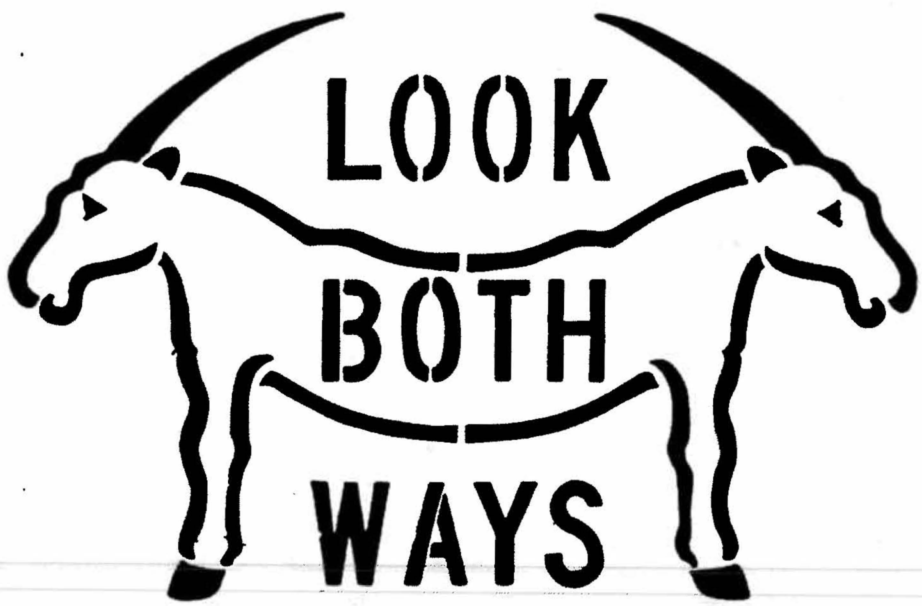


Figure 30. LOOK BOTH WAYS sidewalk message used in Seattle, Washington.

5. Edwards and Kelsey, Inc., "3M's Dynamic Pedestrian (3M Report) Signal: An Evaluation", Traffic Control Devices Department, Minnesota Mining and Manufacturing Company, St. Paul, Minnesota, 1974.

6. Valette, G.R., and McDivitt, J.A., "Pedestrian Safety Programs - A Review of the Literature and Operational Experience", Biotechnology, Inc., prepared for FHWA, January, 1981.

7. "Manual on Uniform Traffic Control Devices for Streets and Highways", FHWA, U.S. DOT, 1963.

8. Fee, J.A., "European Experience in Pedestrian and Bicycle Facilities", FHWA, U.S. DOT, 1975.

9. Robertson, H.D., "Signalized Intersection Controls for Pedestrians", Draft Report of Ph.D. Dissertation, 1982.

APPENDIX G - DETAILS OF PEDESTRIAN CLEARANCE ALTERNATIVES

Alternative 1

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE CLEARANCE

Description (Color, Movement, Message, Size, Etc.)

Educational campaign to inform pedestrians as to the meaning of the flashing DONT WALK (or hand). Radio, newspaper ads., handouts, and/or Television ads. may be used in one somewhat isolated city.

Sketch or Drawing of the Alternative

These advertisements should be used in conjunction with existing pedestrian signals in a specific area (preferably with the standard word or symbol message). The selected city should be one which is known to have a pedestrian safety problem.

Past Use of the Alternative

Various educational campaigns have been used in the past to inform the public about the meaning of traffic control devices, use of seatbelts, need to not liter along the highway, etc.

Justification for Use

There already exists various combinations of pedestrian signal indications in terms of colors, flashing versus non-flashing messages, standard vs. non-standard messages, etc. Instead of only trying more "new" indications (which could cause more confusion), it may be more effective to inform the public of the meaning of existing pedestrian indications.

Potential Advantages

- Such an educational campaign could include an explanation of not only the clearence interval (flashing DONT WALK) but also the flashing WALK and possibly the Yield sign or signal for pedestrians.
- Pedestrians would not have to guess about the meaning of the standard pedestrian indications.
- The public would not be burdened with still another new type of pedestrian signal to understand.

Potential Disadvantages

- Could be very expensive to educate people at the national level.
- All pedestrians would probably not be reached, regardless of the amount or type of advertisement.
- Current standards for pedestrian signal indications may be far from optimal, and it may be more appropriate to provide a more self-explanatory indication.

Estimated Cost of Installation

Moderate to high, depending on the type of advertisement and whether radio/TV/newspapers are willing to donate free time or space as a public service announcement.

Estimated Cost of Maintenance and Operation

Ongoing advertisement costs are required.

Alternative 2

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE CLEARANCE

Description (Color, Movement, Message, Size, Etc.)

School education program regarding pedestrian safety. A brief 5-10 minute presentation with slides (or movie footage) could be developed to be shown to school-age children and also possibly to other groups (women's club, etc.).

Sketch or Drawing of the Alternative

N/A

Past Use of the Alternative

The American Automobile Association maintains a program of pedestrian safety which includes emphasis on school-age children. Also, Goodell-Grivas, Inc. has developed a comprehensive school safety program for the Rochester school district.

Dade County, Florida is currently conducting an urban pedestrian safety demonstration project under contract with NHTSA which includes a primary school education program in the county.

Justification for Use

The particular alternative would be geared to the pedestrian group with the least understanding of signals and the highest pedestrian accident experience of any age group. It could be implemented possibly in conjunction with the AAA program of child safety.

TECHNIQUES TO INDICATE CLEARANCE (Continued)

Potential Advantages

- This would be an organized program which could reach a large segment of the young inexperienced population regarding the meaning of existing pedestrian signal alternatives.
- It could be merged with existing programs (AAA program, part of routine instruction, or programs conducted by police departments, etc.) in various school district.

Potential Disadvantages

- Would only reach a small percentage of the total pedestrian population, even if it is instituted in all schools.
- Children are likely to forget the information presented in the program unless it is reinforced several times.
- The specific pedestrian signal alternatives and laws differ somewhat between cities and states throughout the U.S.
- The elderly is another group which is overrepresented in pedestrian accidents. They, however, would be largely excluded from this education program.

Estimated Cost of Installation

Varies

Estimated Cost of Maintenance and Operation

Costs would continue depending on the number of times that presentation is given. However, costs would mostly include time for presenting course.

Alternative 3

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE CLEARANCE

Description (Color, Movement, Message, Size, Etc.)

Driver education program through inclusion of pedestrian signal information in Drivers Manual.

Sketch or Drawing of the Alternative

N/A

Past Use of the Alternative

Some information related to pedestrians is contained in state Drivers Manuals throughout the country. However, details of the meaning of the various indications is often not given.

Justification for Use

The majority of pedestrians in many areas are licensed drivers. Studies have shown that there is a wide spread lack of understanding of the flashing DONT WALK as well as the flashing WALK. Therefore, one method of improving understanding of pedestrians is to include such information in the Drivers Manual and work with one or more states to ask questions about pedestrians on the drivers test.

TECHNIQUES TO INDICATE CLEARANCE (Continued)

Potential Advantages

- A large portion of the population (new drivers) would at least be expected to learn about the meaning of pedestrian signals.
- It would eliminate the need to replace all existing pedestrian signals.

Potential Disadvantages

- Very slow and indirect method of educating pedestrians.
- Evaluation of its effectiveness would be very difficult and require data collection several years later.
- No impact on the young pedestrian group and those who do not have a drivers license.

Estimated Cost of Installation

Unknown

Estimated Cost of Maintenance and Operation

N/A

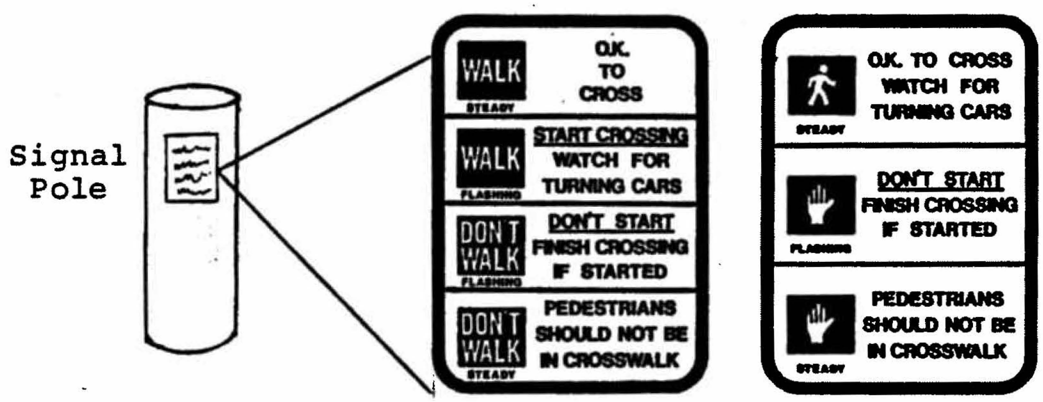
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE CLEARANCE

Description (Color, Movement, Message, Size, Etc.)

Post a notice of the meaning of WALK and DONT WALK signals at the corners with pedestrian signals (educational campaign).

Sketch or Drawing of the Alternative



Past Use of the Alternative

This program has been implemented in Broward County, Florida on poles with push buttons and pedestrian signals. Albany, New York uses a similar sign to explain the use of signal actuation devices. Also, Albany publishes "Street Sense" literature.

Justification for Use

- Inexpensive.
- Constant reminder to pedestrians.
- It effects only those who are using the crossing. Time and money for education or explanation of signal operation are not spent on others.

TECHNIQUES TO INDICATE CLEARANCE (Continued)

Potential Advantages

- Provides a simple meaning of all pedestrian messages/symbols that are used.
- On-going public education program.

Potential Disadvantages

- Must be clearly worded to avoid confusion.
- Useless to those who cannot read (young, those who do not understand English, blind, etc.).
- May be defaced by vandals.

Estimated Cost of Installation

Low

Estimated Cost of Maintenance and Operation

Low

Alternative 5

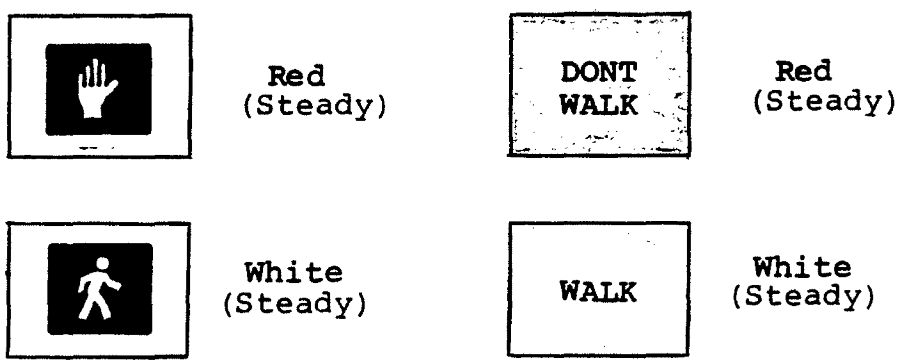
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE CLEARANCE

Description (Color, Movement, Message, Size, Etc.)

The steady DONT WALK or flashing hand during the clearance and prohibitive crossing interval, and eliminate the flashing indication.

Sketch or Drawing of the Alternative



Past Use of the Alternative

The solid DONT WALK (or hand) has been used by various agencies for clearance instead of the flashing indications.

Justification for Use

Most pedestrians do not understand the flashing indications as compared to steady indications. The use of the steady DONT WALK (or hand) during clearance provides a margin of safety.

Potential Advantages

- The pedestrian doesn't have to interpret a flashing DONT WALK or symbol message.
- The pedestrian is given a margin of safety with a longer steady DONT WALK (or hand) indication.
- This is simpler to understand, particularly for very young pedestrians who don't understand the concept of a clearance interval.

Potential Disadvantages

- Pedestrians who are already in the street and see a steady DONT WALK (or hand) may be "intimidated", and think that cars immediately have the green. However, if this occurs, they are likely to hasten their crossing instead of either stopping midway across the street or turning back to where they started.

Estimated Cost of Installation

Low

Estimated Cost of Maintenance and Operation

Operation and maintenance may be lower than the flashing signal due to fewer on-offs for the bulbs.

Alternative 6

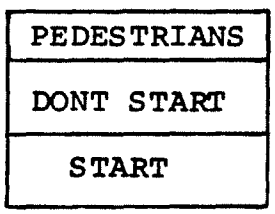
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE CLEARANCE

Description (Color, Movement, Message, Size, Etc.)

START - DONT START message with the word "Pedestrians" at the top of the signal.

Sketch or Drawing of the Alternative



Standard double section signal face with addition of the of the word "Pedestrian" at top.

Past Use of the Alternative

Unknown

Justification for Use

Simple and low cost.

TECHNIQUES TO INDICATE CLEARANCE (Continued)

Potential Advantages

- Clear, unambiguous and low chance of confusion.
- The "Pedestrians" sign can be used with any signal display or configuration.

Potential Disadvantages

- Likely poor compliance resulting from simplicity of operation.

Estimated Cost of Installation

Low

Estimated Cost of Maintenance and Operation

Low

Alternative 7

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

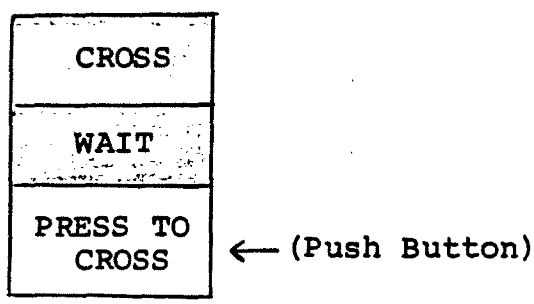
TECHNIQUES TO INDICATE CLEARANCE

Description (Color, Movement, Message, Size, Etc.)

For pedestrian actuated intersections, use a push button concept that shows WAIT/CROSS message on the actuation device as well as on the pedestrian signal. Operates in the same manner as a push button system on an elevator. When the actuation device is pressed the WAIT message is shown until it is safe to cross.

This concept uses pedestrian indications which have only two modes: Go (CROSS) and Stop (WAIT). Build the clearance interval into the beginning of the WAIT indication such that WAIT (or DONT WALK) is shown during the clearance interval.

Sketch or Drawing of the Alternative



Past Use of the Alternative

The WAIT/CROSS concept has been used in the past as well as the steady WAIT (DONT WALK or DONT START).

Justification for Use

Simple non-confusing could elicit uniform response. Most people are familiar with bi-modal concept such as "CROSS STREET/WAIT". Could set up like elevator button and display and have bi-modal color/word concept - add audio message signal (just as elevator does when car arrives) when pedestrian signal goes from CROSS to WAIT and WAIT to CROSS.

TECHNIQUES TO INDICATE CLEARANCE (Continued)

Potential Advantages

- Simple.
- Won't confuse pedestrians.
- No education campaign for pedestrians required.
- Uses established concepts.

Potential Disadvantages

- Traffic engineer has to set proper timing for both vehicular and pedestrian traffic, wait signal must permit elderly person in middle to continue across or to go back to starting place.

Estimated Cost of Installation

Moderate

Estimated Cost of Maintenance and Operation

Moderate

Alternative 8

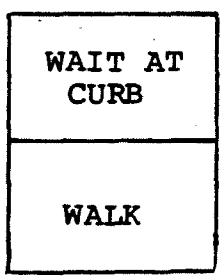
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE CLEARANCE

Description (Color, Movement, Message, Size, Etc.)

"WALK - WAIT AT CURB" - word message either steady or flashing. The WAIT AT CURB message is shown during the clearance and DONT WALK interval.

Sketch or Drawing of the Alternative



Standard double section signal face.

Past Use of the Alternative

None known

Justification for Use

Simplistic

TECHNIQUES TO INDICATE CLEARANCE (Continued)

Potential Advantages

- Less chance of confusion, as message is clear and unambiguous.

Potential Disadvantages

- A simplistic word message like this may result in poor compliance.
- Difficult to understand by young children and those who cannot read English.
- May not offer any real advantage over the WALK/DONT WALK message.

Estimated Cost of Installation

Moderate

Estimated Cost of Maintenance and Operation

Moderate

Alternative 9

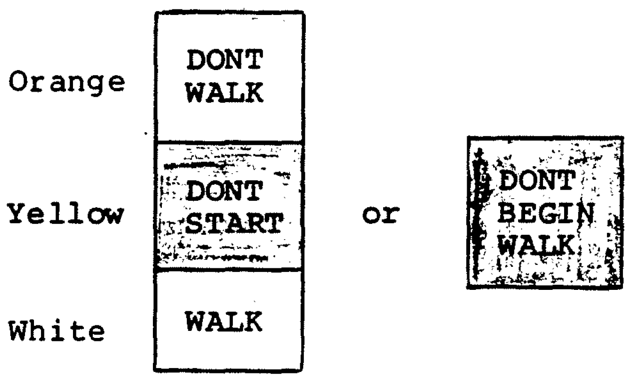
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE CLEARANCE

Description (Color, Movement, Message, Size, Etc.)

Three-section signal with center section (yellow) for clearance, steady orange DONT WALK with flashing or steady yellow DONT START, and steady white WALK.

Sketch or Drawing of the Alternative



Past Use of the Alternative

The DONT START in a two-head signal was tested by Robertson in a FHWA study and by an ITE committee in Miami.

Justification for Use

Motorists and pedestrians generally understand that the yellow color and the center signal head indicate a clearance interval. A flashing DONT WALK is not understood by pedestrians, since the same words are used after the clearance is over.

Potential Advantages

- Simple and unambiguous, more readily understood by pedestrians.
- More directly and accurately indicates the proper message to the pedestrian compared to the flashing DONT WALK.

Potential Disadvantages

- Not a currently used design, so a period of acclamation/ adjustment would be needed.
- There may be a question whether the pedestrian really needs to know when the clearance interval is in effect.

Estimated Cost of Installation

Moderate or slightly higher than traditional signals due to the extra hardware needed.

Estimated Cost of Maintenance and Operation

Moderate to slightly higher due to three signal sections.

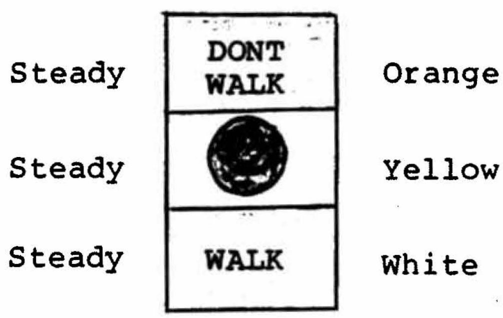
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE CLEARANCE

Description (Color, Movement, Message, Size, Etc.)

Three lens pedestrian signal using a yellow ball to indicate clearance interval.

Sketch or Drawing of the Alternative



Past Use of the Alternative

Some New England cities utilize a steady red and yellow ball to indicate the pedestrian clearance interval on regular signal heads (side mounted signals).

Justification for Use

Pedestrians are accustomed to traffic signals and associate a yellow indication as a "prepare to stop" or "clear the intersection" display. This display has a good possibility of being properly interpreted by the pedestrian.

TECHNIQUES TO INDICATE CLEARANCE (Continued)

Potential Advantages

- No complicated word display needed.
- Simplistic, symbolic clearance display.

Potential Disadvantages

- May confuse drivers seeing a yellow ball.
- Very young pedestrians may not understand the meaning of the yellow ball.
- An educational program may be needed to inform the public.

Estimated Cost of Installation

Moderate to slightly higher than the existing standard WALK/DONT WALK pedestrian signal.

Estimated Cost of Maintenance and Operation

Moderate

Alternative 11

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

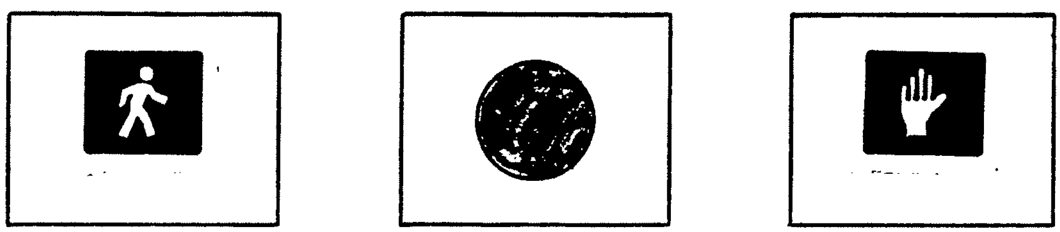
TECHNIQUES TO INDICATE CLEARANCE

Description (Color, Movement, Message, Size, Etc.)

Symbolic message using green-yellow-red colors to communicate WALK/DONT WALK instructions to pedestrians. All three indications are shown on one face thus decreasing the size of the signal while increasing the visibility of the symbol message.

Sketch or Drawing of the Alternative

Green Yellow Red



Past Use of the Alternative

Standard symbols used for WALK and DONT WALK. Different colors have been used in the past.

Justification for Use

Symbols can be interpreted by those too young to read. Colors are standard for "Go", "Prepare to Stop", "Don't Go". Three distinct symbols for three distinct intervals.

TECHNIQUES TO INDICATE CLEARANCE (Continued)

Potential Advantages

- Young children can understand, as can those who can't read English.
- Same colors as shown to drivers. Pedestrians may associate the yellow indication in the same manner as the traffic amber signal and not start crossing or "run like the wind" to complete their crossing.

Potential Disadvantages

- In past studies, green and red have not performed as the best colors.
- Technology may not exist to display all three symbols on the same lense.

Estimated Cost of Installation

Moderate or somewhat higher than existing two-indication pedestrian signals.

Estimated Cost of Maintenance and Operation

Moderate

Alternative 12

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

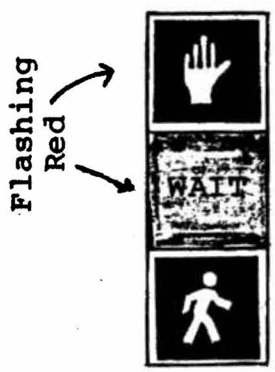
TECHNIQUES TO INDICATE CLEARANCE

Description (Color, Movement, Message, Size, Etc.)

Pedestrian symbols used in combination with a word message in the following manner:

- WALK interval - Walking man (steady).
- Clearance interval - Red hand with WAIT message. (flashing).
- DONT WALK interval - Red hand with WAIT message. (steady).

Sketch or Drawing of the Alternative



Standard symbolic signal face as shown with combination of flashing DONT WALK message and raised hand symbol for the clearance interval and a steady WAIT message and raised hand symbol during the don't walk interval.

Past Use of the Alternative

None known

Justification for Use

Will bring more attention to the pedestrian signal, particularly during the clearance interval.

TECHNIQUES TO INDICATE CLEARANCE (Continued)

Potential Advantages

- Additional factor of safety due to symbol reinforced by word message.
- Attracts attention to pedestrian signal.

Potential Disadvantages

- May be misinterpreted as a pedestrian 'Yield' sign due to the flashing.

Estimated Cost of Installation

Moderate to slightly higher.

Estimated Cost of Maintenance and Operation

Moderate to slightly higher.

Alternative 13

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

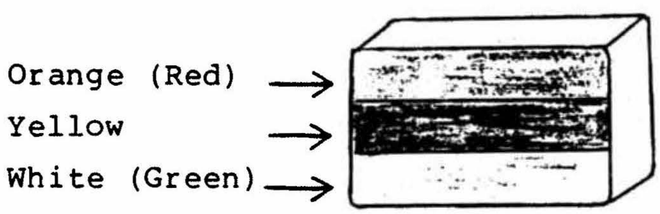
TECHNIQUES TO INDICATE CLEARANCE

Description (Color, Movement, Message, Size, Etc.)

Use a three color signal to indicate "go", "clearance", and "stop" for pedestrians (green, yellow, red). Change shape and locate the pedestrian signal so it does not cause confusion (not visible to operators of motor vehicles). A "Pedestrian" sign may be used at the top of signal to avoid confusion.

Sketch or Drawing of the Alternative

Since traffic signals for motor vehicles are round, use rectangular pedestrian signals.



Past Use of the Alternative

Every pedestrian that drives or has been an observant passenger in a car will understand the three color message.

Justification for Use

Uses standard colors. Not a difficult concept to communicate to all ages which make up pedestrian population.

TECHNIQUES TO INDICATE CLEARANCE (Continued)

Potential Advantages

- Simple message, no words are needed.

Potential Disadvantages

- Should have education campaign for the meaning and use of three color pedestrian signal.
- Color blind pedestrians might have same problem as with other traffic control signals, but can tell from placement of light what to do.

Estimated Cost of Installation

Low to Moderate

Estimated Cost of Maintenance and Operation

Low to Moderate

Alternative 14

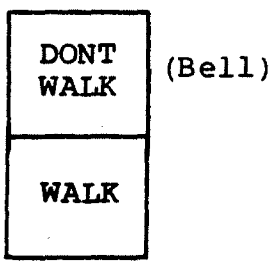
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE CLEARANCE

Description (Color, Movement, Message, Size, Etc.)

WALK - DONT WALK with audible bell (as in railroad crossing). The clearance interval is built in to the don't walk interval such that a steady DONT WALK indication is shown throughout both intervals. A steady WALK is shown during the crossing interval.

Sketch or Drawing of the Alternative



Standard double section signal face with the audible bell coordinated with the DONT WALK message during the clearance interval (and possibly during the entire DONT WALK interval).

Past Use of the Alternative

The use of an audible message during the DONT WALK is unknown.

Justification for Use

Will increase attention to signal indications at pedestrian crossing.

TECHNIQUES TO INDICATE CLEARANCE (Continued)

Potential Advantages

- May prevent pedestrians from starting to cross when there is not sufficient clearance time.
- Will be particularly helpful to the blind and the elderly.

Potential Disadvantages

- Noise may be disturbing/distracting attention of motorists.
- May create more confusion among pedestrians crossing in the perpendicular direction. The use of an audible message may be more appropriate when used with an exclusive pedestrian crossing phase.

Estimated Cost of Installation

Moderate to higher than existing pedestrian signals due to the hardware needed for the audible message.

Estimated Cost of Maintenance and Operation

Moderate to high due to maintenance for the audible hardware.

Alternative 15

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE CLEARANCE

Description (Color, Movement, Message, Size, Etc.)

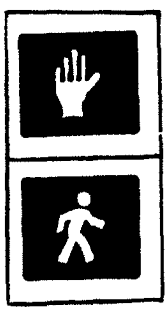
Walking man - raised hand symbols with an audible message. The flashing hand symbol may be used during the clearance interval.

Examples of audible message can include:

1. Pedestrians, please do not start crossing main street.

2. Pedestrians, please wait at the curb until the walking man symbol appears.

Sketch or Drawing of the Alternative



Standard symbolic signal coordinated with audible message.

Past Use of the Alternative

Limited experience of the audible signal in England and the U.S. No known studies using an audible word message.

Justification for Use

Will increase safety elements of pedestrian crossing by providing explicit directions to pedestrians.

TECHNIQUES TO INDICATE CLEARANCE (Continued)

Potential Advantages

- May prevent pedestrians from starting to cross when there is not sufficient clearance time by providing explicit instructions.
- Will be particularly helpful to the blind and the elderly.
- Message in different languages can be made in bilingual areas or in cities with large numbers of tourists from foreign countries.

Potential Disadvantages

- Noise may be disturbing/distracting attention of motorists as well as businesses and residents in the area.
- May create more confusion among pedestrians crossing the perpendicular direction. However, pedestrian confusion may be minimized as the street name will be mentioned in the message.
- May be difficult to hear the message due to background noise or poor sound reproduction from the speaker.
- The message may only be repeated once or twice when the clearance interval is short.

Estimated Cost of Installation

Moderate to high due to audible hardware.

Estimated Cost of Maintenance and Operation

Moderate to high due to audible hardware.

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE CLEARANCE

Description (Color, Movement, Message, Size, Etc.)

Walking man - raised hand pedestrian symbol and word message coordinated with either: (1) audible bell or (2) audible message.

During the clearance interval an audible message is coordinated with the flashing symbol and word message. During the DONT WALK interval, a different audible message is used with steady indication.

Sketch or Drawing of the Alternative

Audible bell or audible message used to reinforce each signal message.

Past Use of the Alternative

Unknown

Justification for Use

Additional attention drawn to the pedestrian signal due to the flashing message and audible message.

TECHNIQUES TO INDICATE CLEARANCE (Continued)

Potential Advantages

- Particularly advantageous to the blind, deaf and the elderly with both symbol, word and audible message.

Potential Disadvantages

- May create undesirable confusion to pedestrians and other motorists. May be most desirable to locations with exclusive pedestrian crossing.
- Audible signal may cause noise problem.

Estimated Cost of Installation

Moderate to high due to audible hardware.

Estimated Cost of Maintenance and Operation

Moderate to high

Alternative 17

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

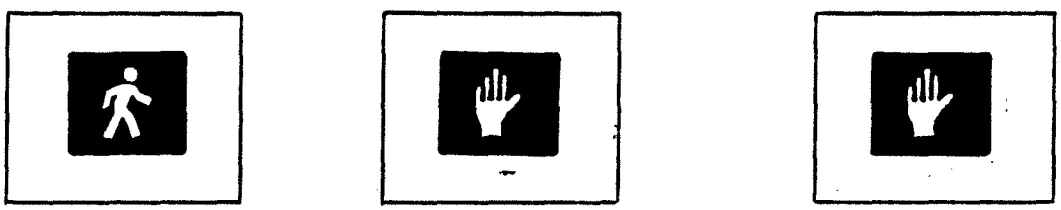
TECHNIQUES TO INDICATE CLEARANCE

Description (Color, Movement, Message, Size, Etc.)

Symbolic message based on the walking man/raised hand concept using a flashing yellow hand to indicate clearance. The symbolic message is reinforced by an audio message (warning buzzing sound). In addition, a bell rings 1-2 seconds after the start of the walk interval. All symbolic messages are indicated on the same signal head to increase the visibility of the symbol.

Sketch or Drawing of the Alternative

Steady White (WALK) | Flashing Yellow (CLEARANCE) | Steady Orange or Red (DONT WALK)



(One bell to indicate walk) | (Warning buzzing Sound)

Past Use of the Alternative

Standard symbolic messages. Audio messages have been used in various studies in the past.

Justification for Use

Symbols - for universal understanding.

Audio message - to aid blind and others with poor eyesight, to catch everyone's attention and to reinforce symbols.

TECHNIQUES TO INDICATE CLEARANCE (Continued)

Potential Advantages

- Audio message will reinforce symbol display and will call more attention to pedestrian signal, hopefully increasing compliance.
- A warning "beeping" or buzzing along with the flashing hand symbol should warn that the walk interval is about to end.

Potential Disadvantages

- May need an education campaign to provide a clear interpretation of clearance message.
- The noise produced by the signal may be a problem.
- The noise from one street crossing may be confusing to the pedestrians crossing another leg at the intersection. Confusion can be eliminated by using an exclusive pedestrian crossing interval.

Estimated Cost of Installation

Average to high

Estimated Cost of Maintenance and Operation

Average to high due to maintenance for the audible hardware.

Alternative 18

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE CLEARANCE

Description (Color, Movement, Message, Size, Etc.)

Variable message sign to spell out what you want pedestrians to know (i.e. "Signal is changing) and what you want them to do (i.e. "Please do not cross"). To attract attention and interest have display spell out a line at time until the entire message is provided.

Sketch or Drawing of the Alternative

... THE SIGNAL IS CHANGING .....

... PLEASE DO NOT CROSS .....

Past Use of the Alternative

Used in roadway (motorist information systems) in the past.

Justification for Use

Provides full message for pedestrians and the pedestrian does not have to interpret a symbol or one-word message.

TECHNIQUES TO INDICATE CLEARANCE (Continued)

Potential Advantages

- Can add emergency and route diversion information.
- It provides unique opportunity to communicate with pedestrians which are conditoned by society to be passive watchers (movie, T.V., etc.). During DONT WALK, provide cartoon with subliminal safety message. People wouldn't want to cross and would wait thru DONT WALK interval to watch show. Then if advertising is added, it could pay for the whole system.

Potential Disadvantages

- Pedestrians must be able to read in English which may cause problems with young children.
- It may take too long to provide full message or to read message and may distract pedestrians from looking for cars.
- May need a large signal.
- Must have an external (or internal) light source to be seen.

Estimated Cost of Installation

May be free if paid by sponsors, otherwise high cost.

Estimated Cost of Maintenance and Operation

May be free if paid by sponsors, otherwise high cost.

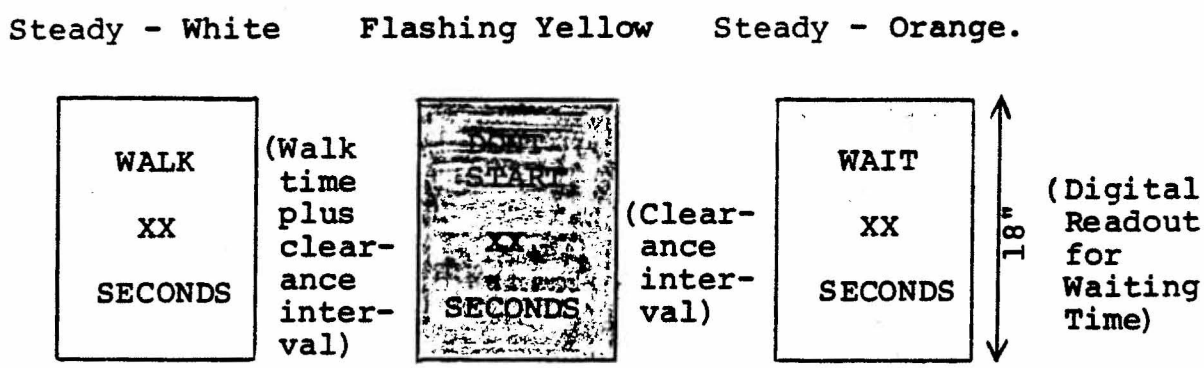
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE CLEARANCE

Description (Color, Movement, Message, Size, Etc.)

One signal head with three distinct messages on the same face and a digital countdown clock as shown below, which indicates crossing time and waiting time. The crossing time at the start of the WALK interval would include the clearance interval and the time remaining to cross is indicated throughout the clearance interval. As an option the display for the time remaining to cross can be eliminated during the clearance interval.

Sketch or Drawing of the Alternative



Past Use of the Alternative

None known.

Justification for Use

This indication has a distinct clearance interval with a clear message. The WAIT interval clearly shows the time the pedestrian will be delayed and that his crossing time may not be "long off" to encourage his/her waiting for a safe crossing.

Potential Advantages

- May encourage pedestrians to cross only during time intervals when a safe crossing can be made.
- Particularly good for pedestrian actuated signals which gives the waiting time after the push button is pressed.
- A single fiber optics head may be possible.

Potential Disadvantages

- If there is a long time to wait pedestrians may be encouraged to cross against the signal. A countdown effect may encourage the pedestrians to cross a few seconds early (before the intersection is cleared). This may be overcome by delaying the WALK for 1 or 2 seconds after the green interval for vehicular traffic.
- Very young pedestrians can not read or may not be able to judge crossing time.
- For very wide streets, the elderly or others with vision problems may not be able to read time values.

Estimated Cost of Installation

Moderate to high

Estimated Cost of Maintenance and Operation

Moderate to high

Alternative 20

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE CLEARANCE

Description (Color, Movement, Message, Size, Etc.)

In addition to the existing pedestrian signal hardware, install a countdown device to communicate:

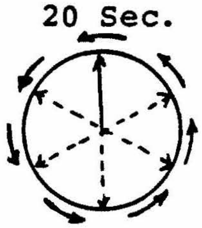
1. Signal changing (from WALK to DONT WALK).
2. How long until change.

It may be advisable to combine an audio message while the clearance device is working.

Sketch or Drawing of the Alternative

Alternative 1

20 Sec.



10 Sec.

Alternative 2 - Red advances

Start Middle Ending

Past Use of the Alternative

Various types of countdown clocks have been tried in the past.

Justification for Use

Countdown clocks will be useful in providing not only clearance, but length of clearance or visual picture for length of remaining crossing time.

TECHNIQUES TO INDICATE CLEARANCE (Continued)

Potential Advantages

- Add to existing signals rather than having to replace current signals.

Potential Disadvantages

- Requires education campaign.
- May be confusing to interpret.
- Audio message may cause noise pollution problem.

Estimated Cost of Installation

Moderate to high

Estimated Cost of Maintenance and Operation

Moderate to high

Alternative 21

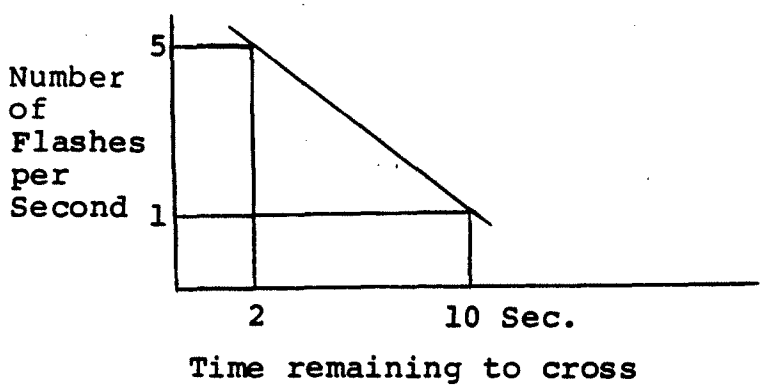
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE CLEARANCE

Description (Color, Movement, Message, Size, Etc.)

A device with a variable rate of flash can be used to indicate the time remaining to cross. Such a device could be used with existing or new signal equipment.

Sketch or Drawing of the Alternative



Past Use of the Alternative

None known.

Justification for Use

This device gives the pedestrian an indication of the amount of crossing time available - thus they may not start or might hurry.

TECHNIQUES TO INDICATE CLEARANCE (Continued)

Potential Advantages

- Gives indication of available crossing time.
- Can be adapted to signal hardware in existance.

Potential Disadvantages

- Flash rate does not tell the exact amount of time available but then the pedestrian has to estimate his crossing time, anyway.
- Pedestrians must understand the meaning, it is likely to be very confusing.
- Low clearance times may not permit a sufficient number of flashes.

Estimated Cost of Installation

Moderate

- Needs a simple micro-chip to control the flash rate once the impulse is given for a don't walk indication.

Estimated Cost of Maintenance and Operation

Moderate

Alternative 22

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

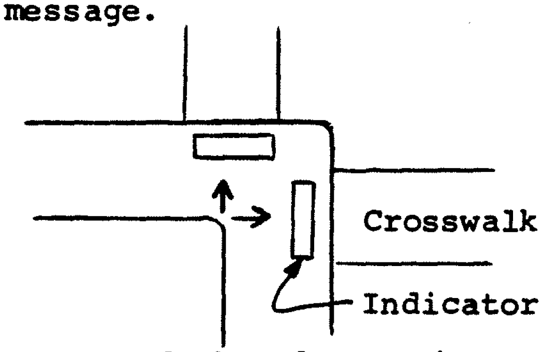
TECHNIQUES TO INDICATE CLEARANCE

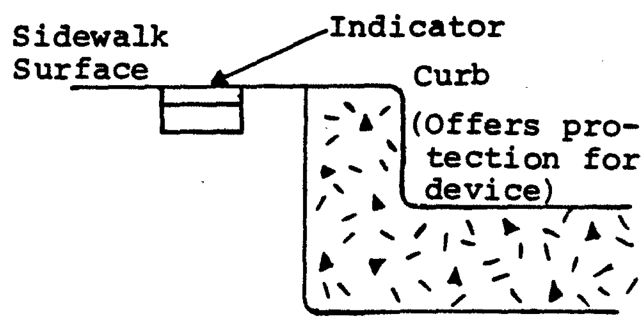
Description (Color, Movement, Message, Size, Etc.)

The use of a flashing warning device imbedded in the pavement surface near the curbs at crosswalks. Pedestrians faced with crossing a street are processing a large amount of information, including watching their step. A flashing system located at curb level may be useful to indicate to the pedestrians not to start. An overhead variation may also prove useful - the color of the indication may be altered to reflect different messages.

Sketch or Drawing of the Alternative

The indicator can be simply a flashing light or a word message.





CROSS SECTION

Past Use of the Alternative

A similar device has been used in the newer transit systems to indicate the approach of a train. The platform edge lights flash when a train approaches.

Justification for Use

Pedestrians, if informed of the meaning of the indication, will be instructed not to start. Pedestrians of all ages (heights) will be able to readily observe this device by looking down. The volume of pedestrians may necessitate the use of larger indicators.

Potential Advantages

- Visible to all pedestrians (also closer to the pedestrian to overcome vision problems).
- May be possible to program different messages using fiber optics - i.e. "Stop", "Don't Start", "Watch for turning vehicles".
- Could be optically programmed.

Potential Disadvantages

- Potentially more difficult to maintain.
- Requires non-skid surface.
- Fails to indicate the amount of crossing time available.
- Visibility is questionable on very bright days or in winter months where the ground is snow covered.
- Devices must be sealed to prevent water from affecting operation.
- Pedestrian must look down to see message, in doing this they can not see turning vehicles or other vehicular traffic.

Estimated Cost of Installation

- High, could be installed with sidewalk replacement (i.e., ramp installation).

Estimated Cost of Maintenance and Operation

- Probably similar to other type signals, but this is dependent upon level of sophistication.
- Requires greater maintenance of drainage aspects.

APPENDIX H - DETAILS OF DEVICES TO INDICATE POTENTIAL PEDESTRIAN-VEHICLE CONFLICTS

Alternative 1

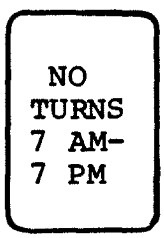
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS

Description (Color, Movement, Message, Size, Etc.)

Eliminate all turns during high pedestrian volumes or selected time period.

Sketch or Drawing of the Alternative



Past Use of the Alternative

Used at many locations.

Justification for Use

Eliminate all possible conflicts with turning vehicles.

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS (Continued)

Potential Advantages

- No chance for accident with turning vehicles.

Potential Disadvantages

- May cause problems with traffic flows and operations at the intersection.
- May not be applicable to all locations.
- May cause a false sense of security to pedestrian if turn prohibitions not effectively enforced.

Estimated Cost of Installation

Low

Estimated Cost of Maintenance and Operation

Low

Alternative 2

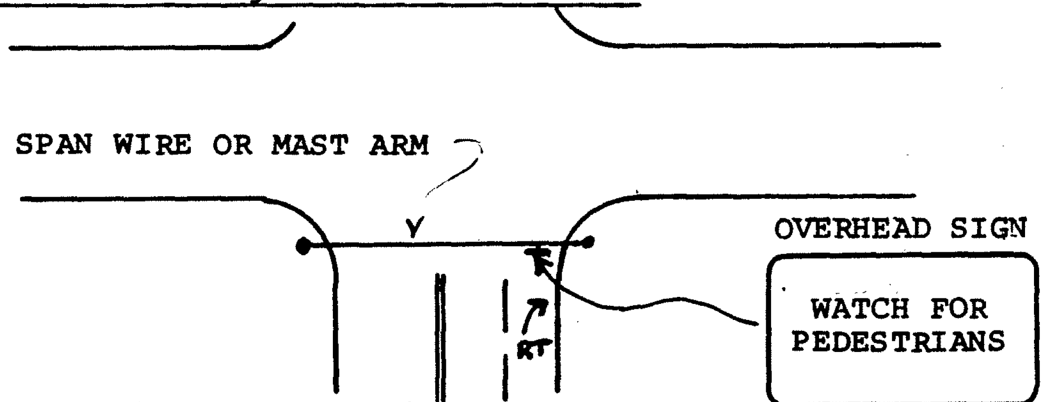
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS

Description (Color, Movement, Message, Size, Etc.)

An overhead sign above the right turn lane which indicates WATCH FOR PEDESTRIANS or a similar message.

Sketch or Drawing of the Alternative



Past Use of the Alternative

Such signing has been used in various forms.

Justification for Use

This alternative is geared toward the motorist and provides information near the traffic signal or span-mounted overhead location. It can be installed at most locations (particularly locations with high-turning volumes) with minimal expense and labor.

Potential Advantages

- Relatively inexpensive to install and maintain.
- Geared toward the motorist.
- Located over right-turn or left-turn lane where it is most likely to be seen by motorist.

Potential Disadvantages

- Does not provide information to the pedestrian.
- May be ignored by some motorists.
- Adds to visual clutter of urban environment.

Estimated Cost of Installation

Low to moderate

Estimated Cost of Maintenance and Operation

Low

Alternative 3

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS

Description (Color, Movement, Message, Size, Etc.)

A regulatory sign for turning motorists requiring them to yield for crossing pedestrians.

(Note: This is directed towards the motorists with no action to be taken by the pedestrian)

Sketch or Drawing of the Alternative

Past Use of the Alternative

Similar signs used in Ann Arbor and Detroit, Michigan as well as other cities.

Justification for Use

- Similar in concept to the "No Right Turn on Red" message currently in use in most states.
- It serves as a reminder to motorists of their legal obligation to yield right-of-way to pedestrians.

Potential Advantages

- Reduces accident potential with pedestrians.
- Burden is on motorists who is likely to be more knowledgeable about traffic control devices than the average pedestrian (children, elderly, handicapped).
- Does not need any action by pedestrians.

Potential Disadvantages

- May result in longer vehicle queues in case of heavy turning vehicles.
- Increases vehicle delay.

Estimated Cost of Installation

Low

Estimated Cost of Maintenance and Operation

Low

Alternative 4

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

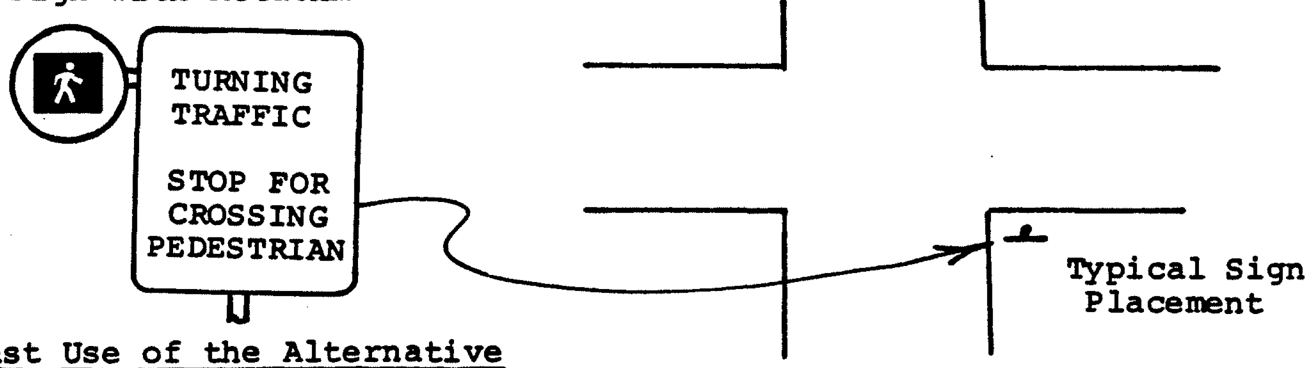
TECHNIQUES TO INDICATE POTENTIAL CONFLICTS

Description (Color, Movement, Message, Size, Etc.)

The message sign and passive symbol are aimed at the driving population at urban intersections. The sign says: "TURNING TRAFFIC - STOP FOR CROSSING PEDESTRIANS". An alternative would be to use a flashing symbol sign.

Sketch or Drawing of the Alternative

Sign with Attachment



Past Use of the Alternative

Unknown

Justification for Use

This message is intended for drivers and would be situated close to the intersection so the motorist would see the pedestrian symbol prior to making a right turn.

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS (Continued)

Potential Advantages

- Would be aimed at drivers who are responsible for yielding to pedestrians while turning.
- Should be an effective way to warn motorists concerning pedestrians.

Potential Disadvantages

- Could be relatively expensive to implement compared to other alternatives.
- Would add to the visual clutter in urban areas.
- May give the pedestrians a false sense of security if the motorist fails to notice and/or obey the sign.

Estimated Cost of Installation

Moderate to High - if a flashing device is used.

Estimated Cost of Maintenance and Operation

Moderate

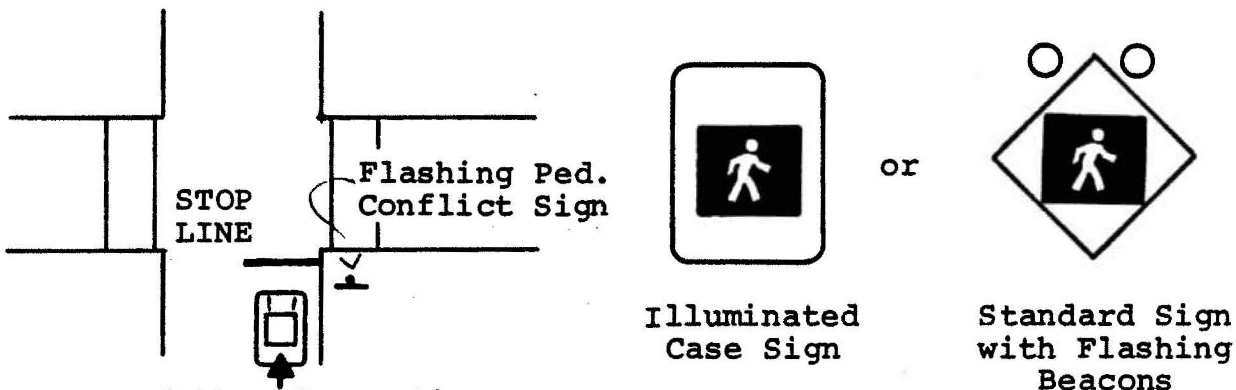
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS

Description (Color, Movement, Message, Size, Etc.)

The flashing symbol of a walking man would be displayed for drivers prior to making a right (or left) turn (when pedestrians have the WALK interval).

Sketch or Drawing of the Alternative



Past Use of the Alternative

Used in Israel in urban areas, such as in Tel-Aviv.

Justification for Use

This type of alternative is aimed at the driver. Drivers are given many types of warning on their driving environment ("Pavement Slippery when Wet" signs, flashing yellow beacons at intersections, etc.) for all types of hazards. This warning sign would help to alert drivers to pedestrians.

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS (Continued)

Potential Advantages

- Attempts to warn the driver to watch for pedestrians.
- Places proper responsibility on the driver to yield to pedestrians during turning maneuver.
- Very visible message to motorists.

Potential Disadvantages

- Could be relatively expensive.
- Would add to visual clutter in the urban areas.
- May provide pedestrians with a false sense of security if motorists ignore or do not see the sign.

Estimated Cost of Installation

Moderate

Estimated Cost of Maintenance and Operation

Moderate

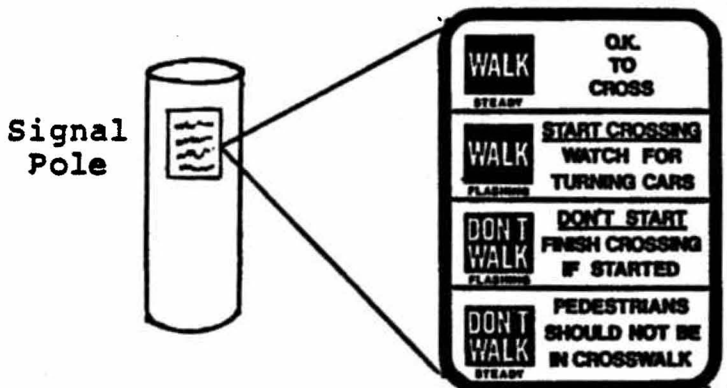
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS

Description (Color, Movement, Message, Size, Etc.)

Post a notice of the meaning of WALK and DONT WALK signals at the corners with pedestrian signals or install a small sign with the meanings of pedestrian signals (educational campaign).

Sketch or Drawing of the Alternative



Past Use of the Alternative

This program has been implemented in Broward County, Florida on poles with push buttons and pedestrian signals. Albany, New York uses a similar sign to explain the use of signal actuated devices. Also, Albany publishes "Street Sense" literature.

Justification for Use

- Inexpensive
- Constant reminder to pedestrians.
- It effects only those who are using the crossing. Time and money for education or explanation of signal operation are not spent on others.

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS (Continued)

Potential Advantages

- Provides a simple meaning of all pedestrian messages/symbols that are used.
- On-going public education program.

Potential Disadvantages

- Must be clearly worded to avoid confusion.
- Useless to those who cannot read (young, those who do not understand English, blind, etc.).
- May be defaced by vandals.

Estimated Cost of Installation

Low

Estimated Cost of Maintenance and Operation

Low

Alternative 7

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS

Description (Color, Movement, Message, Size, Etc.)

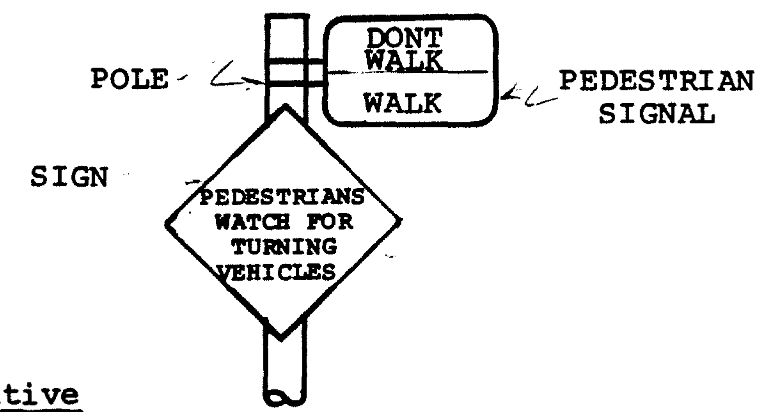
A sign which is placed on the pedestrian signal pole which states:

PEDESTRIANS WATCH FOR TURNING VEHICLES

or

PEDESTRIANS CAUTION - TURNING VEHICLES

Sketch or Drawing of the Alternative



Past Use of the Alternative

Unknown

Justification for Use

- The cost of installation and operation would be very low.
- Pedestrians would be given a clear message of the potential for turning vehicles.
- The signs could be installed at many locations with pedestrian signals.

Potential Advantages

- Relatively low cost.
- Provides a clear and concise message.
- Will be easily understood by most pedestrians compared to the flashing WALK interval.

Potential Disadvantages

- Many pedestrians may not look for or read the signs, since they will be watching the pedestrian signal heads.
- School children who cannot read would not be helped by the sign.
- Would add to visual clutter in the urban areas.

Estimated Cost of Installation

Low

Estimated Cost of Maintenance and Operation

Low

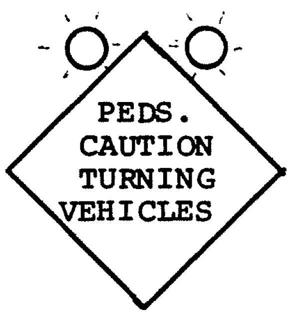
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS

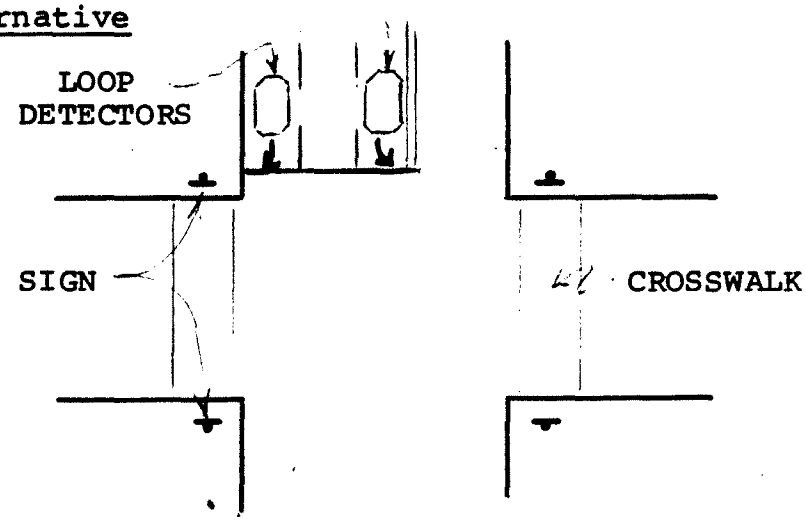
Description (Color, Movement, Message, Size, Etc.)

By use of inductive loops implanted in exclusive right or left-turn lanes, a beeping sound along with a flashing warning will occur when cars are detected which could cross a pedestrian's path on a WALK interval. The warning message would say: "PEDESTRIANS WATCH FOR TURNING VEHICLES". This sign would be used in conjunction with the existing WALK/DON'T WALK (or symbolic) pedestrian message.

Sketch or Drawing of the Alternative



Sign with flashing beacons



Past Use of the Alternative

Unknown

Justification for Use

Warns pedestrians of actual potential conflicts with a flashing message and by a warning buzzer. Therefore, pedestrians are not conditioned to ignore the indication. This type of alternative would best be limited to those intersections with special turning lanes. It is highly applicable to locations with high turning volumes during certain times and exclusive turn lanes. It is also highly applicable to fully actuated signals where loop detectors may already be in place.

Potential Advantages

- Warns pedestrian in an effective means only when the hazard exists, therefore, the pedestrian does not get conditioned to always hearing or seeing the warning.
- The buzzing sound may also warn drivers.
- May be quite appropriate at locations with existing vehicle loop detectors.

Potential Disadvantages

- Could create confusion in areas where some signs give warning of hazards and others do not.
- Must have exclusive turning lanes to work properly.
- Problems may exist when motorists turn from the wrong lanes.
- Would not be uniform to all intersections within an area due to the presence or lack of special turn lanes.

Estimated Cost of Installation

High

Estimated Cost of Maintenance and Operation

High (in terms of maintaining the vehicle detection loops).

Alternative 9

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

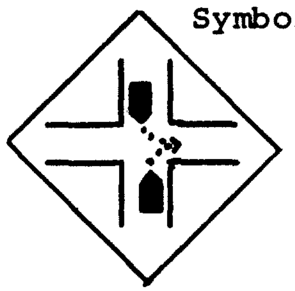
TECHNIQUES TO INDICATE POTENTIAL CONFLICTS

Description (Color, Movement, Message, Size, Etc.)

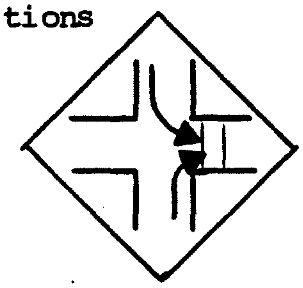
Symbolic sign to communicate vehicular conflict due to turning vehicles to pedestrians in conjuntion with existing pedestrian signals.

Sketch or Drawing of the Alternative

Symbolic Sign Options



or



Past Use of the Alternative

Unknown

Justification for Use

These messages would be intended to warn pedestrians of the potential for turning vehicles. It would express a symbolic message in conjunction with the existing pedestrian signal heads.

Potential Advantages

- The signs would be relatively inexpensive
- They would be easy to install.

Potential Disadvantages

- Some education efforts (radio, TV, etc.) may be necessary to educate the population as to the meaning of the message.
- Additional visual clutter in urban areas.
- May add to pedestrian delay.

Estimated Cost of Installation

Low

Estimated Cost of Maintenance and Operation

Low

Alternative 10

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS

Description (Color, Movement, Message, Size, Etc.)

Remove all pedestrian signal indications except where absolutely necessary (such as due to an exclusive pedestrian phase, or to reduce pedestrian confusion).

Sketch or Drawing of the Alternative

None

Past Use of the Alternative

Some agencies discourage the widespread use of pedestrian signals due to a lack of proven safety benefits.

Justification for Use

Simpler devices tend to work better when there is little public education on the meaning of sophisticated warning messages.

Potential Advantages

- Pedestrians would not be confused by complicated warning messages.
- Pedestrians would be more cautious and have to look around more to determine if it is safe to cross.

Potential Disadvantages

- No warning devices would be present for the pedestrian.
- May cause more confusion to young pedestrians.

Estimated Cost of Installation

Low

Estimated Cost of Maintenance and Operation

Low

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS

Description (Color, Movement, Message, Size, Etc.)

Use the flashing WALK indication to indicate potential conflicts with turning vehicles.

Sketch or Drawing of the Alternative

Flashing

Past Use of the Alternative

This has been and is currently in use in many states and cities, and is recommended in the MUTCD.

Justification for Use

Recommended in the MUTCD and used in many cities and states across the country.

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS (Continued)

Potential Advantages

- Reduce accident potential.
- Less interference with vehicular flow.

Potential Disadvantages

- Increase pedestrian delay.
- May be confusing to pedestrians.
- Signal size may have to be increased to accommodate added display.

Estimated Cost of Installation

Moderate

Estimated Cost of Maintenance and Operation

Moderate

Alternative 12

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

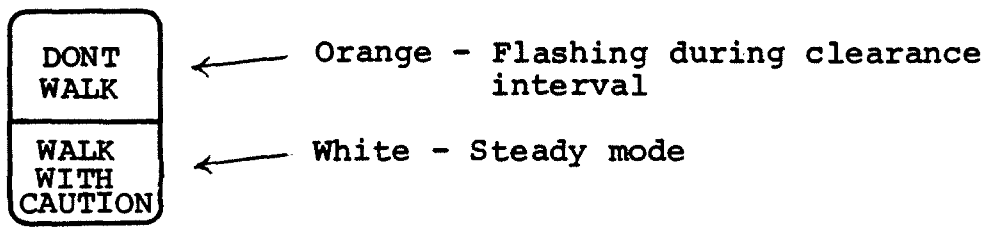
TECHNIQUES TO INDICATE POTENTIAL CONFLICTS

Description (Color, Movement, Message, Size, Etc.)

Replace current WALK signal with additional precautionary indication.

Sketch or Drawing of the Alternative

Pedestrian Signal Head



Past Use of the Alternative

None

Justification for Use

Caution pedestrians against approaching/turning vehicles.

Reduce pedestrian-vehicle conflict.

Potential Advantages

- Simple display.
- Inexpensive

Potential Disadvantages

- Does not convey the danger from turning vehicles to the pedestrians.
- In past surveys less than three percent of the pedestrians surveyed understood the meaning of the flashing WALK. Not uniformly used across the country.
- If not used uniformly across a city it could create considerable confusion and be a safety hazard.

Estimated Cost of Installation

Low

Estimated Cost of Maintenance and Operation

Low

Alternative 13

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

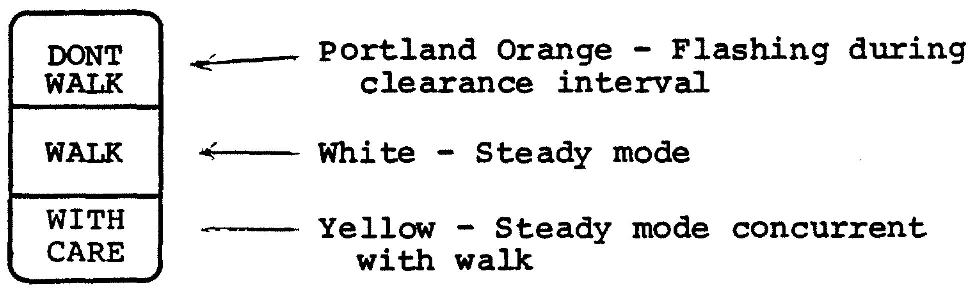
TECHNIQUES TO INDICATE POTENTIAL CONFLICTS

Description (Color, Movement, Message, Size, Etc.)

A word display on the pedestrian signal requiring pedestrians to watch for turning motorists.

Sketch or Drawing of the Alternative

Pedestrian Signal Head



Past Use of the Alternative

None known.

Justification for Use

- Caution pedestrians against turning motorists.
- Reduce pedestrian-vehicle conflict.

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS (Continued)

Potential Advantages

- Reduce accident potential.
- Less interference with vehicular flow.

Potential Disadvantages

- Increase pedestrian delay.
- Non compliance by pedestrian may cause hazardous situations.
- The young pedestrian may be confused.
- The size of the pedestrian signal would have to be increased to accommodate to added display.

Estimated Cost of Installation

Moderate

Estimated Cost of Maintenance and Operation

Moderate

Alternative 14

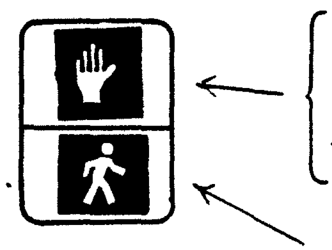
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS

Description (Color, Movement, Message, Size, Etc.)

A flashing yellow symbol superimposed on walking man.

Sketch or Drawing of the Alternative



Past Use of the Alternative

None

Justification for Use

- Would automatically caution the pedestrian before he starts walking.
- Pedestrians would interpret flashing yellow as a caution message, so they would stop, look in all directions and start crossing.

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS (Continued)

Potential Advantages

- Would take away the false sense of security as currently provided by the steady WALK sign.
- Less vehicular delay.

Potential Disadvantages

- Increase pedestrian delay.
- May be confusing to pedestrians.
- Too much burden on the pedestrian.

Estimated Cost of Installation

Moderate

Estimated Cost of Maintenance and Operation

Moderate

Alternative 15

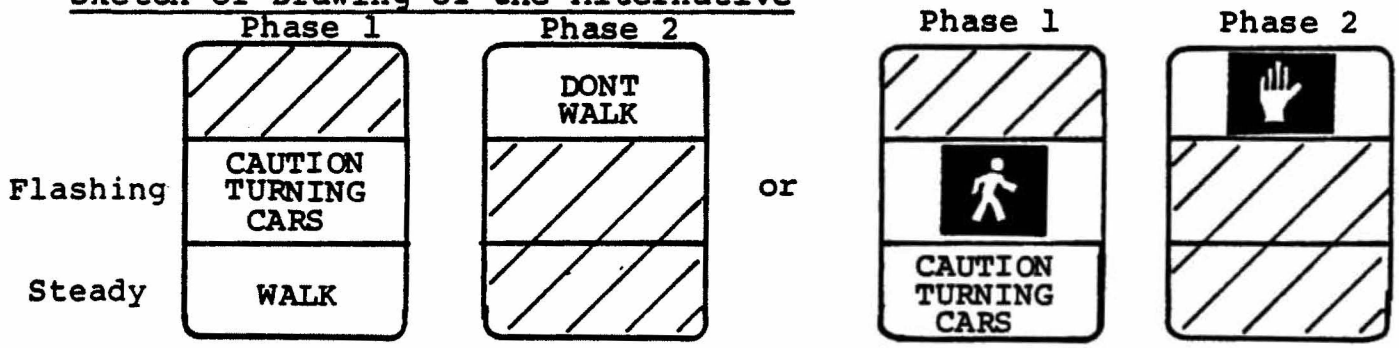
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS

Description (Color, Movement, Message, Size, Etc.)

Sign above the pedestrian signal flashing a display during WALK phase which says: CAUTION TURNING VEHICLES.

Sketch or Drawing of the Alternative



Pedestrian Signal Heads

Past Use of the Alternative

Not known.

Justification for Use

This alternative provides a clear message to the pedestrian and is given directly on the pedestrian signal head when the pedestrian is likely to be looking. It would be incorporated as a part of the pedestrian signal.

Potential Advantages

- Can be added onto existing message or symbolic pedestrian signals.
- The caution message appears only when the walk message is activated.
- Does not confuse pedestrians with flashing walk message (which no one understands).
- Could be installed at locations with a high volume right-turning movement.

Potential Disadvantages

- The pedestrians still may not obey display even though it will be more easily understood.
- May be more expensive than simple signing installations.
- The size of the pedestrian signal will have to be increased to accommodate the added display.

Estimated Cost of Installation

Moderate

Estimated Cost of Maintenance and Operation

Moderate

Alternative 16

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS

Description (Color, Movement, Message, Size, Etc.)

Reduce or eliminate all sight obstructions at the intersection so that drivers and pedestrians may have a better chance of seeing each other and avoiding collisions.

Sketch or Drawing of the Alternative

None

Past Use of the Alternative

Elimination of parking is being used to reduce sight obstructions in many cities.

Justification for Use

Many accidents are caused when the driver can not see the pedestrian due to sight obstructions (or vice versa). Therefore, one logical approach would be to reduce or eliminate as many sight obstructions as possible.

Potential Advantages

- The pedestrians would have a better chance of seeing turning vehicles to avoid a collision (and vice versa).
- Visually more attractive.

Potential Disadvantages

- May be very costly or infeasible to remove some objects such as light poles, buildings, needed traffic signs, etc.
- There is no warning device for pedestrians.

Estimated Cost of Installation

Low to high - depending on the existing street furniture.

Estimated Cost of Maintenance and Operation

Low

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS

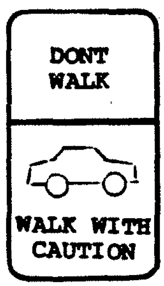
Description (Color, Movement, Message, Size, Etc.)

A combination of symbol and word message to caution pedestrians against approaching vehicles, in conjunction with a sign used to warn turning motorists to yield for pedestrians.

(Note: Here both the pedestrian and the vehicle would be required to act.)

Sketch or Drawing of the Alternative

Pedestrian Signal Head



(for the pedestrian)

in combination with

SIGN

(for the motorist)

Past Use of the Alternative

None known.

Justification for Use

- Cautions pedestrians before they start crossing.
- The flashing car symbol will tell the pedestrian that a potential conflict exists.
- The yield sign will caution the turning vehicle against crossing pedestrian.

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS (Continued)

Potential Advantages

- Both parties (pedestrians and vehicular traffic) know about the conflict.
- Both parties would be required to take action independently.
- System would be safe even if one party disregards the message.

Potential Disadvantages

- Would increase both pedestrian and vehicular delay.
- Size of signal head would have to be increased to accommodate additional display.

Estimated Cost of Installation

Moderate

Estimated Cost of Maintenance and Operation

Moderate

Alternative 18

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS

Description (Color, Movement, Message, Size, Etc.)

Variable display pedestrian signals programmed to indicate information relative to traffic conditions. Detectors could be used to trigger the display that turning vehicles are present, or historical information could be used to program the signal on a time-of-day basis.

Sketch or Drawing of the Alternative

Display 1	Display 2	Display 3
WALK	WALK - WATCH FOR TURNING VEHICLES	DON'T WALK

Past Use of the Alternative

Variable message sign technology is in widespread use today for various highway safety purposes.

Justification for Use

More information would be presented to the pedestrian than is currently given by the flashing walk message. It could be installed mainly at intersections which have high volumes of both pedestrians and right-turning vehicles.

Potential Advantages

Through the provision of more information the pedestrian/driver could be more cautious, or the information provided by such a sign could develop such caution.

Potential Disadvantages

- Sign size may have to be large in order to be seen.
- Display may not be understood by everyone, particularly pedestrians who cannot read English (i.e. young pedestrians, illiterate people, foreigners, etc.).

Estimated Cost of Installation

High

Estimated Cost of Maintenance and Operation

High

Alternative 19

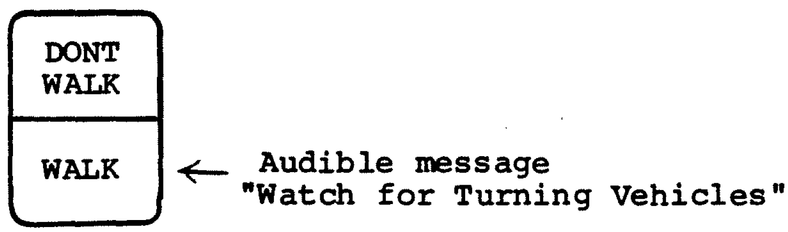
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

TECHNIQUES TO INDICATE POTENTIAL CONFLICTS

Description (Color, Movement, Message, Size, Etc.)

An audible word message to caution the pedestrian against approaching vehicles used in conjunction with the standard WALK/DONT WALK pedestrian signal.

Sketch or Drawing of the Alternative



Pedestrian Signal Head

Past Use of the Alternative

Audible message has been used with some success in England, Japan, and the U.S. (Washington, D.C.) to designate clearance intervals.

Justification for Use

Would caution the pedestrian against approaching vehicles without requiring the pedestrian to see and interpret a word/symbolic message.

Potential Advantages

- The pedestrian is cautioned "clearly and loudly".
- Reduce vehicle-pedestrian conflict.
- The pedestrian does not have to interpret a word message or a symbol.
- Catches the attention of the pedestrian.

Potential Disadvantages

- May confuse the motorist.
- Additional noise.
- Vulnerable to mechanical failure.

Estimated Cost of Installation

Moderate

Estimated Cost of Maintenance and Operation

Moderate to High

APPENDIX I - PEDESTRIAN SIGNALIZATION PROVISIONS FOR ELDERLY AND HANDICAPPED

Table 25 lists classification of handicaps, subgroups and the estimated population of each classification in the U.S. from a recent study by Templer [1].

In a recent Implementation Manual by Templer for the FHWA regarding elderly and handicapped pedestrians, several problems and recommendations regarding traffic signals were discussed [2]. These include:

- Traffic signals are sometimes poorly located such that they are too far away to see, blocked by other objects or are confusing because of visual clutter caused by other traffic and advertising signs. To correct this problem, signal locations should be selected to provide a full and unobstructed view by pedestrians.

- Complex signal timing patterns (such as those with special turn phases or locations with five or more legs) can be very confusing to pedestrians, particularly for pedestrians with slower reaction times or poor vision. To reduce confusion, this situation calls for special pedestrian messages (signs/signals) which are clear and simple and will eliminate confusion.

- Elderly and handicapped pedestrians have slower walking speeds and therefore take longer to cross a street. Signal timing should be adjusted where significant numbers of elderly and handicapped people cross. Timing should account for a walking speed of 2 ft/sec (0.6 m/sec) or slower. The use of actuation devices or actuated WALK time extension systems may also be desirable to reduce vehicle delay at these locations.

- Signal timing schemes which allow the late release of pedestrians (i.e., cars are allowed to turn before pedestrians are allowed to cross) are confusing to people with visual impairments and should be avoided.

- Some pedestrian push-button devices cannot be used by some pedestrians because they require too much manual dexterity. In addition, some pedestrian actuation devices are located too high for pedestrians in wheelchairs to reach. Pedestrian actuation devices should be located between 35 inches to 54 inches (87 to 135 cm) above the ground, where the height of 40 inches (100 cm) is preferred. The report also recommends that actuation devices that require a high degree of accurate motion or grasping, pinching, or twisting movements should not be used. The buttons should not be recessed, and controls that require a push or pull force of more than 5 lbs. (0.69 N) should not be used and a maximum of 3 lbs. (0.41 N) is preferred.

Table 25. Typology of handicapped pedestrians.

Handicap	Sub-Group	Est. Population 1975 (000)
Developmental restrictions (size and maturity)	1. Pre-school children	20,926
	2. School-age children	46,482
Chronic restrictive conditions related to agility, stamina, and reaction time	3. Persons over 65	22,170
Lower extremity impairment (legs, feet)	4. Confined to wheelchair	445
	5. Walking using special aids	5,042
	6. Walking with difficulty without the use of special aids	2,344
Chronic impairment of upper extremities and shoulders (arms, shoulders and neck)	7. Chronic impairment of upper extremities and shoulders	2,588
Severe auditory impairment	8. Severe auditory impairment	1,867
Severe visual impairment	9. Severe visual impairment	482
Obvious confusion, and/or disorientation	10. Obvious confusion and/or disorientation	20,000

Source: Reference 1.

- Inadequate visibility (caused by vegetation, buildings, parked vehicles, trucks in the traffic, etc.) often makes right-turn-on-red hazardous for elderly and handicapped pedestrians, particularly where vehicles must be in or across the crosswalk to have an adequate view of the approaching cross-street traffic. Right-turn-on-red should be avoided in these situations.

In a 1981 report by Valette for the FHWA, a review of operational experience was conducted for 19 cities representing a cross section of different city sizes, socio-economic characteristics and different regions of the country [3]. As a part of this review, special attention was provided to programs and countermeasures directed towards elderly and handicapped pedestrians. A summary of these programs and practices relating to safety and signalization are as follows:

- Several cities (e.g., Atlanta, Georgia, Manchester, New Hampshire, San Diego, California, and West Palm Beach, Florida) have implemented push-buttons for pedestrians to extend the WALK interval, particularly in the areas of high concentrations of elderly pedestrians. In addition to utilizing the pedestrian push-buttons, Milwaukee, Wisconsin, has the locations posted with signs stating ELDERLY/DISABLED PUSH BUTTON FOR EXTRA WALK TIME.

- At least two cities surveyed (West Palm Beach, Florida and Milwaukee, Wisconsin) utilize an audible message (bell) during the WALK interval at locations with high numbers of visually impaired pedestrians.

- Some cities have increased the cycle length (on a fixed-time basis) in areas with high concentrations of elderly pedestrians to permit adequate crossing intervals. This alternative has, however, caused detrimental effects to vehicular traffic operations.

- Several cities have noted a disproportionately high number of elderly pedestrians involved in accidents along with higher severities resulting from these accidents and have developed special pedestrian safety education for senior citizens. These programs have included developing special brochures, using radio/TV/newspaper advertisements, and conducting special training and safety sessions.

- Some cities have had special training programs for handicapped pedestrians (such as blind or deaf pedestrians) who may not be reached through conventional media or safety programs.

- The City of San Diego, California, reported that one of the reasons it discontinued the use of the dynamically programmed signals is that it did not compensate for the slower walking speed of elderly pedestrians. Since the dynamically programmed signals portray a moving message within a narrow visual band, two different messages may be seen by pedestrians of differing height who walk side by side. In addition, problems were encountered due to different pedestrian heights, particularly with children.

- Many communities have installed signs for motorists to be cautious of pedestrians with visual or auditory impairments in areas with high concentrations of these handicapped pedestrians.

Audible messages to accompany the standard WALK/DONT WALK signals have been suggested and, in some cases utilized, to help visually impaired pedestrians cross safely. While these signals have been utilized in Israel, England, Japan, and Washington, D.C., their impact has not been fully evaluated.

An audible signal was tested by Wilson [4] at a location where blind pedestrians cross in England. Due to the low volume of blind pedestrians, no effect on the behavior group could be assessed. However, with the use of the audible message, the following effect was found on the total population of pedestrians crossing at the site.

- The average pedestrian crossing time was reduced by 5 percent.

- Pedestrian delay after the onset of the crossing interval was decreased by over 20 percent.

- For those starting to cross during the crossing interval, there was a significant reduction in the proportion failing to complete their crossing before the prohibited crossing interval.

An ITE Committee investigated traffic control devices for elderly and handicapped pedestrian crossings. They conducted a review of current practices regarding signal warrants, signal displays and signal timing [5]. Since many of the elderly pedestrians were confused by the flashing DONT WALK indication (many felt they should be able to make their entire crossing with the WALK indication), an experimental three section pedestrian signal indication was fabricated and evaluated. The third indication was a yellow DONT START message. The intent of the message was to clearly advise the pedestrian not to start crossing during the clearance interval, and the yellow display was used since it is recognized as a standard clearance display. The signal was field tested, and observations were made of 203 pedestrians, most of which were over 70 years old. The test indicated that 43 percent complied with the WALK indication, but 28 percent violated the DONT START and 35 percent violated the DONT WALK message. Before data or data from a comparison site were not collected for use in the evaluation. However, an interview of the pedestrians violating the signal included the following reasons for violations:

- Pedestrians were watching the vehicular traffic, looking for adequate gaps and ignored the pedestrian signals.
- The wait for the WALK indication was too long.
- Some of the pedestrians did not understand the messages.
- Pedestrian inattentiveness (i.e., too busy talking).

The authors stated that the survey indicated that the DONT START message did not appear to be effective, but that more research and evaluation is necessary.

A study of walking speed was conducted and it was found that age alone was not the only factor in determining the crossing rate [5]. Crossing rate was also a function of: (1) group size; (2) whether they were holding packages; (3) whether they were handicapped; (4) the presence of barriers caused by street furniture; and (5) whether or not the pedestrians relied on signal information or used their judgement to determine an adequate gap. The following walking speeds were found for different age groups based on this study:

Elderly Crossings - 2.5 ft/sec (0.8 m/sec)
School Crossings - 3.5 ft/sec (1.0 m/sec)
Other Crossings - 4.0 ft/sec (1.2 m/sec)

A review of the state-of-the-art, and discussions were conducted with handicapped organizations as a part of the ITE study which indicated the following recommendations [5]:

- Any warrant for the installation of special traffic signal equipment for the visually handicapped would be completely arbitrary and should not be established. The installation of a special crossing device for a handicapped pedestrian (such as an audible message) is only useful at that location. Many organizations for handicapped individuals feel that handicappers should be trained to cope with the total environment instead of modifying a few locations for them.
- Audible rather than tactile or other signal devices appear to be preferred by the blind. A tactile device is one that operates using the sense of feel, such as a vibrating pole. A vibrating pole, however, gives no sense of direction and once the visually impaired pedestrian leaves the pole, they are not longer aware of the signal indication. The vibrating pole is also expensive to

operate and maintain and is susceptible to vandalism. Devices such as a radio frequency message transmitted to a crossing pedestrian with a hand held receiver is also an option, but is extremely expensive.

- The audible signal should only operate on pedestrian actuation and only with the green or WALK indications. The audible signal should only be used when necessary (i.e., when a visually impaired pedestrian is present) to reduce noise pollution, and the message should be as simple as possible. If a different audible message (pitch, tone, pattern) is made for different indications for both crossing directions at an intersection, a minimum of six audible messages would be needed. This number of messages could cause considerable confusion.

- For audible signals, an intermittent sound is more desirable than a constant tone. An intermittent noise is more discernable from the ambient roadway noise and can be used at a lower volume or frequency than a constant tone without a reduction in effectiveness.

- Larger size pedestrian signal indications should be used at locations where visually impaired cross, regardless of the crossing width. Many people have severely impaired vision but not a total loss of sight. The large indications will provide assistance to these individuals.

References

1. Templer, J.A., "Provisions for Elderly and Handicapped Pedestrians: Volume I", prepared by the Georgia Institute of Technology, Pedestrian Research Laboratory for the FHWA, January, 1979.

2. Templer, J.A., "Development of Priority Accessible Networks: Implementation Manual", prepared by the Georgia Institute of Technology, Pedestrian Research Laboratory for the FHWA, January, 1980.

3. Valette, G.R., and McDivvitt, J.A., "Pedestrian Safety Programs - A Review of the Literature and Operational Experience", Biotechnology, Inc., prepared for FHWA, January, 1981.

4. Wilson, D.G., "The Effects of Installing an Audible Signal for Pedestrians at a Light Controlled Junction", TRRL Report 917, England, 1980.

5. "Traffic Control Devices for Elderly and Handicapped Crossings", ITE Committee Number 4A-6, Unpublished draft report, April, 1981.

APPENDIX J - DESCRIPTION OF SITES USED IN FIELD TESTING OF EXPERIMENTAL SIGN AND SIGNAL DEVICES

SITE DESCRIPTION

Experiment: Pedestrian Signal Explanation Signs (Symbolic)

City: Saginaw, Michigan Site: Court St. and Michigan Ave. (1)

Crosswalk: East (Court St.)

Number of Lanes: 4 through lanes, 1 left-lane, 2 parking lanes

Approximate Street Width: 76 feet (23 m)

Roadway Operation: Court St., 2-way; Michigan Ave., 2-way

	Before	After
Cycle Length:	60/70	60/70
WALK Interval:	15/18	15/18
Clearance Interval:	15/17	15/17
DONT WALK Interval:	30/35	30/35
Average Hourly Traffic Volume (Crossing Crosswalk):	840	660
Average Hourly Right-Turn Volume (Crossing Crosswalk):	77	54
Average Hourly Left-Turn Volume (Crossing Crosswalk):	47	33
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	110	55

SITE DESCRIPTION

Experiment: Pedestrian Signal Explanation Signs (Symbolic)

City: Saginaw, Michigan Site: Court St. and Hamilton St. (2)

Crosswalk: West (Court St.)

Number of Lanes: 4 through lanes, 1 left-turn lane, 2 parking lanes

Approximate Street Width: 76 feet (23 m)

Roadway Operation: Court St., 2-way; Hamilton St., 2-way

	Before	After
Cycle Length:	60/70	60/70
WALK Interval:	18/18	18/18
Clearance Interval:	12/17	12/17
DONT WALK Interval:	30/35	30/35
Avgerage Hourly Traffic Volume (Crossing Crosswalk):	814	716
Avgerage Hourly Right-Turn Volume (Crossing Crosswalk):	83	68
Avgerage Hourly Left-Turn Volume (Crossing Crosswalk):	43	46
Avgerage Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	58	49

SITE DESCRIPTION

Experiment: Pedestrian Signal Explanation Signs (Word)

City: Washington, D.C. Site: 17th St. and L St., N.W. (3)

Crosswalk: South (17th St.)

Number of Lanes: 4 through lanes, 2 parking lanes

Approximate Street Width: 68 feet (20 m)

Roadway Operation: 17th St., 2-way; L St., 1-way (eastbound)

	Before	After
Cycle Length:	80	80
WALK Interval:	18	18
Clearance Interval:	17	17
DONT WALK Interval:	45	45
Average Hourly Traffic Volume (Crossing Crosswalk):	822	867
Average Hourly Right-Turn Volume (Crossing Crosswalk):	103	124
Average Hourly Left-Turn Volume (Crossing Crosswalk):	0	0
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	442	464

SITE DESCRIPTION

Experiment: Pedestrian Signal Explanation Signs (Word)

City: Washington, D.C. Site: 18th St. and L St., N.W. (4)

Crosswalk: North (18th St.)

Number of Lanes: 3 through lanes, 1 parking lane

Approximate Street Width: 46 feet (14 m)

Roadway Operation: 18th St., 1-way (northbound); L St., 1-way (eastbound)

	Before	After
Cycle Length:	80	80
WALK Interval:	9	9
Clearance Interval:	11	11
DONT WALK Interval:	60	60
Average Hourly Traffic Volume (Crossing Crosswalk):	685	571
Average Hourly Right-Turn Volume (Crossing Crosswalk):	0	0
Average Hourly Left-Turn Volume (Crossing Crosswalk):	222	236
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	1,125	926

SITE DESCRIPTION

Experiment: DONT START Signal Indication

City: Ann Arbor, Michigan Site: S. State St. and Washington St. (5)

Crosswalk: South (State St.)

Number of Lanes: 2 through lanes, 2 parking lanes

Approximate Street Width: 44 feet (13 m)

Roadway Operation: S. State St., 2-way; Washington St., 2-way

	Before	After
Cycle Length:	80/90	80
WALK Interval:	16/20	16
Clearance Interval:	15/16	11
DONT WALK Interval:	49/54	53
Average Hourly Traffic Volume (Crossing Crosswalk):	439	374
Average Hourly Right-Turn Volume (Crossing Crosswalk):	42	46
Average Hourly Left-Turn Volume (Crossing Crosswalk):	119	118
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	153	125

SITE DESCRIPTION

Experiment: DONT START Signal Indication

City: Washington, D.C. Site: 20th St. and L St., N.W. (6)

Crosswalk: East (L St.)

Number of Lanes: 3 through lanes, 1 parking lane

Approximate Street Width: 46 feet (14 m)

Roadway Operation: 20th St., 1-way (northbound); L St., 1-way (eastbound)

	Before	After
Cycle Length:	80	80
WALK Interval:	25	12
Clearance Interval:	19	12
DONT WALK Interval:	36	56
Average Hourly Traffic Volume (Crossing Crosswalk):	625	816
Average Hourly Right-Turn Volume (Crossing Crosswalk):	277	314
Average Hourly Left-Turn Volume (Crossing Crosswalk):	0	0
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	662	519

SITE DESCRIPTION

Experiment: DONT START Signal Indication

City: Milwaukee, Wisconsin Site: Broadway and Mason St. (7)

Crosswalk: South (Broadway)

Number of Lanes: 4 through lanes, 2 parking lanes

Approximate Street Width: 68 feet (20 m)

Roadway Operation: Broadway, 1-way (southbound); Mason St., 2-way

	Before	After
Cycle Length:	90	90
WALK Interval:	31	31
Clearance Interval:	13	13
DONT WALK Interval:	46	46
Average Hourly Traffic Volume (Crossing Crosswalk):	420	361
Average Hourly Right-Turn Volume (Crossing Crosswalk):	74	75
Average Hourly Left-Turn Volume (Crossing Crosswalk):	73	80
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	184	166

SITE DESCRIPTION

Experiment: DONT START Signal Indication

City: Milwaukee, Wisconsin Site: Mason St. and Jackson St. (8)

Crosswalk: North (Jackson St.)

Number of Lanes: 4 through lanes, 1 parking lane

Approximate Street Width: 58 feet (17 m)

Roadway Operation: Mason St., 2-way; Jackson St., 1-way (southbound)

	Before	After
Cycle Length:	90	90
WALK Interval:	23	23
Clearance Interval:	11	11
DONT WALK Interval:	56	56
Average Hourly Traffic Volume (Crossing Crosswalk):	551	608
Average Hourly Right-Turn Volume (Crossing Crosswalk):	0	0
Average Hourly Left-Turn Volume (Crossing Crosswalk):	0	0
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	109	146

SITE DESCRIPTION

Experiment: Steady Versus Flashing WALK and Steady Versus Flashing DONT WALK

City: Washington, D.C. Site: 30th St., and M St., N.W. (9)

Crosswalk: North (30th St.)

Number of Lanes: 2 through lanes, 2 parking lanes

Approximate Street Width: 40 feet (12 m)

Roadway Operation: 30th St., 2-way; M St., 2-way

	Before	After
Cycle Length:	80	80
WALK Interval:	50	50
Clearance Interval:	-	10
DONT WALK Interval:	30*	20
Average Hourly Traffic Volume (Crossing Crosswalk):	181	175
Average Hourly Right-Turn Volume (Crossing Crosswalk):	63	55
Average Hourly Left-Turn Volume (Crossing Crosswalk):	65	72
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	371	361

SITE DESCRIPTION

Experiment: Steady Versus Flashing WALK and Steady Versus Flashing DONT WALK

City: Washington, D.C. Site: 7th St. and D St., N.W. (10)

Crosswalk: East (D St.)

Number of Lanes: 2 through lanes, 2 parking lanes

Approximate Street Width: 48 feet (14 m)

Roadway Operation: 7th St., 2-way; D St., 2-way

	Before	After
Cycle Length:	80	80
WALK Interval:	24	24
Clearance Interval:	-	23
DONT WALK Interval:	56*	33
Average Hourly Traffic Volume (Crossing Crosswalk):	465	415
Average Hourly Right-Turn Volume (Crossing Crosswalk):	55	54
Average Hourly Left-Turn Volume (Crossing Crosswalk):	54	53
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	256	347

*The steady DONT WALK indication was used during the clearance and DONT WALK interval in the before period. Therefore, the observer was not able to distinguish between the two intervals.

SITE DESCRIPTION

Experiment: YIELD TO PEDESTRIANS WHEN TURNING Sign

City: Detroit, Michigan Site: Cass Ave. and Lafayette St. (11)

Crosswalk: West (Lafayette St.)

Number of Lanes: 4 through lanes

Approximate Street Width: 46 feet (14 m)

Roadway Operation: Cass Ave., 2-way; Lafayette St., 2-way

	Before	After
Cycle Length:	60	60
WALK Interval:	20	20
Clearance Interval:	11	11
DONT WALK Interval:	29	29
Average Hourly Traffic Volume (Crossing Crosswalk):	270	281
Average Hourly Right-Turn Volume (Crossing Crosswalk):	114	133
Average Hourly Left-Turn Volume (Crossing Crosswalk):	19	17
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	163	170

SITE DESCRIPTION

Experiment: YIELD TO PEDESTRIANS WHEN TURNING Sign

City: Detroit, Michigan Site: Woodward Ave. and Grand Blvd. (12)

Crosswalk: South (Woodward Ave.)

Number of Lanes: 6 through lanes, 2 parking lanes, 1 median lane

Approximate Street Width: 102 feet (31 m)

Roadway Operation: Woodward Ave., 2-way; Grand Blvd., 2-way divided

	Before	After
Cycle Length:	70	70
WALK Interval:	13	13
Clearance Interval:	16	16
DONT WALK Interval:	41	41
Average Hourly Traffic Volume (Crossing Crosswalk):	1,309	1,344
Average Hourly Right-Turn Volume (Crossing Crosswalk):	131	157
Average Hourly Left-Turn Volume (Crossing Crosswalk):	0	0
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	304	232

SITE DESCRIPTION

Experiment: YIELD TO PEDESTRIANS WHEN TURNING Sign

City: Milwaukee, Wisconsin Site: 27th St. and Wisconsin Ave. (13)

Crosswalk: North (27th St.)

Number of Lanes: 6 through lanes

Approximate Street Width: 72 feet (22 m)

Roadway Operation: 27th St., 2-way; Wisconsin Ave., 2-way divided

	Before	After
Cycle Length:	90	90
WALK Interval:	7/13	7
Clearance Interval:	13/13	13
DONT WALK Interval:	70/64	70
Average Hourly Traffic Volume (Crossing Crosswalk):	870	659
Average Hourly Right-Turn Volume (Crossing Crosswalk):	85	70
Average Hourly Left-Turn Volume (Crossing Crosswalk):	50	37
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	103	76

SITE DESCRIPTION

Experiment: YIELD TO PEDESTRIANS WHEN TURNING Sign

City: Milwaukee, Wisconsin Site: Michigan Ave. and Broadway (14)

Crosswalk: East and West (Michigan Ave.)

Number of Lanes: 4 through lanes, 1 left-turn lane (west crosswalk), 1 median lane (east crosswalk)

Approximate Street Width: 60 feet (17 m)

Roadway Operation: Michigan Ave., 2-way; Broadway, 1-way (southbound)

	Before	After
Cycle Length:	90	90
WALK Interval:	28	28
Clearance Interval:	15	15
DONT WALK Interval:	47	47
Average Hourly Traffic Volume (Crossing Crosswalk):	551	666
Average Hourly Right-Turn Volume (Crossing Crosswalk):	39	45
Average Hourly Left-Turn Volume (Crossing Crosswalk):	41	33
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	106	143

SITE DESCRIPTION

Experiment: PEDESTRIANS WATCH FOR TURNING VEHICLES Sign

City: Detroit, Michigan   Site: Griswald St. and Larned St. (15)

Crosswalk: South (Griswald St.)

Number of Lanes: 4 through lanes

Approximate Street Width: 48 feet (14 m)

Roadway Operation: Griswald St., 2-way; Larned St., 1-way (eastbound)

	Before	After
Cycle Length:	60/70	60/70
WALK Interval:	16/26	16/26
Clearance Interval:	13/13	13/13
DONT WALK Interval:	31/31	31/31
Average Hourly Traffic Volume (Crossing Crosswalk):	353	418
Average Hourly Right-Turn Volume (Crossing Crosswalk):	73	93
Average Hourly Left-Turn Volume (Crossing Crosswalk):	0	0
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	233	219

SITE DESCRIPTION

Experiment: PEDESTRIANS WATCH FOR TURNING VEHICLES Sign

City: Detroit, Michigan   Site: Cass Ave. and Warren Ave. (16)

Crosswalk: North (Cass Ave.)

Number of Lanes: 4 through lanes

Approximate Street Width: 48 feet (14 m)

Roadway Operation: Cass Ave., 2-way; Warren Ave., 2-way divided

	Before	After
Cycle Length:	70	50
WALK Interval:	27	18
Clearance Interval:	11	13
DONT WALK Interval:	32	19
Average Hourly Traffic Volume (Crossing Crosswalk):	879	463
Average Hourly Right-Turn Volume (Crossing Crosswalk):	278	180
Average Hourly Left-Turn Volume (Crossing Crosswalk):	0	86
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	440	168

SITE DESCRIPTION

Experiment: PEDESTRIANS WATCH FOR TURNING VEHICLES Sign

City: Milwaukee, Wisconsin   Site: 11th St. and Mitchell St. (17)

Crosswalk: South (11th St.)

Number of Lanes: 3 through lanes, 1 parking lane

Approximate Street Width: 44 feet (13 m)

Roadway Operation: 11th St., 2-way; Mitchell St., 2-way

	Before	After
Cycle Length:	80	80
WALK Interval:	24	24
Clearance Interval:	10	10
DONT WALK Interval:	46	46
Average Hourly Traffic Volume (Crossing Crosswalk):	396	290
Average Hourly Right-Turn Volume (Crossing Crosswalk):	28	24
Average Hourly Left-Turn Volume (Crossing Crosswalk):	1	2
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	211	175

SITE DESCRIPTION

Experiment: PEDESTRIANS WATCH FOR TURNING VEHICLES Sign

City: Milwaukee, Wisconsin   Site: 13th St. and Lincoln Ave. (18)

Crosswalk: East (Lincoln Ave.)

Number of Lanes: 4 through lanes

Approximate Street Width: 48 feet (14 m)

Roadway Operation: 13th St., 2-way; Lincoln Ave., 2-way

	Before	After
Cycle Length:	60	60
WALK Interval:	17	17
Clearance Interval:	12	12
DONT WALK Interval:	31	31
Average Hourly Traffic Volume (Crossing Crosswalk):	732	747
Average Hourly Right-Turn Volume (Crossing Crosswalk):	72	77
Average Hourly Left-Turn Volume (Crossing Crosswalk):	26	21
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	67	45

SITE DESCRIPTION

Experiment: WALK WITH CARE Signal Indication

City: Ann Arbor, Michigan Site: Main St. and Washington St. (19)

Crosswalk: North (Main St.)

Number of Lanes: 2 through lanes, 1 left-turn lane

Approximate Street Width: 36 feet (11 m)

Roadway Operation: Main St., 2-way; Washington St., 2-way

	Before	After
Cycle Length:	70	70/80
WALK Interval:	21	21/26
Clearance Interval:	11	11/14
DONT WALK Interval:	38	40/40
Average Hourly Traffic Volume (Crossing Crosswalk):	649	636
Average Hourly Right-Turn Volume (Crossing Crosswalk):	49	40
Average Hourly Left-Turn Volume (Crossing Crosswalk):	15	14
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	130	209

SITE DESCRIPTION

Experiment: WALK WITH CARE Signal Indication

City: Washington, D.C. Site: M St. and Wisconsin Ave. (20)

Crosswalk: West (M St.)

Number of Lanes: 6 through lanes

Approximate Street Width: 68 feet (20 m)

Roadway Operation: M St., 2-way; Wisconsin Ave., 2-way

	Before	After
Cycle Length:	80	80/90
WALK Interval:	9	9/12
Clearance Interval:	14	14/16
DONT WALK Interval:	57	57/62
Average Hourly Traffic Volume (Crossing Crosswalk):	1,395	1,425
Average Hourly Right-Turn Volume (Crossing Crosswalk):	168	157
Average Hourly Left-Turn Volume (Crossing Crosswalk):	142	162
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	450	488

SITE DESCRIPTION

Experiment: WALK WITH CARE Signal Indication

City: Milwaukee, Wisconsin   Site: Mason St. and Milwaukee Ave. (21)

Crosswalk: North (Milwaukee Ave.)

Number of Lanes: 4 through lanes, 2 parking lanes

Approximate Street Width: 68 feet (20 m)

Roadway Operation: Mason St., 2-way; Milwaukee Ave., 2-way

	Before	After
Cycle Length:	90	90
WALK Interval:	26	26
Clearance Interval:	13	13
DONT WALK Interval:	51	51
Average Hourly Traffic Volume (Crossing Crosswalk):	321	354
Average Hourly Right-Turn Volume (Crossing Crosswalk):	82	76
Average Hourly Left-Turn Volume (Crossing Crosswalk):	29	39
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	202	135

SITE DESCRIPTION

Experiment: WALK WITH CARE Signal Indication

City: Milwaukee, Wisconsin   Site: 16th St. and Wisconsin Ave. (22)

Crosswalk: North (16th St.)

Number of Lanes: 3 through lanes, 1 parking lane

Approximate Street Width: 46 feet (14 m)

Roadway Operation: 16th St., 1-way (northbound); Wisconsin Ave., 2-way divided

	Before	After
Cycle Length:	90	90
WALK Interval:	42	42
Clearance Interval:	10	10
DONT WALK Interval:	38	38
Average Hourly Traffic Volume (Crossing Crosswalk):	266	268
Average Hourly Right-Turn Volume (Crossing Crosswalk):	57	62
Average Hourly Left-Turn Volume (Crossing Crosswalk):	61	57
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	330	177

SITE DESCRIPTION

Experiment: Steady Versus Flashing WALK

City: Milwaukee, Wisconsin Site: Mason St. and Jefferson St. (23)

Crosswalk: South (Jefferson St.)

Number of Lanes: 4 through lanes, 2 parking lanes

Approximate Street Width: 68 feet (20 m)

Roadway Operation: Mason St., 2-way; Jefferson St., 2-way

	Before	After
Cycle Length:	90	90
WALK Interval:	36	36
Clearance Interval:	12	12
DONT WALK Interval:	42	12
Average Hourly Traffic Volume (Crossing Crosswalk):	173	155
Average Hourly Right-Turn Volume (Crossing Crosswalk):	48	28
Average Hourly Left-Turn Volume (Crossing Crosswalk):	16	27
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	134	290

SITE DESCRIPTION

Experiment: Steady Versus Flashing WALK

City: Milwaukee, Wisconsin Site: 27th St. and Wells St. (24)

Crosswalk: North (27th St.)

Number of Lanes: 4 through lanes, 1 parking lane

Approximate Street Width: 58 feet (17 m)

Roadway Operation: 27th St., 2-way; Wells St., 1-way (eastbound)

	Before	After
Cycle Length:	90	90
WALK Interval:	23	32
Clearance Interval:	12	10
DONT WALK Interval:	55	48
Average Hourly Traffic Volume (Crossing Crosswalk):	1,103	1,082
Average Hourly Right-Turn Volume (Crossing Crosswalk):	0	0
Average Hourly Left-Turn Volume (Crossing Crosswalk):	71	73
Average Hourly Pedestrian Volume (Crosswalk Where Device Was Installed):	76	83

APPENDIX K - FORMS USED IN THE COLLECTING AND REDUCTION OF DATA FOR THE ANALYSIS OF SIGN AND SIGNAL DEVICES

PEDESTRIAN BEHAVIOR DATA COLLECTION FORM

City____________________
Location____________________
Site No.__________ Reel No.__________
Crosswalk____________________
Device Tested____________________

Date Filmed_______________
Time Filmed_______________
Weather Condition_______________
Time Period_______________

W	FDW	DW

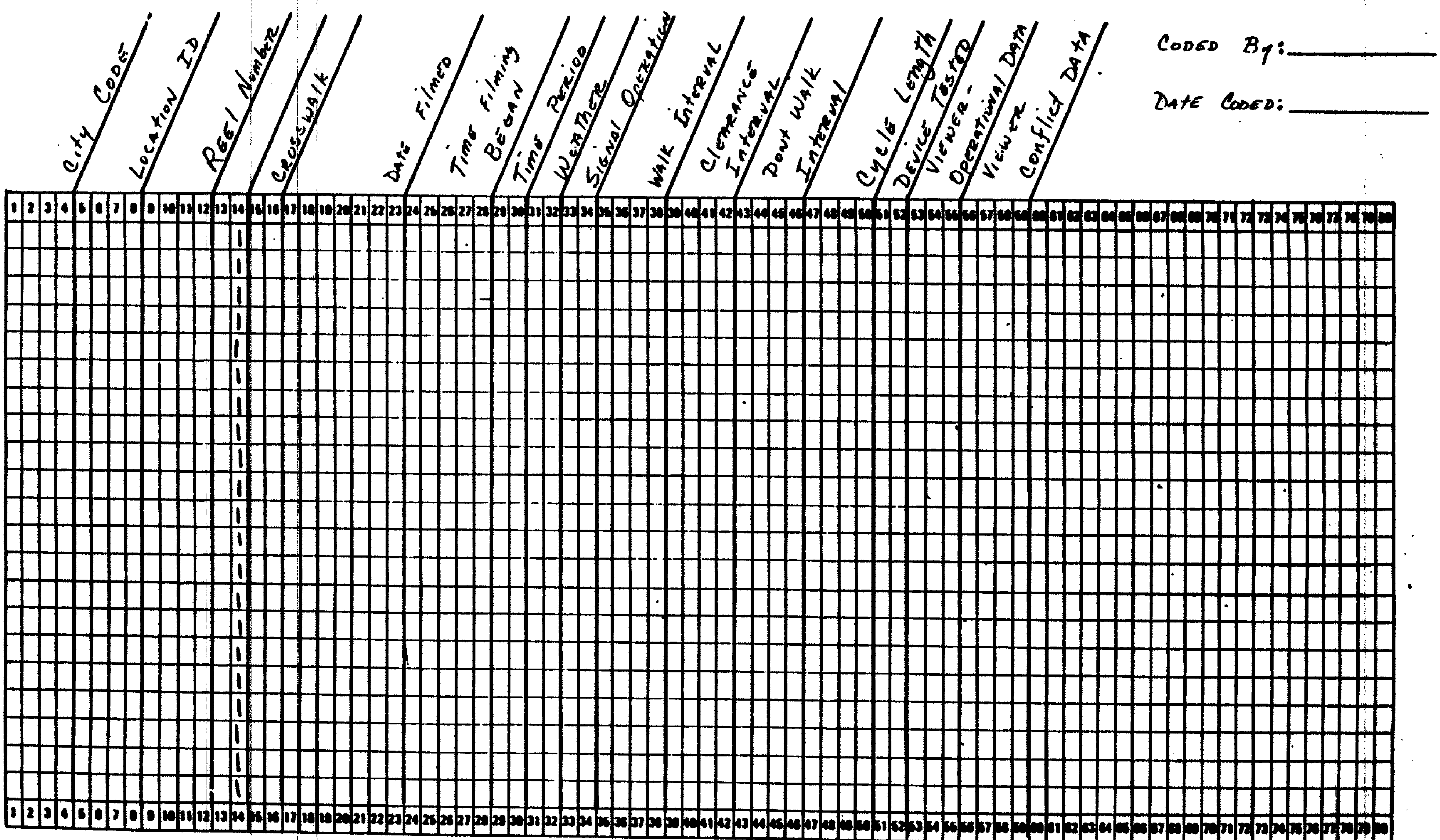
Signal Operation_______________
Walk Interval_______________
Clearance Interval_______________
DONT WALK Interval_______________
Cycle Length_______________

Date Viewed_______________
Viewed By_______________
Checked By_______________

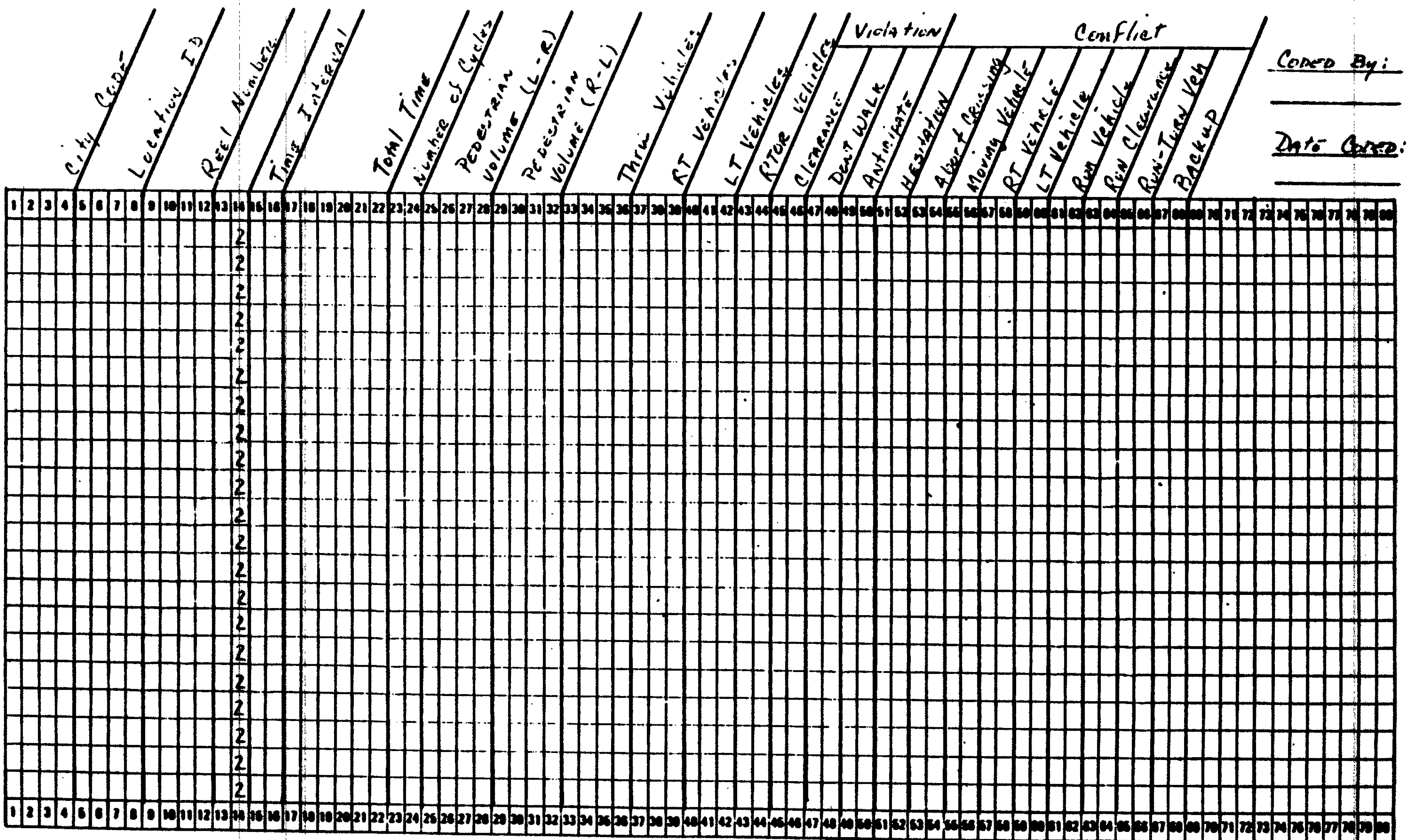
Time Interval	Time Image		Total Time	No. of Cycles	Operational Data						Compliance Measures			Behavior Measures							
					Pedestrians		Vehicles										Turning Vehicle				
	Start	End			L-R	R-L	Thru	RT	LT	RTOR	Clearance	Dont Walk	Anticipate Walk	Hesitation	Abort Crossing	Moving Vehicle	RT	LT	Run Vehicle	Run Clearance	Run Turn
1																					
2																					
3																					
4																					
5																					
6																					
7																					
Total																					

DATA COLLECTION LOG

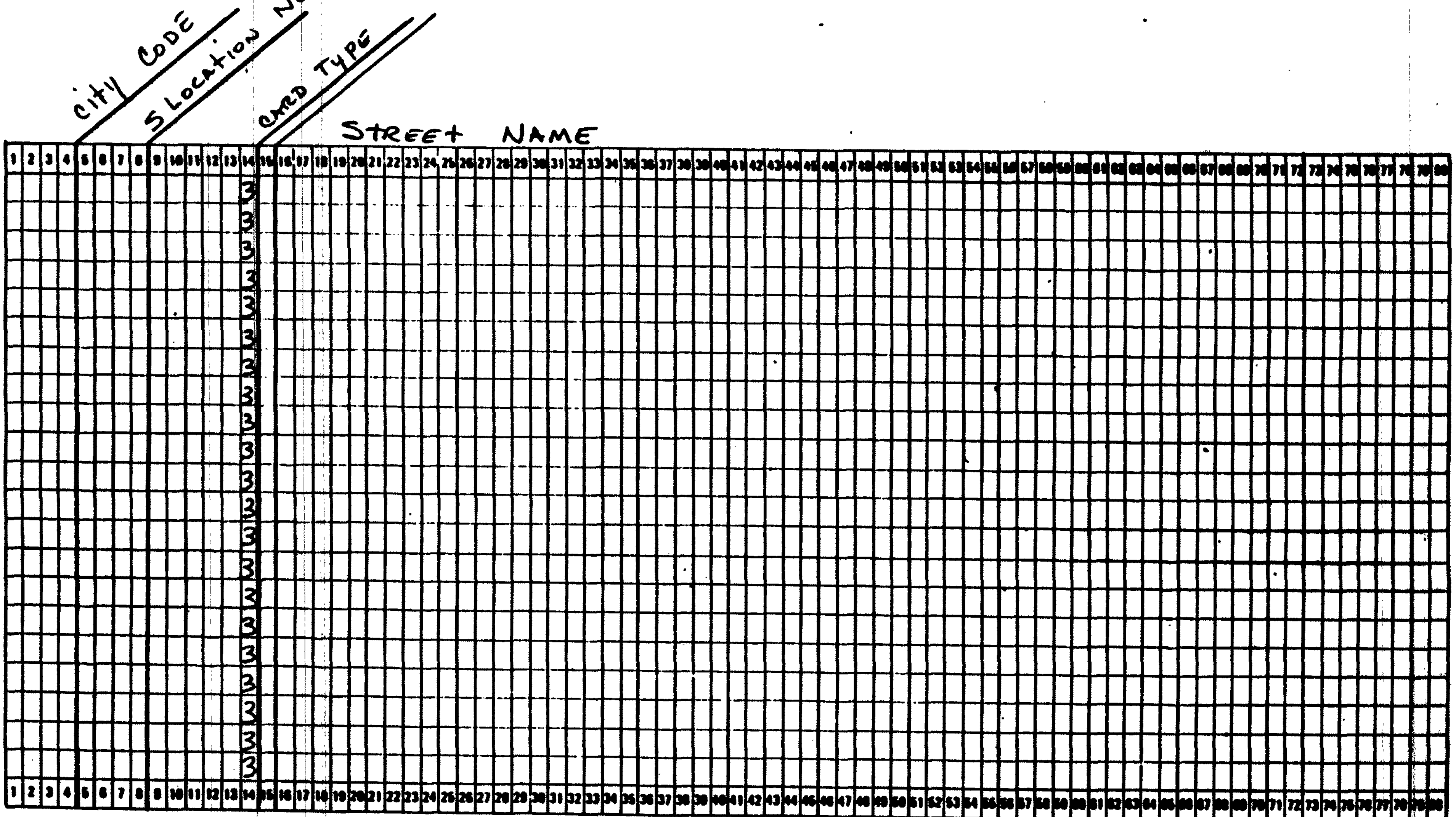
Data Collector	City	Date	Site Number	Intersection Name	Vantage Point and Crosswalk	Reel Number	Start Time	Time Period	Weather Condition	Notes



Coding form 1 - Site characteristics



Coding form 2 - Operational, conflict and violation data



Coding form 3 - Street names

APPENDIX L - DATA FILE FORMAT FOR THE ANALYSIS OF EXPERIMENTAL SIGN AND SIGNAL DEVICES

DATA FILE LAYOUT DESCRIPTION

Page 1 of 5

PROJECT: Pedestrian Signalization Alternatives Behavior Data

Item Number	Card Number	Column	Format Code	Item Description
1	1	1-4	I4	City Code (Starting in Column 2) 1 - Detroit 2 - Saginaw 3 - Milwaukee 4 - Washington, D.C. 5 - Ann Arbor
2	1	5-8	I4	Location ID Number
3	1	9-12	I4	Reel Number (Assigned to Video Tape Reel)
4	1	13-14	I2	Card Type 1
5	1	15-16	I2	Crosswalk (Leg of Intersection) 1 - North 2 - East 3 - South 4 - West
6	1	17-23	I7	Date Filmed (Collected) (Month, Day, Year)
7	1	24-28	I5	Time Filming Began (Military Time)
8	1	29-30	I2	Time Period 1 - Before 2 - After 3 - Second After Period
9	1	31-32	I2	Weather 1 - Warm/Sunny/Overcast 2 - Rain 3 - Cold 4 - Snow

DATA FILE LAYOUT DESCRIPTION

PROJECT: Pedestrian Signalization Alternatives Behavior Data

Item Number	Card Number	Column	Format Code	Item Description
10	1	33-34	I2	Signal Operation 1 - Fixed 2 - Continuously Changing (Computer Controlled) 3 - Fixed, Timing Plan Changes during Filming
11	1	35-38	F4.0	Duration of WALK interval to nearest second. 999 - variable length WALK interval
12	1	39-42	F4.0	Duration of clearance interval to nearest second. Decimal point assumed between 999 - variable length clearance interval
13	1	43-46	F4.0	Duration of DONT WALK interval to nearest second. 999 - variable length DONT WALK interval
14	1	47-50	F4.0	Cycle length (seconds) 999 - variable cycle length
15	1	51-52	I2	Device Tested: Blank - not known 1. Signal Device - DONT START 2. Signal Device - WITH CARE 3. Sign - Explaination of pedestrian symbol messages 4. Sign - Explaination of pedestrian word messages 5. Sign - Pedestrian yield sign 6. Sign - Pedestrian warning sign 7. Flashing Walk 8. Control Site 9. Not Known 10. Install Ped Signals

DATA FILE LAYOUT DESCRIPTION

PROJECT: Pedestrian Signalization Alternatives Behavior Data

Item Number	Card Number	Column	Format Code	Item Description
16	1	53-55	I3	Operation Data Viewed By: 1 - Gary Lucy 2 - Liz Luzsinski 3 - Erik Greer 4 - Mike Cynecki 5 - Marvin Burton 6 - Bill Conley
17	1	56-59	I4	Conflict Data Viewed By: 1 - Gary Lucy 2 - Liz Luzsinski 3 - Erik Greer 4 - Mike Cynecki
18	2	1-4	I4	City Code 1 - Detroit 2 - Saginaw 3 - Milwaukee 4 - Washington, D.C. 5 - Ann Arbor
19	2	5-8	I4	Location ID Number
20	2	9-12	I4	Reel Number (Assigned to Video Tape Reel)
21	2	13-14	I2	Card Type 2
22	2	15-16	I2	Time Interval
23	2	17-22	I6	Total time to nearest second
24	2	23-24	I2	Number of cycles
25	2	25-28	I4	Pedestrian volume crossing from left to right (from the perspective of the viewer)
26	2	29-32	I4	Pedestrian volume crossing from right to left (from the perspective of the viewer)

DATA FILE LAYOUT DESCRIPTION

PROJECT: Pedestrian Signalization Alternatives Behavior Data

Item Number	Card Number	Column	Format Code	Item Description
27	2	33-36	I4	Thru Vehicles - Number of vehicles driving across the crosswalk during the DONT WALK interval
28	2	37-39	I3	RT Vehicles - Number of vehicles turning right across the crosswalk during the WALK and clearance interval
29	2	40-42	I3	LT Vehicles - Number of vehicles turning left across the crosswalk during the WALK and clearance interval
30	2	43-44	I2	RTOR Vehicles - Number of vehicles making RTOR maneuvers across the crosswalk
				Number of Pedestrian Violations of Signal Messages
31	2	45-46	I2	Number of pedestrians starting to cross during the clearance interval
32	2	47-49	I3	Number of pedestrians starting to cross during the DONT WALK interval
33	2	50-51	I2	Number of pedestrians anticipating the WALK interval
				Number of Pedestrian Conflicts by Conflict Type
34	2	52-52	I2	Pedestrian Hesitation (PH)
35	2	54-55	I2	Abort Crossing (AC)
36	2	56-57	I2	Moving Vehicle (MV)
37	2	58-59	I2	Right Turning Vehicle (TV-R)
38	2	60-61	I2	Left Turning Vehicle (TV-L)
40	2	62-63	I2	Run Vehicle (RV)

DATA FILE LAYOUT DESCRIPTION

PROJECT: Pedestrian Signalization Alternatives Behavior Data

Item Number	Card Number	Column	Format Code	Item Description
41	2	64-65	I2	Run on Clearance (RC)
42	2	66-67	I2	Run due to Turning Vehicle (RTV)
43	2	68-69	I2	Backup Conflict (BC)

APPENDIX M - INSTRUCTIONS FOR THE COLLECTION OF OPERATIONAL, CONFLICT, AND VIOLATION DATA

Steps in Reducing Pedestrian Data - Operational Data

1. Select film and record the date of viewing for the reel number on the Data Reduction Progress Log.

2. Fill in the first two columns at the top of pedestrian behavior data collection form (except "Device Tested"). Determine which crosswalk is being filmed from the audio message on the tape and notes on the data collection log. Also indicate date viewed and record your initials.

3. Using the time image generator determine the length of the WALK, clearance, DONT WALK intervals and the entire cycle length. You are viewing at real time. The time image generator provides elapsed time to the 0.1 second. A cycle begins at the start of the WALK interval. A complete cycle is from the beginning of one WALK interval to the beginning of the next WALK interval.

4. Rewind the tape to the beginning of the first cycle where the time image generator is running and begin collecting operational data. A time interval corresponds to a duration of approximately 10 minutes (rounded off to the nearest complete cycle). Never begin or end a time interval in the middle of a cycle. For fixed-time cycle lengths, the conversion of cycle lengths to time intervals should be as follows:

Cycle Length (seconds)	Number of Cycles	Total Time (minutes/seconds)
50	12	10:00/600
55	11	10:05/605
60	10	10:00/600
65	9	9:45/585
70	9	10:30/630
75	8	10:00/600
80	8	10:40/640
85	7	9:55/595
90	7	10:30/630
95	6	9:30/570
100	6	10:00/600
110	6	11:00/660
120	5	10:00/600

For actuated signals and locations without fixed cycle lengths you must keep track of the time and number of cycles per 10 minute intervals (600 seconds). In addition, the cycle length may also change during the day at locations with a fixed cycle length.

5. Record start time, end time, and total duration of each time interval to the nearest 0.1 second.

6. Count pedestrian and vehicle movements continuously for each time interval using the counters. Record the totals for each interval on the data form. The movements are defined as follows:

   - Operational Data

     -Pedestrian Crossing Left to Right (looking at the intersection from the perspective of teh camera): All pedestrians on that leg within 1 (one) car length, approximately 20 feet (6 m), of the crosswalk shall be counted. If a bicyclist crosses in the manner of a pedestrian, it shold be counted as a pedestrian. If any unusual occurance is viewed, put an astrick in the box and make a note of the occurance elsewhere on the form.

     -Pedestrian Crossing Right to Left (looking at the intersection from the perspective of the camera): Same as above.

     -Thru Vehicle Movements: All vehicles crossing the crosswalk during the DONT WALK interval (both directions and all turning vehicles are counted). Put an astrick in the box for each thru vehicle which violates the traffic signal during the interval.

     -Right Turn Vehicle Movements: All vehicles turning right across the crosswalk during the WALK and clearance intervals.

     -Left Turn Vehicle Movements: All vehicles turning left across the crosswalk during the WALK and clearance intervals.

     -RTOR Vehicle Movements: All vehicles making right-turn-on-red movements across the crosswalk during the WALK or clearance interval.

7. Rewind film and return video tape to the shelf numerically by reel number. Return coded form to your supervisor.

Collecting Pedestrian Violation and Conflict Data

1. Obtain reel and corresponding pedestrian behavior data collection form with the top portion of the form and the operational data already completed. Record the data viewed for the reel number on the Data Reduction Progress Log.

2. Record date viewed and your initials on the Pedestrian Data Collection Form.

3. Begin collecting data for the time intervals and start/end time images used for the operational data. Make sure you are recording data for the same crosswalk.

4. Record the total number of each event for each interval on the data collection form. If no event of a particular type occured, record a zero in that box. Do not leave any boxes blank. If a time interval was not used or a data item was not collected, draw a line thru the box.

5. The definition for each of the data items are:

- Violations

  -Cross on Clearance: The pedestrian begins crossing while the pedestrian signal displays a flashing DONT WALK or other clearance message.

  -Cross on DONT WALK: The pedestrian begins crossing while the pedestrian signal is displaying a DONT WALK or other prohibitive crossing message (i.e. the thru vehicular traffic has the right-of-way).

  -Anticipate Walk: The pedestrian begins crossing just prior to the WALK message, while the pedestrian signal is displaying a DONT WALK message. This is a judgement observation based on the pedestrian anticipating the walk and not totally ignoring the pedestrian/vehicle signal.

- Conflicts

  -Pedestrian Hesitation Movement (PH): Pedestrian momentarily reverses his or her direction of travel in the traffic lane or the pedestrian hesitates in response to a vehicle in a traffic lane during the WALK or clearance intervals.

  -Aborted Crossing (AC): Pedestrian steps off curb during WALK interval, but at the onset of the clearance interval the pedestrian reverses his direction back to the curb.

  -Moving Vehicle (MV): Through traffic is moving through the crosswalk while a pedestrian is in a traffic lane during the DONT WALK interval (prohibited crossing). This conflict type may also occur during the WALK and clearance intervals under certain circumstances.

-Turning Vehicle (RT) and (LT): Pedestrian is in the path and within 20 feet (6 m) downstream of a turning vehicle. This conflict is recorded separately for right turn vehicles and left turn vehicles (defined previously) during the WALK or clearance intervals.

-Running Vehicle Hazard Conflict (RV): Pedestrian runs in a traffic lane in an effort to avoid a possible collision with a thru vehicle during the DONT WALK (prohibited crossing) interval. This conflict type may also occur during the WALK and clearance intervals under certain circumstances.

-Run on Clearance (RC): Pedestrian runs during the clearance interval in response to the signal message.

-Running Turning Vehicle (RTV): Pedestrian runs in a traffic lane in response to a turning vehicle or turning vehicle potential during the WALK or clearance interval.

- Multiple Conflicts

When counting events, a pedestrian violations can be counted for each pedestrian only once per crossing. For this study only one conflict can be counted for a pedestrian or vehicle. Therefore, if a particular pedestrian is involved in 2 or 3 conlficts, record the most severe conflict. If several pedestrians, crossing as a group are involved in a conflict with a vehicle then only one conflict shall be counted. Similarly if a pedestrian is involved in conflicts with several cars, count only one conflict (the most severe type). Plese note that both a violation event and a conflict can be counted for a pedestrian.

APPENDIX N - Z-TEST OF PROPORTION RESULTS FOR SIGN AND SIGNAL TEST SITES

EXPERIMENT: Pedestrian Signal Explanation Sign (Symbolic)

SITE: Saginaw, Michigan - Court St. and Michigan Ave. (1)

Violations	Frequency Before	Frequency After	Percent Before	Percent After	Z-Value
CL	56	68	7.6	8.6	-0.74
DW	29	36	3.9	4.6	-
AW	31	18	4.2	2.3	-
Total	116	122	15.7	15.5	0.13
Conflicts					
PH	14	16	1.9	2.0	-
AC	8	6	1.1	0.8	-
MV	17	4	2.3	0.5	-
RT	124	151	16.8	19.2	-1.20
LT	31	41	4.2	5.2	-0.92
RV	7	6	0.9	0.8	-
RC	12	13	1.6	1.7	-
RTV	9	0	1.2	0.0	-
THRU	58	45	7.9	5.7	1.67
TURN	164	192	22.3	24.4	-0.99
Total	222	237	30.1	30.1	0.00
Pedestrian Volume	737	787			

EXPERIMENT: Pedestrian Signal Explanation Sign (Symbolic)

SITE: Saginaw, Michigan - Court St. and Hamilton St. (2)

Violations	Frequency Before	Frequency After	Percent Before	Percent After	Z-Value
CL	30	39	8.5	6.4	1.21
DW	17	36	4.8	6.0	-
AW	13	16	3.7	2.6	-
Total	60	91	17.1	15.0	0.84
Conflicts					
PH	9	11	2.6	1.8	-
AC	9	0	2.6	0.0	-
MV	7	3	2.0	0.5	-
RT	61	111	17.4	18.3	-0.38
LT	36	59	10.0	9.8	0.11
RV	2	7	0.6	1.2	-
RC	10	15	2.8	2.5	-
RTV	1	0	0.3	0.0	-
THRU	37	36	10.5	6.0	2.58
TURN	97	170	27.6	28.1	-0.15
Total	134	206	38.2	34.0	1.28
Pedestrian Volume	351	605			

Legend

Violations

CL = Pedestrians starting during clearance interval
DW = Pedestrians starting during DONT WALK interval
AW = Pedestrians anticipating WALK interval

Conflicts

PH = Pedestrian hesitation
AC = Aborted crossing
MV = Moving vehicle conflict
RT = Right-turn vehicle conflict
LT = Left-turn vehicle conflict
RV = Pedestrian runs to avoid vehicle
RC = Run on clearance
RTV = Run-turning conflict
THRU = Total clearance (through vehicle) conflicts
TURN = Total turning conflicts

Z-Value

\- = Insufficient sample size
NA = Not applicable

EXPERIMENT: Pedestrian Signal Explanation Sign (Symbolic)

SITE: Saginaw, Michigan - Court St. and Michigan Ave. (1)
Court St. and Hamilton Ave. (2)

	Frequency		Percent		
Violations	Before	After	Before	After	Z-Value
CL	86	107	7.9	7.7	0.20
DW	46	72	4.2	5.2	-1.10
AW	44	34	4.0	2.4	2.27
Total	176	213	16.2	15.3	0.59
Conflicts					
PH	23	27	2.1	1.9	-
AC	17	6	1.6	0.4	-
MV	24	7	2.2	0.5	-
RT	185	262	17.0	18.8	-1.17
LT	66	100	6.1	7.2	-1.11
RV	9	13	0.8	0.9	-
RC	22	28	2.0	2.0	-
RTV	10	0	0.9	0.0	-
THRU	95	81	8.7	5.8	2.80
TURN	261	362	24.0	26.0	-1.15
Total	356	443	32.7	31.8	0.47
Pedestrian Volume	1,088	1,392			

Legend

Violations

CL = Pedestrians starting during clearance interval
DW = Pedestrians starting during DONT WALK interval
AW = Pedestrians anticipating WALK interval

Conflicts

PH = Pedestrian hesitation
AC = Aborted crossing
MV = Moving vehicle conflict
RT = Right-turn vehicle conflict
LT = Left-turn vehicle conflict
RV = Pedestrian runs to avoid vehicle
RC = Run on clearance
RTV = Run-turning conflict
THRU = Total clearance (through vehicle) conflicts
TURN = Total turning conflicts

Z-Value

\- = Insufficient sample size
NA = Not applicable

EXPERIMENT: Pedestrian Signal Explanation Sign (Word)

SITE: Washington, D.C. - 17th and L St., N.W. (3)

	Frequency		Percent		
Violations	**Before**	**After**	**Before**	**After**	**Z-Value**
CL	308	306	11.6	9.2	3.13
DW	183	186	6.9	5.6	2.15
AW	407	148	15.4	4.4	14.50
Total	898	640	33.9	19.1	12.90
Conflicts					
PH	77	68	2.9	2.0	2.18
AC	20	6	0.8	0.2	-
MV	49	56	1.8	1.7	0.61
RT	317	326	12.0	9.7	2.79
LT	←		NA		→
RV	22	12	0.8	0.4	-
RC	55	45	2.1	1.3	2.19
RTV	9	8	0.3	0.2	-
THRU	223	187	8.4	5.6	4.30
TURN	326	333	12.3	10.0	2.88
Total	549	520	20.7	15.6	5.10
Pedestrian Volume	2,660	3,343			

EXPERIMENT: Pedestrian Signal Explanation Sign (Word)

SITE: Washington, D.C. - 18th St. and L St., N.W. (4)

	Frequency		Percent		
Violations	**Before**	**After**	**Before**	**After**	**Z-Value**
CL	636	648	10.3	14.0	-5.92
DW	2,129	1,159	34.4	25.0	10.47
AW	262	317	4.2	6.8	-5.98
Total	3,027	2,124	48.9	45.9	3.11
Conflicts					
PH	94	97	1.5	2.1	-2.25
AC	14	6	0.2	0.1	-
MV	52	82	0.8	1.8	-4.33
RT	←		NA		→
LT	340	187	5.5	4.0	3.47
RV	38	50	0.6	1.1	-2.67
RC	47	31	0.8	0.7	0.56
RTV	21	15	0.3	0.3	-
THRU	245	266	4.0	5.7	-4.34
TURN	361	202	5.8	4.4	3.40
Total	606	468	9.8	10.1	-0.55
Pedestrian Volume	6,188	4,628			

Legend

Violations

CL = Pedestrians starting during clearance interval
DW = Pedestrians starting during DONT WALK interval
AW = Pedestrians anticipating WALK interval

Conflicts

PH = Pedestrian hesitation
AC = Aborted crossing
MV = Moving vehicle conflict
RT = Right-turn vehicle conflict
LT = Left-turn vehicle conflict
RV = Pedestrian runs to avoid vehicle
RC = Run on clearance
RTV = Run-turning conflict
THRU = Total clearance (through vehicle) conflicts
TURN = Total turning conflicts

Z-Value

\- = Insufficient sample size
NA = Not applicable

EXPERIMENT: Pedestrian Signal Explanation Sign (Word)

SITE: Washington, D.C. - 17th St. and L St., N.W. (3)
18th St. and L St., N.W. (4)

	Frequency		Percent		
Violations	**Before**	**After**	**Before**	**After**	**Z-Value**
CL	944	954	10.7	12.0	-2.63
DW	2,312	1,345	26.2	16.9	14.57
AW	669	465	7.6	5.8	4.48
Total	3,925	2,764	44.4	34.7	12.88
Conflicts					
PH	171	165	1.9	2.1	-0.63
AC	34	12	0.4	0.2	-
MV	101	138	1.1	1.7	-3.22
RT*	317	325	3.6	4.1	-1.66
LT**	340	187	3.8	2.3	5.58
RV	60	62	0.7	0.8	-0.75
RC	102	76	1.2	1.0	1.27
RTV	30	23	0.3	0.3	-
THRU	468	453	5.3	5.7	-1.10
TURN	687	535	7.8	6.7	2.65
Total	1,155	988	13.1	12.4	1.31
Pedestrian Volume	8,838	7,971			

*Data for 17th St. and L St. N.W. (3) only.
**Data for 18th St. and L St. N.W. (4) only.

Legend

Violations

CL = Pedestrians starting during clearance interval
DW = Pedestrians starting during DONT WALK interval
AW = Pedestrians anticipating WALK interval

Conflicts

PH = Pedestrian hesitation
AC = Aborted crossing
MV = Moving vehicle conflict
RT = Right-turn vehicle conflict
LT = Left-turn vehicle conflict
RV = Pedestrian runs to avoid vehicle
RC = Run on clearance
RTV = Run-turning conflict
THRU = Total clearance (through vehicle) conflicts
TURN = Total turning conflicts

Z-Value

\- = Insufficient sample size
NA = Not applicable

EXPERIMENT: DONT START Signal Indication

SITE: Ann Arbor, Michigan - S. State St. and Washington St. (5)

	Frequency		Percent		
Violations	**Before**	**After**	**Before**	**After**	**Z-Value**
CL	138	170	14.5	11.2	2.40
DW	310	658	32.6	43.5	-5.38
AW	68	61	7.2	4.0	3.39
Total	516	889	54.3	58.8	-2.19
Conflicts					
PH	44	100	4.6	6.6	-2.04
AC	9	6	0.9	0.4	-
MV	46	48	4.8	3.2	2.10
RT	51	65	5.4	4.3	1.22
LT	107	165	11.3	10.9	0.27
RV	4	27	0.4	1.8	-
RC	15	21	1.6	1.4	-
RTV	3	17	0.3	1.1	-
THRU	118	202	12.4	13.4	-0.67
TURN	161	247	16.9	16.3	0.40
Total	279	449	29.4	29.7	-0.17
Pedestrian Volume	950	1,512			

EXPERIMENT: DONT START Signal Indication

SITE: Washington, D.C. - 20th St. and L St., N.W. (6)

	Frequency		Percent		
Violations	**Before**	**After**	**Before**	**After**	**Z-Value**
CL	429	178	13.0	6.7	7.90
DW	207	283	6.3	10.7	-6.20
AW	119	33	3.6	1.2	5.71
Total	755	494	22.8	18.7	3.90
Conflicts					
PH	31	75	0.9	2.8	-5.50
AC	5	1	0.2	0.0	-
MV	11	12	0.3	0.5	-
RT	517	191	15.6	7.2	9.95
LT	←		NA		→
RV	19	7	0.6	0.3	-
RC	44	41	1.3	1.5	-0.71
RTV	13	18	0.4	0.7	-
THRU	110	136	3.3	5.1	-3.50
TURN	530	209	16.0	7.9	9.44
Total	640	345	19.3	13.0	6.50
Pedestrian Volume	3,310	2,646			

Legend

Violations

CL = Pedestrians starting during clearance interval
DW = Pedestrians starting during DONT WALK interval
AW = Pedestrians anticipating WALK interval

Conflicts

PH = Pedestrian hesitation
AC = Aborted crossing
MV = Moving vehicle conflict
RT = Right-turn vehicle conflict
LT = Left-turn vehicle conflict
RV = Pedestrian runs to avoid vehicle
RC = Run on clearance
RTV = Run-turning conflict
THRU = Total clearance (through vehicle) conflicts
TURN = Total turning conflicts

Z-Value

\- = Insufficient sample size
NA = Not applicable

EXPERIMENT: DONT START Signal Indication

SITE: Milwaukee, Wisconsin - Broadway and Mason St. (7)

	Frequency		Percent		
Violations	Before	After	Before	After	Z-Value
CL	157	66	13.8	5.7	6.58
DW	153	100	13.4	8.6	3.71
AW	96	32	8.4	2.8	5.94
Total	406	198	35.7	17.0	10.16
Conflicts					
PH	42	23	3.7	2.0	-
AC	4	1	0.4	0.1	-
MV	29	18	2.5	1.5	-
RT	90	120	7.9	10.3	-2.01
LT	123	119	10.8	10.2	0.44
RV	8	1	0.7	0.1	-
RC	45	10	4.0	0.9	-
RTV	11	3	1.0	0.3	-
THRU	128	53	11.2	4.6	5.95
TURN	224	242	19.7	20.8	-0.68
Total	352	295	30.9	25.4	2.96
Pedestrian Volume	1,138	1,162			

EXPERIMENT: DONT START Signal Indication

SITE: Milwaukee, Wisconsin - Mason St. and Jackson St. (8)

	Frequency		Percent		
Violations	Before	After	Before	After	Z-Value
CL	64	57	8.7	4.6	3.66
DW	276	216	37.7	17.6	9.96
AW	32	74	4.4	6.0	-1.56
Total	372	347	50.8	28.2	10.05
Conflicts					
PH	13	10	1.8	0.8	-
AC	1	0	0.1	0.0	-
MV	13	8	1.8	0.7	-
RT	←		NA		→
LT	←		NA		→
RV	0	1	0.0	0.1	-
RC	12	17	1.6	1.4	-
RTV	←		NA		→
THRU	39	36	5.3	2.9	2.68
TURN	←		NA		→
Total	39	36	5.3	2.9	2.68
Pedestrian Volume	732	1,230			

Legend

Violations

CL = Pedestrians starting during clearance interval
DW = Pedestrians starting during DONT WALK interval
AW = Pedestrians anticipating WALK interval

Conflicts

PH = Pedestrian hesitation
AC = Aborted crossing
MV = Moving vehicle conflict
RT = Right-turn vehicle conflict
LT = Left-turn vehicle conflict
RV = Pedestrian runs to avoid vehicle
RC = Run on clearance
RTV = Run-turning conflict
THRU = Total clearance (through vehicle) conflicts
TURN = Total turning conflicts

Z-Value

\- = Insufficient sample size
NA = Not applicable

EXPERIMENT: DONT START Signal Indication

SITE: Milwaukee, Wisconsin - Broadway and Mason St. (7)
Mason St. and Jackson St. (8)

	Frequency		Percent		
Violations	Before	After	Before	After	Z-Value
CL	221	123	11.8	5.1	7.94
DW	429	316	22.9	13.2	8.30
AW	128	106	6.8	4.4	3.43
Total	778	545	41.6	22.8	13.18
Conflicts					
PH	55	33	2.9	1.4	3.56
AC	5	1	0.3	0.0	-
MV	42	26	2.2	1.1	-
RT	90	120	4.8	5.0	-0.31
LT	123	119	6.6	5.0	2.24
RV	8	2	0.4	0.1	-
RC	57	27	3.0	1.1	-
RTV*	11	3	0.6	0.1	-
THRU	167	89	8.9	3.7	7.10
TURN	224	242	12.0	10.1	1.93
Total	391	331	20.9	13.8	6.11
Pedestrian Volume	1,870	2,392			

*Data for Broadway and Mason St. (7) only.

Legend

Violations

CL = Pedestrians starting during clearance interval
DW = Pedestrians starting during DONT WALK interval
AW = Pedestrians anticipating WALK interval

Conflicts

PH = Pedestrian hesitation
AC = Aborted crossing
MV = Moving vehicle conflict
RT = Right-turn vehicle conflict
LT = Left-turn vehicle conflict
RV = Pedestrian runs to avoid vehicle
RC = Run on clearance
RTV = Run-turning conflict
THRU = Total clearance (through vehicle) conflicts
TURN = Total turning conflicts

Z-Value

\- = Insufficient sample size
NA = Not applicable

EXPERIMENT: Steady Versus Flashing WALK and DONT WALK

SITE: Washington, D.C. - 30th St. and M St., N.W. (9)

Violations	Frequency Before	Frequency After	Percent Before	Percent After	Z-Value
CL	←		NA		→
DW	←		NA		→
AW	75	28	3.6	1.6	-
Total	542	348	26.1	20.1	4.39
Conflicts					
PH	68	43	3.3	2.5	1.45
AC	6	2	0.3	0.1	-
MV	17	10	0.8	0.6	-
RT	129	76	6.2	4.4	2.49
LT	91	70	4.4	4.0	0.53
RV	6	0	0.3	0.0	-
RC	0	20	0.0	1.2	-
RTV	4	6	0.2	0.3	-
THRU	97	75	4.7	4.3	0.51
TURN	224	152	10.8	8.8	2.09
Total	321	227	15.5	13.1	2.08
Pedestrian Volume	2,076	1,734			

EXPERIMENT: Steady Versus Flashing WALK and DONT WALK

SITE: Washington, D.C. - 7th St. and D St. (10)

Violations	Frequency Before	Frequency After	Percent Before	Percent After	Z-Value
CL	←		NA		→
DW	←		NA		→
AW	110	115	9.0	4.0	6.30
Total	428	993	34.9	34.9	-0.03
Conflicts					
PH	30	83	2.4	2.9	-0.85
AC	1	8	0.1	0.3	-
MV	24	34	2.0	1.2	-
RT	98	146	8.0	5.1	3.52
LT	51	92	4.2	3.2	1.46
RV	10	11	0.8	0.4	-
RC	0	84	0.0	3.0	-
RTV	8	19	0.7	0.7	-
THRU	65	220	5.3	7.7	-2.80
TURN	157	257	12.8	9.0	3.64
Total	222	477	18.1	16.8	1.02
Pedestrian Volume	1,228	2,846			

Legend

Violations

CL = Pedestrians starting during clearance interval
DW = Pedestrians starting during DONT WALK interval
AW = Pedestrians anticipating WALK interval

Conflicts

PH = Pedestrian hesitation
AC = Aborted crossing
MV = Moving vehicle conflict
RT = Right-turn vehicle conflict
LT = Left-turn vehicle conflict
RV = Pedestrian runs to avoid vehicle
RC = Run on clearance
RTV = Run-turning conflict
THRU = Total clearance (through vehicle) conflicts
TURN = Total turning conflicts

Z-Value

\- = Insufficient sample size
NA = Not applicable

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EXPERIMENT: Steady Versus Flashing WALK and DONT WALK

SITE: Washington, D.C. - 30th St. and M St. (9)
7th St. and D St. (10)

Violations	Frequency Before	Frequency After	Percent Before	Percent After	Z-Value
CL	←		NA	→	
DW	←		NA	→	
AW	185	143	5.6	3.1	5.43
Total	970	1,341	29.4	29.3	0.07
Conflicts					
PH	98	126	3.0	2.8	0.57
AC	7	10	0.2	0.2	-
MV	41	44	1.2	1.0	1.19
RT	227	222	6.9	4.8	3.82
LT	142	162	4.3	3.5	1.73
RV	16	11	0.5	0.2	-
RC	0	104	0.0	2.3	-
RTV	12	25	0.4	0.5	-
THRU	162	295	4.9	6.4	-2.89
TURN	381	409	11.5	8.9	3.79
Total	543	704	16.4	15.4	1.27
Pedestrian Volume	3,304	4,579			

Legend

Violations

CL = Pedestrians starting during clearance interval
DW = Pedestrians starting during DONT WALK interval
AW = Pedestrians anticipating WALK interval

Conflicts

PH = Pedestrian hesitation
AC = Aborted crossing
MV = Moving vehicle conflict
RT = Right-turn vehicle conflict
LT = Left-turn vehicle conflict
RV = Pedestrian runs to avoid vehicle
RC = Run on clearance
RTV = Run-turning conflict
THRU = Total clearance (through vehicle) conflicts
TURN = Total turning conflicts

Z-Value

\- = Insufficient sample size
NA = Not applicable

EXPERIMENT: YIELD TO PEDESTRIANS WHEN TURNING Sign

SITE: Detroit, Michigan - Cass Ave. and Lafayette St. (11)

	Frequency		Percent		
Violations	Before	After	Before	After	Z-Value
CL	←		NA		→
DW	←		NA		→
AW	←		NA		→
Total	←		NA		→
Conflicts					
PH	17	6	2.1	0.5	-
AC	3	2	0.4	0.2	-
MV	6	0	0.7	0.0	NA
RT	142	101	17.4	8.9	5.64
LT	20	13	2.4	1.1	-
RV	1	3	0.1	0.3	NA
RC	6	5	0.7	0.4	NA
RTV	9	1	1.1	0.1	-
THRU	33	16	4.0	1.4	-
TURN	171	115	20.9	10.1	6.70
Total	204	131	25.0	11.5	7.82
Pedestrian Volume	817	1,141			

EXPERIMENT: YIELD TO PEDESTRIANS WHEN TURNING Sign

SITE: Detroit, Michigan - Woodward Ave. and Grand Blvd. (12)

	Frequency		Percent		
Violations	Before	After	Before	After	Z-Value
CL	←		NA		→
DW	←		NA		→
AW	←		NA		→
Total	←		NA		→
Conflicts					
PH	15	20	1.2	1.1	-
AC	0	3	0.0	0.2	-
MV	5	13	0.4	0.7	NA
RT	273	313	21.9	17.5	3.00
LT	←		NA		→
RV	6	5	0.5	0.3	NA
RC	24	46	1.9	2.6	NA
RTV	2	30	0.2	1.7	-
THRU	50	87	4.0	4.9	-1.12
TURN	275	343	22.1	19.2	1.92
Total	325	430	26.1	24.1	1.25
Pedestrian Volume	1,246	1,785			

Legend

Violations

CL = Pedestrians starting during clearance interval
DW = Pedestrians starting during DONT WALK interval
AW = Pedestrians anticipating WALK interval

Conflicts

PH = Pedestrian hesitation
AC = Aborted crossing
MV = Moving vehicle conflict
RT = Right-turn vehicle conflict
LT = Left-turn vehicle conflict
RV = Pedestrian runs to avoid vehicle
RC = Run on clearance
RTV = Run-turning conflict
THRU = Total clearance (through vehicle) conflicts
TURN = Total turning conflicts

Z-Value

\- = Insufficient sample size
NA = Not applicable

EXPERIMENT: YIELD TO PEDESTRIANS WHEN TURNING Sign

SITE: Detroit, Michigan - Cass Ave. and Lafayette St. (11)
Woodward Ave. and Grand Blvd. (12)

	Frequency		Percent		
Violations	**Before**	**After**	**Before**	**After**	**Z-Value**
CL	← NA →				
DW	← NA →				
AW	← NA →				
Total	← NA →				
Conflicts					
PH	32	26	1.6	0.9	-
AC	3	5	0.1	0.2	-
MV	11	13	0.5	0.4	NA
RT	415	414	20.1	14.1	5.58
LT*	20	13	1.0	0.4	-
RV	7	8	0.3	0.3	NA
RC	30	51	1.5	1.7	NA
RTV	11	31	0.5	1.1	-
THRU	83	103	4.0	3.5	0.92
TURN	446	458	21.6	15.7	5.39
Total	529	561	25.6	19.2	5.45
Pedestrian Volume	2,063	2,926			

Legend

Violations

CL = Pedestrians starting during clearance interval
DW = Pedestrians starting during DONT WALK interval
AW = Pedestrians anticipating WALK interval

Conflicts

PH = Pedestrian hesitation
AC = Aborted crossing
MV = Moving vehicle conflict
RT = Right-turn vehicle conflict
LT = Left-turn vehicle conflict
RV = Pedestrian runs to avoid vehicle
RC = Run on clearance
RTV = Run-turning conflict
THRU = Total clearance (through vehicle) conflicts
TURN = Total turning conflicts

Z-Value

\- = Insufficiant sample size
NA = Not applicable

EXPERIMENT: YIELD TO PEDESTRIANS WHEN TURNING Sign

SITE: Milwaukee, Wisconsin - 27th St. and Wisconsin Ave. (13)

	Frequency		Percent		
Violations	**Before**	**After**	**Before**	**After**	**Z-Value**
CL	←	←	NA	→	→
DW	←	←	NA	→	→
AW	←	←	NA	→	→
Total	←	←	NA	→	→
Conflicts					
PH	4	6	0.6	0.9	-
AC	2	0	0.3	0.0	-
MV	1	3	0.1	0.5	NA
RT	76	53	10.7	8.1	1.64
LT	14	7	2.0	1.1	-
RV	5	1	0.7	0.2	NA
RC	12	10	1.7	1.5	NA
RTV	6	2	0.8	0.3	-
THRU	24	20	3.4	3.1	-
TURN	96	62	13.5	9.5	2.33
Total	120	82	16.9	12.5	2.27
Pedestrian Volume	710	654			

EXPERIMENT: YIELD TO PEDESTRIANS WHEN TURNING Sign

SITE: Milwaukee, Wisconsin - Michigan Ave. and Broadway (14)

	Frequency		Percent		
Violations	**Before**	**After**	**Before**	**After**	**Z-Value**
CL	←	←	NA	→	→
DW	←	←	NA	→	→
AW	←	←	NA	→	→
Total	←	←	NA	→	→
Conflicts					
PH	9	7	1.5	0.6	-
AC	0	0	0.0	0.0	-
MV	14	10	2.4	0.8	NA
RT	39	56	6.6	4.6	1.82
LT	28	43	4.7	3.5	-
RV	9	1	1.5	0.1	NA
RC	9	11	1.5	0.9	NA
RTV	5	3	0.8	0.2	-
THRU	41	29	6.9	2.4	-
TURN	72	102	12.2	8.3	2.62
Total	113	131	19.1	10.7	4.94
Pedestrian Volume	592	1,228			

Legend

Violations

CL = Pedestrians starting during clearance interval
DW = Pedestrians starting during DONT WALK interval
AW = Pedestrians anticipating WALK interval

Conflicts

PH = Pedestrian hesitation
AC = Aborted crossing
MV = Moving vehicle conflict
RT = Right-turn vehicle conflict
LT = Left-turn vehicle conflict
RV = Pedestrian runs to avoid vehicle
RC = Run on clearance
RTV = Run-turning conflict
THRU = Total clearance (through vehicle) conflicts
TURN = Total turning conflicts

Z-Value

\- = Insufficient sample size
NA = Not applicable

EXPERIMENT: YIELD TO PEDESTRIANS WHEN TURNING Sign

SITE: Milwaukee, Wisconsin - 27th St. and Wisconsin Ave. (13)
Michigan Ave. and Broadway (14)

	Frequency		Percent		
Violations	**Before**	**After**	**Before**	**After**	**Z-Value**
CL	←		NA		→
DW	←		NA		→
AW	←		NA		→
Total	←		NA		→
Conflicts					
PH	13	13	1.0	0.7	-
AC	2	0	0.2	0.0	-
MV	15	13	1.2	0.7	NA
RT	115	109	8.8	5.8	3.30
LT	42	50	3.2	2.7	0.94
RV	14	2	1.1	0.1	NA
RC	21	21	1.6	1.1	NA
RTV	11	5	0.8	0.3	-
THRU	65	49	5.0	2.6	3.57
TURN	168	164	12.9	8.7	3.80
Total	233	213	17.9	11.3	5.26
Pedestrian Volume	1,302	1,882			

Legend

Violations

CL = Pedestrians starting during clearance interval
DW = Pedestrians starting during DONT WALK interval
AW = Pedestrians anticipating WALK interval

Conflicts

PH = Pedestrian hesitation
AC = Aborted crossing
MV = Moving vehicle conflict
RT = Right-turn vehicle conflict
LT = Left-turn vehicle conflict
RV = Pedestrian runs to avoid vehicle
RC = Run on clearance
RTV = Run-turning conflict
THRU = Total clearance (through vehicle) conflicts
TURN = Total turning conflicts

Z-Value

\- = Insufficient sample size
NA = Not applicable

EXPERIMENT: PEDESTRIANS WATCH FOR TURNING VEHICLES Sign

SITE: Detroit, Michigan - Griswald St. and Larned St. (15)

	Frequency		Percent		
Violations	**Before**	**After**	**Before**	**After**	**Z-Value**
CL	←		NA		→
DW	←		NA		→
AW	←		NA		→
Total	←		NA		→
Conflicts					
PH	5	12	1.1	0.8	-
AC	1	0	0.2	0.0	-
MV	3	3	0.6	0.2	NA
RT	35	51	7.5	3.5	3.61
LT			NA		
RV	1	3	0.2	0.2	NA
RC	9	12	1.9	0.8	NA
RTV	2	1	0.4	0.1	-
THRU	19	30	4.1	2.1	-
TURN	37	52	8.0	3.6	3.87
Total	56	82	12.0	5.7	4.61
Pedestrian Volume	465	1,444			

EXPERIMENT: PEDESTRIANS WATCH FOR TURNING VEHICLES Sign

SITE: Detroit, Michigan - Cass Ave. and Warren Ave. (16)

	Frequency		Percent		
Violations	**Before**	**After**	**Before**	**After**	**Z-Value**
CL	←		NA		→
DW	←		NA		→
AW	←		NA		→
Total	←		NA		→
Conflicts					
PH	41	24	2.0	2.5	-
AC	3	2	0.1	0.2	-
MV	27	17	1.3	1.8	NA
RT	401	144	19.8	15.0	3.17
LT	0	2	0.0	0.2	-
RV	9	15	0.4	1.6	NA
RC	28	20	1.4	2.1	NA
RTV	30	4	1.5	0.4	-
THRU	108	78	5.3	8.1	-2.95
TURN	421	150	21.3	15.7	3.64
Total	539	228	26.7	23.8	1.67
Pedestrian Volume	2,022	958			

Legend

Violations

CL = Pedestrians starting during clearance interval
DW = Pedestrians starting during DONT WALK interval
AW = Pedestrians anticipating WALK interval

Conflicts

PH = Pedestrian hesitation
AC = Aborted crossing
MV = Moving vehicle conflict
RT = Right-turn vehicle conflict
LT = Left-turn vehicle conflict
RV = Pedestrian runs to avoid vehicle
RC = Run on clearance
RTV = Run-turning conflict
THRU = Total clearance (through vehicle) conflicts
TURN = Total turning conflicts

Z-Value

\- = Insufficient sample size
NA = Not applicable

EXPERIMENT: PEDESTRIANS WATCH FOR TURNING VEHICLES Sign

SITE: Detroit, Michigan - Griswald Ave. and Larned St. (15)
Cass Ave. and Warren Ave. (16)

	Frequency		Percent		
Violations	Before	After	Before	After	Z-Value
CL	←	←	NA	→	→
DW	←	←	NA	→	→
AW	←	←	NA	→	→
Total	←	←	NA	→	→
Conflicts					
PH	46	36	1.8	1.5	0.96
AC	4	2	0.2	0.1	-
MV	30	20	1.2	0.8	NA
RT	436	195	17.5	8.1	9.81
LT*	0	2	0.0	0.1	-
RV	10	18	0.4	0.7	NA
RC	37	32	1.5	1.3	NA
RTV	32	5	1.3	0.2	-
THRU	127	108	5.1	4.5	1.00
TURN	468	202	18.8	8.4	10.58
Total	595	310	23.9	12.9	9.92
Pedestrian Volume	2,487	2,402			

*Data from Cass Ave. and Warren Ave. (16) only.

Legend

Violations

CL = Pedestrians starting during clearance interval
DW = Pedestrians starting during DONT WALK interval
AW = Pedestrians anticipating WALK interval

Conflicts

PH = Pedestrian hesitation
AC = Aborted crossing
MV = Moving vehicle conflict
RT = Right-turn vehicle conflict
LT = Left-turn vehicle conflict
RV = Pedestrian runs to avoid vehicle
RC = Run on clearance
RTV = Run-turning conflict
THRU = Total clearance (through vehicle) conflicts
TURN = Total turning conflicts

Z-Value

\- = Insufficiant sample size
NA = Not applicable

EXPERIMENT: PEDESTRIANS WATCH FOR TURNING VEHICLES Sign

SITE: Milwaukee, Wisconsin - 11th St. and Mitchell St. (17)

	Frequency		Percent		
Violations	Before	After	Before	After	Z-Value
CL	←	←	NA	→	→
DW	←	←	NA	→	→
AW	←	←	NA	→	→
Total	←	←	NA	→	→
Conflicts					
PH	17	11	1.4	0.8	-
AC	5	3	0.4	0.2	-
MV	17	10	1.4	0.7	NA
RT	40	15	3.2	1.0	-
LT	2	2	0.2	0.1	-
RV	1	4	0.1	0.3	NA
RC	18	8	1.4	0.6	NA
RTV	2	0	0.2	0.0	-
THRU	58	36	4.7	2.5	3.03
TURN	44	17	3.5	1.2	-
Total	102	53	8.2	3.7	4.99
Pedestrian Volume	1,243	1,435			

EXPERIMENT: PEDESTRIANS WATCH FOR TURNING VEHICLES Sign

SITE: Milwaukee, Wisconsin - 13th St. and Lincoln Ave. (18)

	Frequency		Percent		
Violations	Before	After	Before	After	Z-Value
CL	←	←	NA	→	→
DW	←	←	NA	→	→
AW	←	←	NA	→	→
Total	←	←	NA	→	→
Conflicts					
PH	10	2	2.3	0.5	-
AC	1	0	0.2	0.0	-
MV	6	0	1.4	0.0	NA
RT	58	47	13.1	12.7	0.17
LT	8	5	1.8	1.3	-
RV	7	0	1.6	0.0	NA
RC	6	9	1.4	2.4	NA
RTV	5	5	1.1	1.3	-
THRU	30	11	6.8	3.0	-
TURN	71	57	16.0	15.4	0.25
Total	101	68	22.7	18.3	1.55
Pedestrian Volume	444	371			

Legend

Violations

CL = Pedestrians starting during clearance interval
DW = Pedestrians starting during DONT WALK interval
AW = Pedestrians anticipating WALK interval

Conflicts

PH = Pedestrian hesitation
AC = Aborted crossing
MV = Moving vehicle conflict
RT = Right-turn vehicle conflict
LT = Left-turn vehicle conflict
RV = Pedestrian runs to avoid vehicle
RC = Run on clearance
RTV = Run-turning conflict
THRU = Total clearance (through vehicle) conflicts
TURN = Total turning conflicts

Z-Value

\- = Insufficient sample size
NA = Not applicable

EXPERIMENT: PEDESTRIANS WATCH FOR TURNING VEHICLES Sign

SITE: Milwaukee, Wisconsin - 11th St. and Mitchell St. (17)
13th St. and Lincoln Ave. (18)

	Frequency		Percent		
Violations	**Before**	**After**	**Before**	**After**	**Z-Value**
CL	←	←	NA	→	→
DW	←	←	NA	→	→
AW	←	←	NA	→	→
Total	←	←	NA	→	→
Conflicts					
PH	27	13	1.6	0.7	-
AC	6	3	0.4	0.2	-
MV	23	10	1.4	0.6	NA
RT	98	62	5.8	3.4	3.36
LT	10	7	0.6	0.4	-
RV	8	4	0.5	0.2	NA
RC	24	17	1.4	0.9	NA
RTV	7	5	0.4	0.3	-
THRU	88	47	5.2	2.6	4.00
TURN	115	74	6.8	4.1	3.55
Total	203	121	12.0	6.7	5.43
Pedestrian Volume	1,687	1,806			

Legend

Violations

CL = Pedestrians starting during clearance interval
DW = Pedestrians starting during DONT WALK interval
AW = Pedestrians anticipating WALK interval

Conflicts

PH = Pedestrian hesitation
AC = Aborted crossing
MV = Moving vehicle conflict
RT = Right-turn vehicle conflict
LT = Left-turn vehicle conflict
RV = Pedestrian runs to avoid vehicle
RC = Run on clearance
RTV = Run-turning conflict
THRU = Total clearance (through vehicle) conflicts
TURN = Total turning conflicts

Z-Value

\- = Insufficiant sample size
NA = Not applicable

EXPERIMENT: WALK WITH CARE Signal Indication

SITE: Ann Arbor, Michigan - Main St. and Washington St. (19)

	Frequency		Percent		
Violations	Before	After	Before	After	Z-Value
CL	47	154	8.2	6.3	1.62
DW	195	198	34.2	8.2	16.56
AW	20	78	3.5	3.2	-
Total	262	430	45.9	17.7	14.37
Conflicts					
PH	19	20	3.3	0.8	-
AC	3	1	0.5	0.0	-
MV	7	9	1.2	0.4	-
RT	46	95	8.1	3.9	4.21
LT	13	37	2.3	1.5	-
RV	5	6	0.9	0.2	-
RC	6	16	1.1	0.7	-
RTV	2	5	0.4	0.2	-
THRU	40	52	7.0	2.1	6.06
TURN	61	137	10.7	5.6	4.36
Total	101	189	17.7	7.8	7.20
Pedestrian Volume	571	2,427			

EXPERIMENT: WALK WITH CARE Signal Indication

SITE: Washington, D.C. - M St. and Wisconsin Ave. (20)

	Frequency		Percent		
Violations	Before	After	Before	After	Z-Value
CL	231	403	12.5	12.3	0.21
DW	131	204	7.1	6.2	1.20
AW	72	39	3.9	1.2	6.39
Total	434	646	23.5	19.8	3.18
Conflicts					
PH	35	97	1.9	3.0	-2.31
AC	14	14	0.8	0.4	-
MV	13	23	0.7	0.7	-
RT	344	502	18.7	15.4	3.05
LT	52	54	2.8	1.7	2.81
RV	5	10	0.3	0.3	-
RC	29	60	1.6	1.8	-
RTV	28	38	1.5	1.2	-
THRU	96	204	5.2	6.2	-1.51
TURN	424	594	23.0	18.2	4.15
Total	520	798	28.2	24.4	2.97
Pedestrian Volume	1,844	3,269			

Legend

Violations

CL = Pedestrians starting during clearance interval
DW = Pedestrians starting during DONT WALK interval
AW = Pedestrians anticipating WALK interval

Conflicts

PH = Pedestrian hesitation
AC = Aborted crossing
MV = Moving vehicle conflict
RT = Right-turn vehicle conflict
LT = Left-turn vehicle conflict
RV = Pedestrian runs to avoid vehicle
RC = Run on clearance
RTV = Run-turning conflict
THRU = Total clearance (through vehicle) conflicts
TURN = Total turning conflicts

Z-Value

\- = Insufficient sample size
NA = Not applicable

EXPERIMENT: WALK WITH CARE Signal Indication

SITE: Milwaukee, Wisconsin - Mason St. and Milwaukee Ave. (21)

Violations	Frequency Before	Frequency After	Percent Before	Percent After	Z-Value
CL	70	46	6.7	5.6	0.97
DW	159	59	15.2	7.2	5.35
AW	114	17	10.9	2.1	-
Total	343	122	32.7	14.8	8.88
Conflicts					
PH	48	19	4.6	2.3	-
AC	4	0	0.4	0.0	-
MV	12	3	1.1	0.4	-
RT	129	61	12.3	7.4	3.47
LT	54	19	5.1	2.3	-
RV	5	2	0.5	0.2	-
RC	12	9	1.1	1.1	-
RTV	3	3	0.3	0.4	-
THRU	81	33	7.7	4.0	3.33
TURN	186	83	17.7	10.1	4.68
Total	267	116	25.5	14.1	6.05
Pedestrian Volume	1,049	823			

EXPERIMENT: WALK WITH CARE Signal Indication

SITE: Milwaukee, Wisconsin - 16th St. and Wisconsin Ave. (22)

Violations	Frequency Before	Frequency After	Percent Before	Percent After	Z-Value
CL	176	38	8.5	3.6	6.03
DW	540	70	26.0	6.7	12.81
AW	63	7	3.0	0.7	-
Total	779	115	37.5	11.0	15.42
Conflicts					
PH	34	11	1.6	1.1	-
AC	2	0	0.1	0.0	-
MV	29	7	1.4	0.7	-
RT	131	47	6.3	4.5	2.04
LT	94	22	4.5	2.1	-
RV	41	3	2.0	0.3	-
RC	31	8	1.5	0.8	-
RTV	14	3	0.7	0.3	-
THRU	137	29	6.6	2.8	-
TURN	239	72	11.5	6.9	4.05
Total	376	101	18.1	9.7	6.16
Pedestrian Volume	2,078	1,043			

Legend

Violations

CL = Pedestrians starting during clearance interval
DW = Pedestrians starting during DONT WALK interval
AW = Pedestrians anticipating WALK interval

Conflicts

PH = Pedestrian hesitation
AC = Aborted crossing
MV = Moving vehicle conflict
RT = Right-turn vehicle conflict
LT = Left-turn vehicle conflict
RV = Pedestrian runs to avoid vehicle
RC = Run on clearance
RTV = Run-turning conflict
THRU = Total clearance (through vehicle) conflicts
TURN = Total turning conflicts

Z-Value

\- = Insufficient sample size
NA = Not applicable

EXPERIMENT: WALK WITH CARE Signal Indication

SITE: Milwaukee, Wisconsin - Mason St. and Milwaukee Ave. (21)
16th St. and Wisconsin Ave. (22)

	Frequency		Percent		
Violations	**Before**	**After**	**Before**	**After**	**Z-Value**
CL	246	84	7.9	4.5	4.63
DW	699	129	22.4	6.9	14.19
AW	177	24	5.7	1.3	-
Total	1,122	237	35.9	12.7	17.80
Conflicts					
PH	82	30	2.6	1.6	2.34
AC	6	0	0.2	0.0	-
MV	41	10	1.3	0.5	-
RT	260	108	8.3	5.8	3.31
LT	148	41	4.7	2.2	4.54
RV	46	5	1.5	0.3	-
RC	43	17	1.4	0.9	-
RTV	17	6	0.5	0.3	-
THRU	218	62	7.0	3.3	5.42
TURN	425	155	13.6	8.3	5.64
Total	643	217	20.6	11.6	8.09
Pedestrian Volume	3,127	1,866			

Legend

Violations

CL = Pedestrians starting during clearance interval
DW = Pedestrians starting during DONT WALK interval
AW = Pedestrians anticipating WALK interval

Conflicts

PH = Pedestrian hesitation
AC = Aborted crossing
MV = Moving vehicle conflict
RT = Right-turn vehicle conflict
LT = Left-turn vehicle conflict
RV = Pedestrian runs to avoid vehicle
RC = Run on clearance
RTV = Run-turning conflict
THRU = Total clearance (through vehicle) conflicts
TURN = Total turning conflicts

Z-Value

\- = Insufficient sample size
NA = Not applicable

EXPERIMENT: Steady Versus Flashing WALK

SITE: Milwaukee, Wisconsin - Mason St. and Jefferson St. (23)

	Frequency		Percent		
Violations	**Before**	**After**	**Before**	**After**	**Z-Value**
CL	27	153	3.6	7.8	-
DW	172	355	22.8	18.0	2.85
AW	30	59	4.0	3.0	1.30
Total	229	567	30.4	28.8	0.84
Conflicts					
PH	11	21	1.5	1.1	-
AC	0	3	0.0	0.2	-
MV	6	7	0.8	0.4	-
RT	15	29	2.0	1.5	-
LT	13	30	1.7	1.5	-
RV	2	2	0.3	0.1	-
RC	11	10	1.5	0.5	-
RTV	2	2	0.3	0.1	-
THRU	30	43	4.0	2.2	2.60
TURN	30	61	4.0	3.1	1.15
Total	60	104	8.0	5.3	2.64
Pedestrian Volume	753	1,970			

EXPERIMENT: Steady Versus Flashing WALK

SITE: Milwaukee, Wiscosin - 27th St. and Wells St. (24)

	Frequency		Percent		
Violations	**Before**	**After**	**Before**	**After**	**Z-Value**
CL	25	30	5.9	4.7	-
DW	8	7	1.9	1.1	-
AW	4	6	0.9	0.9	-
Total	37	43	8.7	6.7	1.21
Conflicts					
PH	5	6	1.2	0.9	-
AC	0	1	0.0	0.2	-
MV	0	0	0.0	0.0	-
RT	←	—	NA	—	→
LT	93	113	22.0	17.7	1.72
RV	3	0	0.7	0.0	-
RC	14	21	3.3	3.3	-
RTV	7	6	1.7	0.9	-
THRU	22	28	5.2	4.4	-
TURN	100	119	23.6	18.7	1.97
Total	122	147	28.8	23.0	2.13
Pedestrian Volume	423	638			

Legend

Violations

CL = Pedestrians starting during clearance interval
DW = Pedestrians starting during DONT WALK interval
AW = Pedestrians anticipating WALK interval

Conflicts

PH = Pedestrian hesitation
AC = Aborted crossing
MV = Moving vehicle conflict
RT = Right-turn vehicle conflict
LT = Left-turn vehicle conflict
RV = Pedestrian runs to avoid vehicle
RC = Run on clearance
RTV = Run-turning conflict
THRU = Total clearance (through vehicle) conflicts
TURN = Total turning conflicts

Z-Value

\- = Insufficient sample size
NA = Not applicable

EXPERIMENT: Steady Versus Flashing WALK

SITE: Milwaukee, Wisconsin - Mason St. and Jefferson St. (23)
27th St. and Wells St. (24)

	Frequency		Percent		
Violations	Before	After	Before	After	Z-Value
CL	52	183	4.4	7.0	-3.06
DW	180	362	15.3	13.9	1.16
AW	34	65	2.9	2.5	0.71
Total	266	610	22.6	23.4	-0.52
Conflicts					
PH	16	27	1.4	1.0	-
AC	0	4	0.0	0.2	-
MV	6	7	0.5	0.3	-
RT*	15	29	1.3	1.1	-
LT	106	143	9.0	5.5	4.05
RV	5	2	0.4	0.1	-
RC	25	31	2.1	1.2	-
RTV	9	8	0.8	0.3	-
THRU	52	71	4.4	2.7	2.73
TURN	130	180	11.1	6.9	4.31
Total	182	251	15.5	9.6	5.23
Pedestrian Volume	1,176	2,608			

*Data from Mason St. and Jefferson St. (23).

Legend

Violations

CL = Pedestrians starting during clearance interval
DW = Pedestrians starting during DONT WALK interval
AW = Pedestrians anticipating WALK interval

Conflicts

PH = Pedestrian hesitation
AC = Aborted crossing
MV = Moving vehicle conflict
RT = Right-turn vehicle conflict
LT = Left-turn vehicle conflict
RV = Pedestrian runs to avoid vehicle
RC = Run on clearance
RTV = Run-turning conflict
THRU = Total clearance (through vehicle) conflicts
TURN = Total turning conflicts

Z-Value

\- = Insufficient sample size
NA = Not applicable

APPENDIX O - SUMMARY OF Z-TEST OF PROPORTIONS RESULTS FOR LOW, MEDIUM AND HIGH TRAFFIC VOLUME LEVELS AT EACH SITE

EXPERIMENT: Pedestrian Signal Explanation Sign (Symbolic)

SITE: Saginaw, Michigan - Court St., and Michigan Ave. (1)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	-	NC	-	-	-	NC	NC
Thru Conflicts	-	-	-	-	-	-	NC
Turn Conflicts	-	NC	NC	-	NC	B*	NC
Total Conflicts	-	NC	NC	-	NC	NC	NC

EXPERIMENT: Pedestrian Signal Explanation Sign (Symbolic)

SITE: Saginaw, Michigan - Court St. and Hamilton St. (2)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	-	-	-	-	-	-	NC
Thru Conflicts	-	-	-	-	-	-	A**
Turn Conflicts	-	NC	NC	-	NC	NC	NC
Total Conflicts	-	NC	NC	-	A**	NC	NC

EXPERIMENT: Pedestrian Signal Explanation Sign (Word)

SITE: Washington, D.C. - 17th St. and L. St., N.W. (3)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	A**	A**	A**	A**	A**	A**	A**
Thru Conflicts	A*	NC	A**	NC	A**	A*	A**
Turn Conflicts	A**	A**	NC	A**	A*	A**	A**
Total Conflicts	A**	A**	A**	A**	A**	A**	A**

EXPERIMENT: Pedestrian Signal Explanation Sign (Word)

SITE: Washington, D.C. - 18th St. and L St., N.W. (4)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	A**	NC	A**	NC	A**	NC	A**
Thru Conflicts	NC	B**	-	B**	NC	NC	B**
Turn Conflicts	NC	NC	A*	NC	A**	A*	A**
Total Conflicts	NC	B*	NC	NC	NC	NC	NC

Legend:
A = Significant difference in favor of after (experimental) condition
B = Significant difference in favor of before (base) condition
NC = No significant difference between before and after conditions
* = Significant at the 0.05 level
** = Significant at the 0.01 level
\- = Insufficient sample size
NA = Not Applicable

EXPERIMENT: DONT START Signal Indication

SITE: Ann Arbor, Michigan - S. State St. and Washington St. (5)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	NC	NC	NC	NC	NC	NC	B*
Thru Conflicts	-	NC	NC	NC	-	NC	NC
Turn Conflicts	-	NC	NC	NC	A*	NC	NC
Total Conflicts	-	NC	NC	NC	NC	NC	NC

EXPERIMENT: DONT START Signal Indication

SITE: Washington, D.C. - 20th St. and L St., N.W. (6)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	NC	NC	A**	NC	A**	A**	A**
Thru Conflicts	-	-	-	B**	NC	NC	B**
Turn Conflicts	-	A**	A**	A**	A**	A**	A**
Total Conflicts	-	A**	A**	A*	A**	A**	A**

EXPERIMENT: DONT START Signal Indication

SITE: Milwaukee, Wisconsin - Broadway and Mason St. (7)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	A**	A**	A**	A**	A**	A**	A**
Thru Conflicts	-	-	-	-	-	A**	A**
Turn Conflicts	NC	NC	NC	NC	NC	B*	NC
Total Conflicts	NC	A**	NC	NC	A**	NC	A**

EXPERIMENT: DONT START Signal Indication

SITE: Milwaukee, Wisconsin - Mason St. and Jackson St. (8)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	A**	A**	A**	NA	NA	NA	A**
Thru Conflicts	-	-	-	NA	NA	NA	A**
Turn Conflicts	NA	NA	NA	NA	NA	NA	NA
Total Conflicts	-	-	-	NA	NA	NA	A**

Legend:
A = Significant difference in favor of after (experimental) condition
B = Significant difference in favor of before (base) condition
NC = No significant difference between before and after conditions
* = Significant at the 0.05 level
** = Significant at the 0.01 level
\- = Insufficient sample size
NA = Not Applicable

EXPERIMENT: Steady versus Flashing WALK and DONT WALK

SITE: Washington, D.C. - 30th St. and M St. (9)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	A*	A*	A**	NC	A**	A*	A**
Thru Conflicts	-	-	NC	-	-	NC	NC
Turn Conflicts	NC	NC	A**	NC	NC	A*	A*
Total Conflicts	NC	NC	A**	NC	NC	A*	A*

EXPERIMENT: Steady versus Flashing WALK and DONT WALK

SITE: Washington, D.C. - 7th St. and D St. (10)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	NC	NC	NC	NC	NC	NC	NC
Thru Conflicts	-	-	-	-	-	B*	B**
Turn Conflicts	NC	-	NC	-	A**	NC	A**
Total Conflicts	NC	NC	NC	NC	NC	NC	NC

EXPERIMENT: YIELD TO PEDESTRIANS WHEN TURNING Sign

SITE: Detroit, Michigan - Cass Ave. and Lafayette St. (11)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	NA	NA	NA	NA	NA	NA	NA
Thru Conflicts	-	-	-	-	-	-	-
Turn Conflicts	-	A**	A**	-	-	A**	A**
Total Conflicts	-	A**	A**	-	A**	A**	A**

EXPERIMENT: YIELD TO PEDESTRIANS WHEN TURNING Sign

SITE: Detroit, Michigan - Woodward Ave. and Grand Blvd. (12)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	NA	NA	NA	NA	NA	NA	NA
Thru Conflicts	-	-	-	-	-	-	NC
Turn Conflicts	NC	NC	A*	A*	A*	NC	NC
Total Conflicts	NC	NC	NC	NC	A*	NC	NC

Legend:
A = Significant difference in favor of after (experimental) condition
B = Significant difference in favor of before (base) condition
NC = No significant difference between before and after conditions
* = Significant at the 0.05 level
** = Significant at the 0.01 level
- = Insufficient sample size
NA = Not Applicable

EXPERIMENT: YIELD TO PEDESTRIANS WHEN TURNING Sign

SITE: Milwaukee, Wisconsin - 27th St. and Wisconsin Ave. (13)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	NA	NA	NA	NA	NA	NA	NA
Thru Conflicts	-	-	-	-	-	-	-
Turn Conflicts	-	-	-	-	-	-	A*
Total Conflicts	-	A**	-	-	NC	NC	A*

EXPERIMENT: YIELD TO PEDESTRIANS WHEN TURNING Sign

SITE: Milwaukee, Wisconsin - Michigan Ave. and Broadway (14)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	NA	NA	NA	NA	NA	NA	NA
Thru Conflicts	-	-	-	-	-	-	-
Turn Conflicts	-	-	-	-	-	A**	A**
Total Conflicts	NC	-	-	-	-	A**	A**

EXPERIMENT: PEDESTRIANS WATCH FOR TURNING VEHICLES Sign

SITE: Detroit, Michigan - Griswald St. and Larned St. (15)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	NA	NA	NA	NA	NA	NA	NA
Thru Conflicts	-	-	-	-	-	-	-
Turn Conflicts	-	-	-	-	-	-	A**
Total Conflicts	-	-	-	-	-	-	A**

EXPERIMENT: PEDESTRIANS WATCH FOR TURNING VEHICLES Sign

SITE: Detroit, Michigan - Cass Ave. and Warren Ave. (16)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	NA	NA	NA	NA	NA	NA	NA
Thru Conflicts	-	-	-	NC	-	-	B**
Turn Conflicts	-	NC	-	A*	A*	A*	A**
Total Conflicts	-	NC	-	NC	NC	NC	NC

Legend:
A = Significant difference in favor of after (experimental) condition
B = Significant difference in favor of before (base) condition
NC = No significant difference between before and after conditions
* = Significant at the 0.05 level
** = Significant at the 0.01 level
\- = Insufficient sample size
NA = Not Applicable

EXPERIMENT: PEDESTRIANS WATCH FOR TURNING VEHICLES Sign

SITE: Milwaukee, Wisconsin - 11th St. and Mitchell St. (17)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	NA	NA	NA	NA	NA	NA	NA
Thru Conflicts	-	-	-	-	-	-	A**
Turn Conflicts	-	-	-	-	-	-	-
Total Conflicts	-	-	-	-	A*	-	A**

EXPERIMENT: PEDESTRIANS WATCH FOR TURNING VEHICLES Sign

SITE: Milwaukee, Wisconsin - 13th St. and Lincoln Ave. (18)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	NA	NA	NA	NA	NA	NA	NA
Thru Conflicts	-	-	-	-	-	-	-
Turn Conflicts	-	-	-	-	-	NC	NC
Total Conflicts	-	-	-	-	-	NC	NC

EXPERIMENT: WALK WITH CARE Signal Indication

SITE: Ann Arbor, Michigan - Main St. and Washington St. (19)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	A**	A**	A**	-	A**	A**	A**
Thru Conflicts	-	-	-	-	-	-	A**
Turn Conflicts	-	-A**	-	-	-	A**	A**
Total Conflicts	A**	A**	-	-	-	A**	A**

EXPERIMENT: WALK WITH CARE Signal Indication

SITE: Washington, D.C. - M St. and Wisconsin Ave. (20)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	NC	A**	NC	NC	NC	A**	A**
Thru Conflicts	-	-	NC	-	-	NC	NC
Turn Conflicts	NC	A*	A**	A**	NC	A**	A**
Total Conflicts	NC	NC	A**	A**	NC	A**	A**

Legend:
A = Significant difference in favor of after (experimental) condition
B = Significant difference in favor of before (base) condition
NC = No significant difference between before and after conditions
* = Significant at the 0.05 level
** = Significant at the 0.01 level
- = Insufficient sample size
NA = Not Applicable

EXPERIMENT: WALK WITH CARE Signal Indication

SITE: Milwaukee, Wisconsin - Mason St. and Milwaukee Ave. (21)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	A**	-	A**	-	A**	A**	A**
Thru Conflicts	-	-	-	-	-	-	A**
Turn Conflicts	-	-	A**	-	NC	A**	A**
Total Conflicts	-	-	A**	-	A*	A**	A**

EXPERIMENT: WALK WITH CARE Signal Indication

SITE: Milwaukee, Wisconsin - 16th St. and Wisconsin Ave. (22)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	A**	A**	A**	-	A**	A**	A**
Thru Conflicts	-	-	-	-	-	-	-
Turn Conflicts	-	-	-	-	-	-	A**
Total Conflicts	-	A**	A**	-	A**	A**	A**

EXPERIMENT: Steady versus Flashing WALK

SITE: Milwaukee, Wisconsin - Mason St. and Jefferson St. (23)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	NC	NC	NC	A**	NC	NC	NC
Thru Conflicts	-	-	-	-	-	-	A**
Turn Conflicts	-	-	-	-	-	-	NC
Total Conflicts	-	-	-	-	-	NC	A**

EXPERIMENT: Steady versus Flashing WALK

SITE: Milwaukee, Wisconsin - 27th St. and Wells St. (24)

	Thru Volume Group			Turn Volume Group			All Volume Groups
	Low	Medium	High	Low	Medium	High	
Total Violations	-	-	-	-	-	-	NC
Thru Conflicts	-	-	-	-	-	-	-
Turn Conflicts	-	NC	A**	-	-	A*	A*
Total Conflicts	-	NC	A**	-	-	A**	A*

Legend:
A = Significant difference in favor of after (experimental) condition
B = Significant difference in favor of before (base) condition
NC = No significant difference between before and after conditions
* = Significant at the 0.05 level
** = Significant at the 0.01 level
- = Insufficient sample size
NA = Not Applicable

APPENDIX P - LETTER FROM A PEDESTRIAN REGARDING THE WALK WITH CARE PEDESTRIAN SIGNAL

March 29 1983

Gentlemen

I have noticed the "WITH CARE" crosswalk signals recently erected at several intersections, and could not figure out why you would bother with this experiment. This morning, however, I was very nearly run over as I crossed Main at Washington; the fact that I was not, I credit to the presence of that sign, and the thought of caution it prompted in my mind as I stepped onto the street.

At 10 am I walked to work as I do every weekday morning; I was close to being late, and for several blocks was half running. I had crossed a previous intersection against the light, and cut across Washington in the middle of the block. As I approached Main, I saw the light change – the "WALK" sign favored me. I ran that last half block to catch the light. As I stepped off the curb, however, the "WITH CARE" light caught my eye. I remember thinking "Now what does that mean? I have the light." The obvious answer is that care should be taken at all times when crossing the street. As this thought occured, I slowed to a quick walk and looked again at the traffic. Only one car was approaching, not fast, but cruising. It had plenty of time to stop, so I kept walking.

It didn't stop. The driver was talking, not looking at me, or the light as she sped through. She missed me by less than a foot. I am convinced that if I had not slowed my pace as a direct result of seeing that sign, this oblivious driver would have hit me.

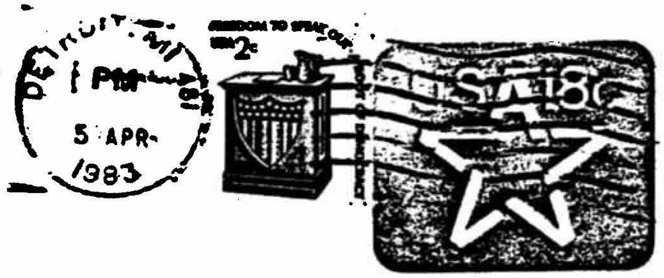
As she drove through the red light after just missing me, I heard her exclaim through open windows and sun roof, "I don't believe I did that!"

I assume you are trying to determine the best way to prompt a warning in the minds of pedestrians and drivers. In this instance, I can report, the "WITH CARE" signal did just that. It's a lesson I'll not soon forget. I hope the clown in that car learned it too.

Sincerely,

Barry G. [redacted]

BARRY G [redacted]
628 W. SUMMIT
ANN ARBOR MI 48103



City of Ann Arbor
Department of Transportation
100 N. 5th Ave
ANN ARBOR MI 48103

APPENDIX Q - DETAILS OF PEDESTRIAN YIELD ALTERNATIVES

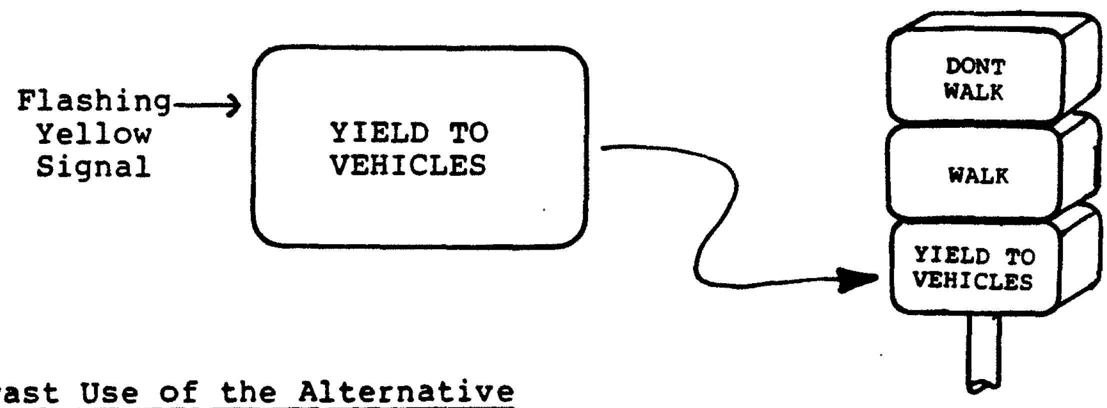
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

YIELD SIGNS OR SIGNALS

Description (Color, Movement, Message, Size, Etc.)

A three-lens signal, with the third lens retrofitted to supplement the standard WALK/DONT WALK pedestrian signal. The message provided on the third lens would be YIELD TO VEHICLES and operate in the flashing mode during off-peak hours when low vehicle volumes occur (i.e. from 10:00 p.m. to 6:00 a.m.). The flashing yield display will be yellow in color, and the DONT WALK message would be turned off during the operation of the YIELD display.

Sketch or Drawing of the Alternative



Past Use of the Alternative

Unknown

Justification for Use

It has the potential of reducing pedestrian delay during times when pedestrians see no reason to wait for the WALK signal (i.e. no vehicles are in sight). This alternative also has the potential for improving the respect for pedestrian signals.

Potential Advantages

- It encourages pedestrians to watch for traffic instead of relying entirely on the pedestrian signals
- Can be maintained as a part of existing pedestrian signal hardware
- Less pedestrian delay (theoretically) than with conventional WALK/DONT WALK signals

Potential Disadvantages

- Retrofit problems are possible
- It gives the pedestrian the right to cross a street "against-the-traffic signal" which is often dangerous
- Confusing message
- It may not be appropriate for young children who can't read or who are not capable of deciding when it is safe to cross on their own
- There may be legal problems associated with encouraging pedestrians to cross against the vehicle traffic signal.

Estimated Cost of Installation

Moderate

Estimated Cost of Maintenance and Operation

Moderate to high

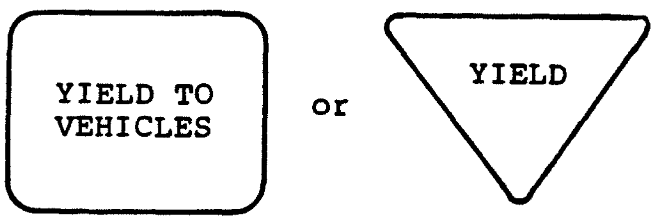
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

YIELD SIGNS OR SIGNALS

Description (Color, Movement, Message, Size, Etc.)

A single illuminated pedestrian signal for each crosswalk which flashes "YIELD" or "YIELD TO VEHICLES" in orange throughout the day. This alternative completely replaces a WALK/DONT WALK pedestrian signal. This alternative is only designated for streets with low traffic volumes.

Sketch or Drawing of the Alternative



Flashing Orange

Past Use of the Alternative

Unknown

Justification for Use

There may be many safe, adequate gaps on low volume roads to allow pedestrians to cross regardless of the vehicle signal indication, thereby reducing pedestrian delay. This flashing yield signal may encourage more pedestrians to watch for traffic before crossing.

YIELD SIGNS OR SIGNALS (Continued)

Potential Advantages

- Reminds pedestrian to watch for traffic
- Reduces pedestrian delay
- Encourages pedestrians to "yield" to turning vehicles which may help reduce these types of accidents

Potential Disadvantages

- May be confusing, may require an education program
- Not applicable to school age children who are not able to determine a safe or adequate crossing gap
- May be legal problems with allowing pedestrians to cross against a red vehicle signal even when vehicular traffic is not present
- Not applicable to high volume, high speed and/or very wide streets where traffic flow conditions may change during the crossing

Estimated Cost of Installation

Medium

Estimated Cost of Maintenance and Operation

Medium

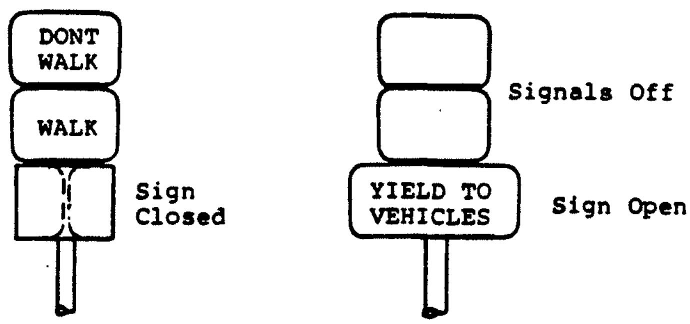
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

YIELD SIGNS OR SIGNALS

Description (Color, Movement, Message, Size, Etc.)

A pedestrian sign which opens or is activated during the off-peak or low vehicle volume periods to replace the WALK/DONT WALK pedestrian signal. The message would be "YIELD" or "YIELD TO VEHICLES".

Sketch or Drawing of the Alternative



Past Use of the Alternative

The open/close sign concept has been used previously with regulatory speed limit signs in school zones which open during school crossing periods.

Justification for Use

The yield message would be displayed during off-peak hours to eliminate unnecessary pedestrian delay, and the message does not conflict with the DONT WALK pedestrian signal (i.e. the WALK/DONT WALK is not operating during the off-peak hours and the yield sign is closed during times when the pedestrian signal is in operation).

Potential Advantages

- Encourages pedestrians to watch for vehicle traffic before crossing
- Is an active message (based on the time of day) which could help to command attention
- Could help to minimize unnecessary pedestrian delay
- Does not conflict with the pedestrian signal message

Potential Disadvantages

- The yield message (as well as the yield concept) may be confusing
- There may be legal problems associated with giving pedestrian the right to cross the street against the traffic signal
- It may not be appropriate for young pedestrians who cannot read or who are not capable of deciding when it is safe to cross on their own.

Estimated Cost of Installation

Moderate

Estimated Cost of Maintenance and Operation

Moderate

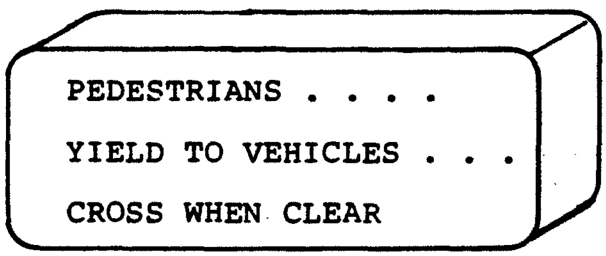
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

YIELD SIGNS OR SIGNALS

Description (Color, Movement, Message, Size, Etc.)

A variable sign message which spells out "PEDESTRIANS - YIELD TO CARS - CROSS WHEN CLEAR", which is activated during off-peak or low vehicle volume conditions.

Sketch or Drawing of the Alternative



Variable Sign Message

Past Use of the Alternative

The variable sign message has been used for providing messages to motorists.

Justification for Use

The sign message should clearly convey the meaning of the yield message, and could be used for providing other safety messages, such as WALK-DONT WALK, or time to next crossing phase.

Potential Advantages

- Easy to understand
- This sign could replace the pedestrian signal and provide the WALK/DONT WALK message
- May reduce pedestrian delay
- Encourages pedestrians to look for traffic before crossing

Potential Disadvantages

- Expensive to develop, install and maintain
- Could lead to a change in pedestrian attitudes at other intersections (i.e. pedestrians may start to cross against the light at other non-signed locations)
- May have difficulty mounting the sign
- Would not be understandable or appropriate for young children who can't read or who are not capable of deciding when it is safe to cross on their own
- The sign would have to be very large to carry the entire message or the message may be shown in parts which may be confusing
- There may be legal problems associated with encouraging pedestrians to cross against the red traffic signal.

Estimated Cost of Installation

High

Estimated Cost of Maintenance and Operation

High - Yes, more "moving parts"

PEDESTRIAN SIGNALIZATION ALTERNATIVES:

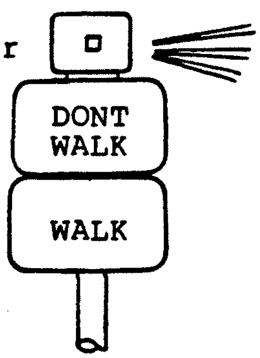
YIELD SIGNS OR SIGNALS

Description (Color, Movement, Message, Size, Etc.)

An audible word message which supplements or replaces the WALK/DONT WALK signal to provide the yield message, PEDESTRIANS, PLEASE YIELD TO VEHICLES AND CROSS ONLY WHEN THE ROADWAY IS CLEAR. This message could also be used in conjunction with other forms of yield sign or signal.

Sketch or Drawing of the Alternative

Speaker



PEDESTRIANS ..... PLEASE YIELD TO VEHICLES AND CROSS ONLY WHEN THE ROADWAY IS CLEAR .....

Past Use of the Alternative

Audible signals have been used with some success in providing crossing and clearance information to pedestrians (i.e. In Washington, D.C.; England; Japan, and many U.S. locations near schools for blind.)

Justification for Use

This device can be retrofitted to existing hardware and provides a clear, simple yield message. Also is applicable to pedestrians with visual impairments.

YIELD SIGNS OR SIGNALS (Continued)

Potential Advantages

- Will draw more attention of pedestrians to the yield message (except for deaf pedestrians).
- More easily understandable
- Reduces pedestrian delay
- Encourages pedestrians to look for traffic before crossing
- Applicable to all crosswalks at the intersection so it does not have to be aimed at a particular crosswalk

Potential Disadvantages

- Causes a noise pollution problem
- Not applicable to deaf people
- Not appropriate to school age children who are not capable of determining when a safe gap exists
- May be legal problems associated with encouraging pedestrians to cross against the red vehicle signal

Estimated Cost of Installation

Moderate

Estimated Cost of Maintenance and Operation

Moderate

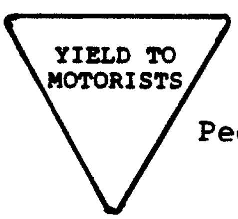
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

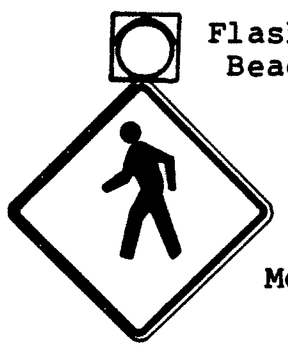
YIELD SIGNS OR SIGNALS

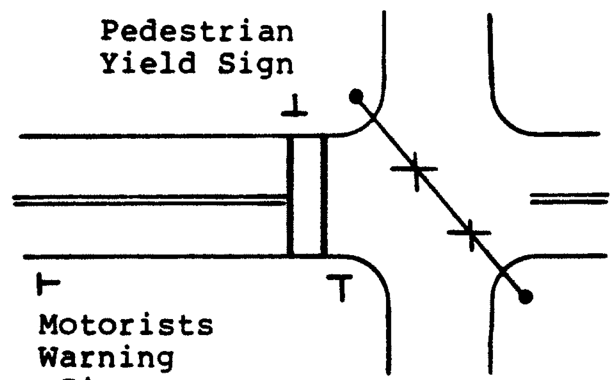
Description (Color, Movement, Message, Size, Etc.)

A combination of yield sign for pedestrians to be placed at each crossing and a warning sign with flashing beacon for approaching motorists indicating that they are approaching a pedestrian crosswalk.

Sketch or Drawing of the Alternative







Past Use of the Alternative

Yield sign for pedestrians has rarely been used. The pedestrian crossing warning sign has been used in the past.

Justification for Use

The general familiarity of road users with triangular yield signs. The yield concept should encourage pedestrians to look for oncoming vehicles.

The flashing beacon and the ped-xing sign will caution approaching vehicles against pedestrians.

Potential Advantages

- Simple and easy to understand message
- Relatively low cost
- Familiarity of road users with the shape and size of the warning sign
- Encourages pedestrians to look for vehicles and encourages motorists to watch for pedestrians

Potential Disadvantages

- May not be effective in drawing the attention of pedestrians
- Warning motorists of pedestrian crossings in past studies has not been shown to be effective
- The yield concept is not appropriate for school age children who are not able to determine what a safe gap is
- There may be legal problems with using the yield signs for pedestrians.

Estimated Cost of Installation

Moderate

Estimated Cost of Maintenance and Operation

Moderate

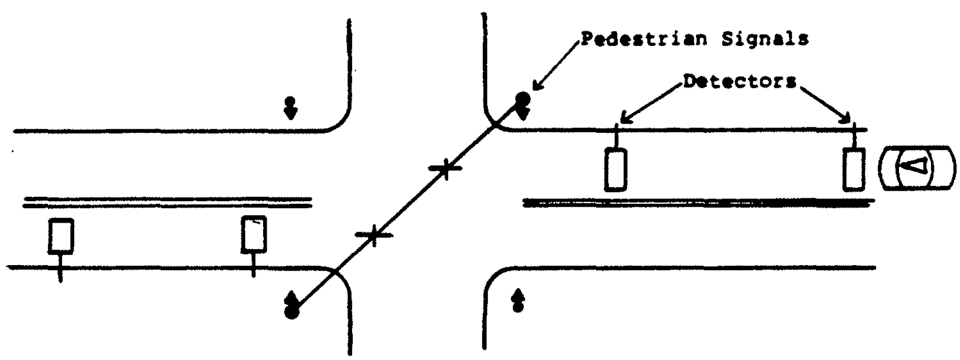
PEDESTRIAN SIGNALIZATION ALTERNATIVES:

YIELD SIGNS OR SIGNALS

Description (Color, Movement, Message, Size, Etc.)

An actuated signal (based on loop detectors imbedded in the pavement) which would display a YIELD signal to pedestrians when no vehicles are detected (to allow all pedestrians to cross against the red vehicle signal). When a vehicle is detected, the DONT WALK display would be displayed and the YIELD display would be eliminated (blanked out).

Sketch or Drawing of the Alternative



Past Use of the Alternative

Unknown, however loop detectors are used for determining signal parameters for actuated and computerized signal systems.

Justification for Use

Detectors would be used to determine when vehicular gaps are present to permit pedestrians to cross. The pedestrian signals would display the appropriate message and make some of the decision making responsiblity for adequate gaps off of the pedestrians.

YIELD SIGNS OR SIGNALS (Continued)

Potential Advantages

- Legal problems could result from allowing pedestrians to cross against the light.
- Pedestrians do not have to determine if a gap is adequate.
- Could eliminate unnecessary delay.

Potential Disadvantages

- Sophisticated and costly
- Detectors may not provide adequate information to give proper signal indication, particularly with turning vehicles and vehicles entering from driveways or parking places between the detector and the pedestrian signal
- The legality of the device may also be open to question in many areas.

Estimated Cost of Installation

High - where the loop detectors are not already installed and placed at the proper distance from the crosswalk

Estimated Cost of Maintenance and Operation

Moderate to high