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A Technical Note

Audible pedestrian traffic signals: Part 1. Prevalence and impact

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Abstract—A collaborative project between the San Diego Association of Governments and San Diego State University (5) evaluated the effectiveness of audible pedestrian traffic signals in aiding visually disabled and elderly persons to walk in their community with greater safety. Three aspects of audible pedestrian traffic signals were investigated: 1) the patterns of use and the impact of these signals on pedestrian traffic safety; 2) the physical characteristics of the sound emitted by the devices; and, 3) the detection of the emitted sounds in the presence of various traffic noise levels. This paper reports on the prevalence and impact of audible traffic signals were ascertained through seeking information from traffic engineers in 71 North American cities; soliciting opinions about these signals from various school officials, social agencies, and volunteer organizations that serve persons with vision impairments; and analyzing pedestrian accident rates at intersections before and after the installation of such signals. The other two aspects of the project are reported in accompanying articles (6,7) that appear in this issue of the *Journal of Rehabilitation Research and Development.*

Key words: *accident rates, audible pedestrian traffic signals, blind and elderly pedestrians, mobility and orientation instructors, reactions, surveys.*

INTRODUCTION

The objective of the project was to learn if audible pedestrian traffic signals helped visually disabled persons to cross streets more safely. To do this, a study was made of: 1) the prevalence and patterns of use and the impact of these signals on pedestrian travel; 2) the physical characteristics of the sound emitted by the devices; and, 3) the detection of the emitted sounds by various persons in the presence of various traffic noise levels. This paper will focus on the prevalence of audible pedestrian traffic signals in North America, their impact on pedestrian traffic safety in nine California cities, and the public's reactions to such signals.

Description of audible pedestrian traffic signals

Various types of audible pedestrian traffic signals (APTS) have been used for a number of years in locales throughout the world, including the United States (2). During the past 10 years, their use in the U.S. has greatly increased due to the availability of several reliable and relatively inexpensive (under $300) devices. APTS are attached to vehicular traffic control signals and emit a distinct sound during the WALK phase of the signal (**Figure 1**). The sounds from the audible signals are intended to alert pedestrians to the WALK phase in the signal cycle thus encouraging them to begin promptly crossing the street before the light changes.

To use an audible signal, the pedestrian pushes the button to activate the WALK signal at the signalized intersection. During the WALK phase of the traffic cycle, the APTS emits one characteristic sound for the north-south direction and a different sound for the east-west direction. No sound is emitted during the flashing or steady DON'T WALK phases. At some intersections, the WALK sign is always active so that audible signals installed at these locations would sound for every traffic cycle. To avoid disturb-

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ing nearby residents, timers can be added to turn off the audible signals at night.

Two brands of audible traffic signals that are commonly used in the United States and Canada are the Sonalert buzzers manufactured by Mallory Capacitor Company's Emhart Electrical/Electronic Group, Indianapolis, IN, and the audio pedestrian signal manufactured by Traconex, Inc., Santa Clara, CA, under license from Nagoya Electric Works of Nagoya, Japan. Both devices attach to the pedestrian signal box of the traffic signal and are wired to emit a distinct sound with the WALK or green portion of the signal.

The Sonalert is a small (4.3 cm diameter, 5.1 cm long cylinder) piezoelectric signaling device intended for installation *inside* the chassis of a crosswalk light box.* Installation of the Sonalert requires that a 3 cm hole be drilled into the crosswalk light box and the unit installed through this opening. According to its manufacturer (3), Sonalert Model SC616WY produces three different sound patterns: pulsating tones at 1750 Hz or 3000 Hz and a warble tone that switches between these two frequencies. Sonalert Model SC616WXY produces five different sound patterns: pulsating tones at 1750 Hz and 3000 Hz, continuous tones at these two frequencies, and a warble tone that switches between these frequencies. Both Sonalert units are controlled and powered from a 6-16 VDC source and can generate a sound pressure of 75 dB at 0.6 m (2 ft).

The Nagoya/Traconex APTS (8) is a self-contained, bell-shaped and weatherproof unit that attaches externally to the pedestrian crosswalk signal box (**Figure 1**). The Nagoya/Traconex signals emit an electronic "cuckoo" sound to denote the north-south direction of travel and an electronic "chirp" sound to denote the east-west direction of travel. The manufacturer lists the following specifications for the "cuckoo" sound: frequency base of 1100 Hz; sound duration of 0.6 seconds; and a frequency deviation (warble) of 120 Hz. The manufacturer's specifications for the "chirp" sound are a continuous frequency variation of 800 Hz that lasts 0.2 s with a frequency base of 2800 Hz. The output for both units is specified to be 90 dB sound pressure level (SPL, re; 20 μPa) at 1 m and self-switching between one of two adjustable output volume levels depending on the ambient noise level. Because the Traconex signal is so widely used in the western United States, especially in California, and because of numerous cooperative study sites in California, this research effort focused on the Nagoya/Traconex unit.

*Personal communication with Windsor P. Waits, Applications Engineer, Mallory Capacitor Company, Indianapolis, IN, June 22, 1989.

Beneficiaries of audible pedestrian traffic signals

The stated purpose for using audible traffic signals is to help visually impaired pedestrians travel more safely and confidently (8,11). Visually impaired and elderly persons may walk slowly and thus would need the full walk cycle to traverse the street completely before the signal changes. Therefore, it is beneficial for them to know definitely that they have the WALK signal so they can begin crossing the street without delay.

Visually impaired and elderly persons comprise a sizable population in the United States. The U.S. Bureau of the Census (9) reports that 12.8 million persons (or 7 percent of the U.S. population over 15 years of age) have visual disabilities, and 1.7 million (or 13 percent) of these have severe visual disabilities. Almost half (45 percent) of the population with vision disabilities are elderly, and 71 percent of those with severe visual dysfunctions are elderly. The number of persons over 65 has almost doubled in the last quarter century, and actuarial trends (9) show that the elderly population will grow even faster in the next 25 years.

A literature search yielded little on the prevalence and impact of audible pedestrian traffic signals. Hulshcer (1) examined problems related to providing an audible device for blind pedestrians. In Wilson's study (11), which was cited in an Issue Paper by the Institute of Transportation Engineers (2), pedestrians were found to cross the street more quickly when APTS were present. In his feasibility study of audible pedestrian signals, Oliver (4) reported that 103 U.S. cities and 34 foreign locations have some type of audible signals. Uslan (10) reported that his blind subjects reacted positively to audible signals, especially at intersections that had complex traffic flow patterns.

To ascertain the prevalence and impact of APTS, this project asked three questions: 1) How prevalent are audible traffic signals in North America? 2) Have these signals had an impact on pedestrian safety? and, 3) What are some of the reactions to these signals?

Answers were sought by contacting persons responsible for the installation of audible traffic signals, analyzing pedestrian traffic accident rates at intersections before and after the installation of audible traffic signals, and interviewing organizations that work with persons who have visual impairments.

PREVALENCE OF AUDIBLE TRAFFIC SIGNALS

To determine the numbers and locations of APTS, a simple fact-finding survey was mailed to traffic engineers

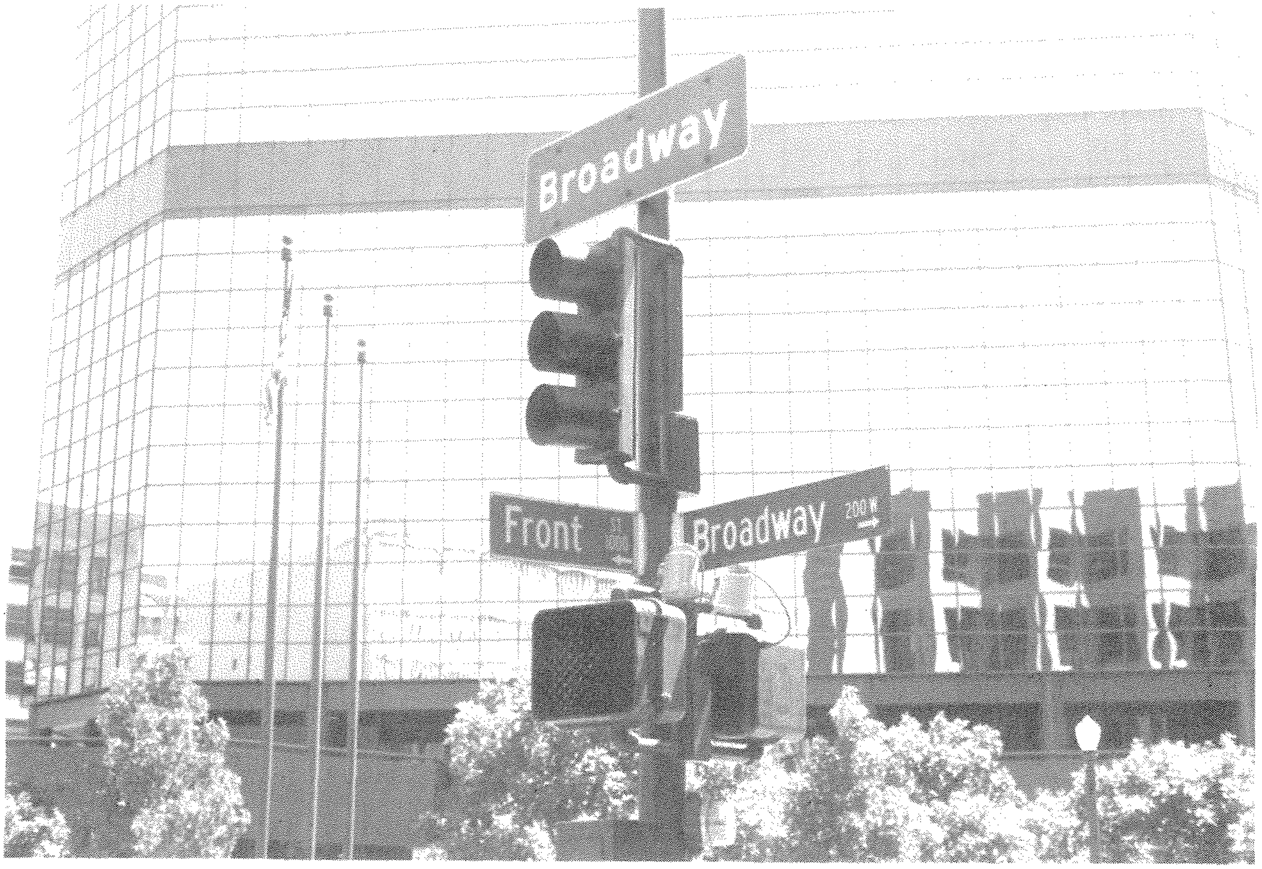

Figure 1.
The bell-shaped Nagaya/Traconex audible pedestrian traffic signal is mounted atop the pedestrian signal box and pointed downward.

in 71 North American cities reported to have one or more audible traffic signals in their jurisdiction. The survey sought information about their signal installations. Follow-up was made by telephone.

Of the 71 cities surveyed in 1988, 52 cities and various locations in Connecticut had audible pedestrian traffic signals. In the 52 cities and the State of Connecticut, there were 288 intersections with audible signals. Of these, 184 (64 percent) intersections have the Nagoya/Traconex units, with the great majority being in the western U.S. and Canada. In contrast, the unit by Mallory (or some similar buzzer system) tended to be more popular in the eastern United States.

The distribution of audible signals was quite uneven. Among the 52 cities identified as having APTS, 25 (47 percent) were in California. Nearly half the 52 cities had only one or two intersections with audible signals. Only seven cities, mostly in California, had audible signals at more than 10 locations. California cities had 129 intersections with audible signals. At the time of the survey, 29 of the 52 cities reported that they expected to install additional audible signals in the near future.

The survey respondents were also asked to identify the locations of their audible signals. The most common location for APTS was in business districts where 60 percent of the cities have installed them. The next most popular locations, with 38 percent each, were entrances to colleges or universities and intersections near service centers for persons with disabilities. Audible signals were also installed near schools (21 percent); residential areas (15 percent); medical centers (13 percent); government offices and seniors' service centers (6 percent each); and tourist attractions and transit centers (2 percent each).

Among the 52 cities with APTS, 43 (81 percent) placed at least one of their signals at intersections with pedestrian actuated controls (push buttons). Ten cities (19 percent) have timers attached to the signals to deactivate the signals at night.

IMPACT ON PEDESTRIAN TRAFFIC SAFETY

Nine California cities were surveyed to learn about pedestrian accidents at the intersections with audible signals. Pedestrian accident records were reviewed for the calendar year in which the signals were installed and for the two previous calendar years and the two calendar years after their installation. The pedestrian accident data from these nine cities are summarized in **Table 1.**

The nine cities were chosen on the following basis: 1) willingness of the city staff to participate in the research; 2) the availability of detailed accident records; 3) a minimum of 2 years of experience with audible signals; and, 4) the usage of the same equipment, the Traconex audible pedestrian signal. By limiting the choice of cities to one state and the type of APTS to the Traconex brand, the number of variables that could affect the data (e.g., the motor vehicle code, installation procedures for APTS, accident reporting requirements, and weather pattern) was minimized.

Table 1 shows that the nine California cities had a total of 58 intersections and two mid-block crossings with audi-

Table 1.
Impact of audible signals on pedestrian accident rates

City	Intersections				Number of		
	T	W	W-O	ACC	ACC	INJ	NO INJ
Beverly Hills	2	0	2		0	0	0
Cupertino	5	3	2		5	4	1
Huntington Beach	13	5	8		9	9	1
Los Angeles	4	2	2		4	6	0
Norwalk	3	1	2		3	3	1
San Diego	6	4	2		8	8	0
San Jose	1	0	1		0	0	0
Santa Monica	5	3	2		3	4	0
West Covina	21	9	12		16	13	3
TOTAL	60	27	33		48	47	6
Before installation of audible signals							
Cupertino					4	3	1
Huntington Beach					5	5	1
Los Angeles					2	2	0
Norwalk					2	1	1
San Diego					5	5	0
Santa Monica					0	0	0
West Covina					6	4	2
Total					24	20	5
After installation of audible signals							
Cupertino					1	1	0
Huntington Beach					4	4	0
Los Angeles					2	4	0
Norwalk					1	2	0
San Diego					3	3	0
Santa Monica					3	4	0
West Covina					10	9	1
Total					24	27	1

T = Total intersections
W = Intersections with accidents
W-O = Intersections without accidents
ACC = Accidents
INJ = Injured pedestrians

ble pedestrian signals. Of these, 31 intersections and the two mid-block crossings had no pedestrian accidents in the 5 years studied. Of the 27 (45 percent) intersections that had accidents, exactly half the 48 accidents occurred before the installation of the audible pedestrian signals and half afterwards. Twenty persons suffered injuries in the 24 accidents before the installation of the audible signals, including one multiple-injury accident. Twenty-seven persons suffered injuries after APTS installation, including three multiple-injury accidents. There were no injuries in six of the 48 accidents.

Of the 47 pedestrians injured in the 48 accidents, two accidents involved persons carrying a white cane. One of these accidents occurred before the installation of the audible signals and one afterwards. Both accidents occurred at intersections near service centers for disabled persons, and the driver/vehicle was at fault. There were no pedestrian deaths, and alcohol was not involved in any of the 48 accidents studied.

Age and sex of the injured pedestrians were detailed in 26 (54 percent) of the accidents. Ten injured pedestrians were in the 0-17 age group, with eight being injured in accidents before installation of the signal and two afterwards. In the over 18 age group, more females than males were injured before the installation of APTS. In the accidents which occurred after the installation, the numbers of males and females injured were approximately the same.

Type of intersection. Two types of intersections were encountered in the analysis of traffic accident data (**Table 2**). Most intersections (72 percent) at which pedestrian accidents occurred were 4-leg intersections in which two streets crossed each other and continued onward. There were 15 intersections of the other type, called a 3-leg or "T" intersection, in which one of the streets ended at the intersection. Thirty-seven (86 percent) of the forty-three 4-leg intersections were regular, that is, the streets crossed at right angles. The other six were skewed, nonperpendicular crossings. For the 3-leg intersections, 12 were regular and three were skewed.

Twenty-one (49 percent) of the 4-leg intersections had accidents during the period studied, and six (40 percent) of the 3-leg intersections had accidents. The number of accidents at 4-leg intersections decreased by one after the installation of the audible pedestrian signals. However, 3-leg intersections experienced an increase of two accidents. The skewed 3-leg intersections experienced no change in the number of accidents before and after APTS installation.

Further analysis of the available accident data showed that intersection type made little difference in the incidence rate for accidents. Whereas 4-leg intersections comprised 72 percent of the intersections, they experienced 78 percent of the intersections at which there were accidents. Likewise, 3-leg intersections comprised 25 percent of the intersections and experienced 22 percent of the accidents.

Table 2.
Pedestrian accidents by type of intersections

	4-leg intersections			3-leg intersections		
	Total	**Regular**	**Skewed**	**Total**	**Regular**	**Skewed**
Number of intersections Total = 60*	43 (72%)	37 (62%)	6 (10%)	15 (25%)	12 (20%)	3 (5%)
Intersections with ped. accidents Total = 27	21 (78%)	19 (70%)	2 (7%)	6 (22%)	4 (15%)	2 (7%)
Intersections without ped. accidents Total = 33	22 (67%)	18 (55%)	4 (12%)	9 (27%)	8 (24%)	1 (3%)
Number of pedestrian accidents Total = 48	40 (83%)	35 (73%)	5 (10%)	8 (17%)	6 (13%)	2 (4%)
Pedestrian accidents before APTS Total = 24	21 (88%)	18 (75%)	3 (13%)	3 (13%)	2 (8%)	1 (5%)
Pedestrian accidents after APTS Total = 24	19 (79%)	17 (71%)	2 (8%)	5 (21%)	4 (17%)	1 (4%)

*Two mid-block pedestrian crossings experienced no accidents.

One important variable—whether any of the injured pedestrians knew of the signal, heard it, and knew what the sound meant—could not be determined from the accident records. Furthermore, the pedestrians involved in these accidents could not be contacted because their names and addresses were confidential. Variables that could be ascertained from the accident data are discussed below.

Vehicle activity. Accidents in which the party at fault was the driver/vehicle were reviewed in terms of when the accidents occurred relative to the installation of the APTS and what was the direction of vehicular travel. Both before and after installation of audible signals, the driver/vehicle was at fault in 60 percent of the accidents, and the vehicle was heading straight ahead through the intersection in half the accidents. There were, however, fewer pedestrian accidents involving cars turning left after the installation of the APTS (25 percent versus 17 percent). This may suggest that fewer pedestrians inappropriately crossed the street during the left turn signal after the installation of audible signals. Two-thirds of the accidents occurred in the first full year following installation of the audible signals, and dropped substantially in the second year.

Pedestrian activity. The accidents in which the pedestrian was at fault were reviewed with respect to the type of intersection and how long the APTS had been installed. Following installation, two-thirds of the accidents occurred in the first full year after the audible signals were installed; the remainder occurred in the year of installation (**Table 3**). In the second year after APTS installation, none of the accidents were caused by the pedestrian. Such a trend may indicate that pedestrians became acquainted with the signal over a period of time before they paid attention to them or understood what the sounds meant.

Prevalence of accidents. The number of accidents per intersection was reviewed. Half (13) of the intersections experienced only one accident, seven intersections had two accidents each, and another seven had three accidents each. The accident records seemed to indicate that fewer pedestrian accidents occurred at the more dangerous intersections (i.e., intersections previously experiencing two or more pedestrian accidents) following APTS installation.

Weather and lighting conditions. The weather and lighting conditions were reviewed for those pedestrian accidents which occurred after the installation of audible signals. Where the driver/vehicle was at fault, the weather was clear in 60 percent of the accidents; and where the pedestrian was at fault, it was clear in 89 percent of the accidents. However, nearly 45 percent of the accidents where the pedestrian was at fault occurred when it was dark.

Table 3.
Party at fault in pedestrian accidents

Time of APTS installation	Party at Fault		
	Vehicle	Pedestrian	Unknown
Before installation of APTS			
2 calendar years before	13	9	2
After installation of APTS			
Calendar year of installation	3	3	—
1st calendar year after	10	6	—
2nd calendar year after	2	0	—
Subtotals for installation	15	9	—

Vehicle traffic volumes. In terms of vehicle traffic volume, two-third of the intersections experiencing pedestrian accidents ranked at the top for traffic volume. These intersections accounted for 83 percent of the accidents before installation of audible signals but only 58 percent after installation. This suggests that audible signals can reduce the number of pedestrians accidents at intersections with high traffic volumes.

REACTIONS TO AUDIBLE PEDESTRIAN TRAFFIC SIGNALS

Installation of audible signals has not been without controversy (4,10,12) with regards to whether they helped persons with vision disabilities to cross streets. Believing that the signals do help, the American Council of the Blind supports their installation. On the other hand, the National Federation of the Blind reports that the signals are greatly disliked by blind persons who do not find them useful (12). One consequence of this disagreement is hesitancy by some public official to continue installing them.

To determine the breadth of the agreement with either points of view, surveys were distributed to: 1) organizations providing services to persons with vision impairments and to older adults; 2) counselors of blind and vision impaired students at educational institutions; and, 3) orientation and mobility instructors who teach blind persons to travel using the long cane technique. The purpose of the surveys was to ascertain how clients and students felt about the usefulness and desirability of the audible signals. Visually impaired persons themselves could not be readily contacted because their names and addresses were confidential.

Survey results from organizations that serve the elderly and persons with visual impairments

Eighty organizations in the United States and one in Canada were surveyed about their knowledge and appraisal of audible traffic signals. Survey responses were received from 37 organizations.

- Thirty-three organizations (89 percent) were familiar with audible signals. Organizations serving blind persons and schools with programs for blind students had higher response rates than organizations serving senior citizens.
- Almost all (94 percent) respondents were aware of audible signals. Four of five reported that their clients had favorable experiences with APTS; the remainder reported that their clients had negative experiences.
- Half the organizations have taken a position on audible signals. Of these, 83 percent support the installation of APTS because the signals were or could be helpful to their clients.
- Almost half the responding organizations have advocated for the installation of audible signals, and 71 percent of these efforts have proven successful.
- Respondents reported that their blind members liked the signals and found them useful at complex intersections (e.g., 5-legged intersections, divided roads with left turn lanes, etc.) and where there is light parallel traffic flow.
- Respondents noted a need for standardization of equipment and for training in its use.

Survey results from educators and school counselors

Because APTS have been installed near educational institutions, all California school districts and institutions of higher education known to have audible signals within their communities were contacted by phone. The instructors and counselors were invited to express their opinions and experiences with the signals and describe student reactions to them. Survey findings from 17 California educational institutions were as follows.

- Blind students were trained to use audible signals at about 12 years of age, and their teachers reported that students found the signals easy to use.
- Counselors at colleges and universities with audible signals nearby reported that their students liked the signals and found them useful. No counselor reported receiving criticism of the signals from any of their blind students.
- Half the respondents volunteered that their sighted students also found the signals useful, as did blind professors at two of the surveyed institutions.

Survey results from instructors of blind person

The entire membership of the California Association of Orientation and Mobility Specialists was surveyed by mail. The instructors reported that they had discussed audible signals at their meetings and that many members have had experience in teaching blind clients how to use them. Of the 45 members surveyed, 27 responded; only one respondent was not personally familiar with audible signals. Major findings from this survey were as follows.

- Most clients found the signals easy to use. Nearly 60 percent of the respondents reported that their clients usually or always found the signals helpful.
- More than half of the clients learned to use the audible signals after only one to two training sessions.
- Clients especially liked knowing when the WALK signal was illuminated, enabling them to feel safer when crossing a street.
- Clients had trouble remembering which sounds designated the north-south and east-west directions of travel.
- Clients had difficulty locating the push button to actuate the pedestrian WALK signal.
- Clients sometimes became disoriented in crossing streets when the audible sound stopped as the WALK light changed to a flashing red DON'T WALK light.
- Some clients had difficulty hearing the signal over the traffic noise, properly aligning themselves at the corner, or became excessively dependent on the audible signal.

CONCLUSIONS AND RECOMMENDATIONS

Audible pedestrian traffic signals have been installed with the intention of helping visually impaired persons cross streets with greater safety and confidence. This article has examined the prevalence of these devices in North America and the impact of the Nagoya/Traconex APTS on accident rates in nine California cities. Reactions and acceptance of APTs were ascertained by surveying knowledgeable professionals and institutions that interact regularly with visually impaired and elderly persons. The survey results and accident data appear to support the following conclusions and recommendations.

- Approximately 300 intersections in the United States and Canada have installed APTS, and many cities are considering installing them in the near future. The Nagoya/Traconex unit is used almost exclusively in the western U.S., while the Sonalert unit by Mallory is more widely used in the eastern U.S.

- Presently, the distribution of APTS is quite uneven, with a vast majority being located in California.
- At intersections where the WALK signal is always operating, traffic engineers have added timers to deactivate the APTS at night and thus avoid disturbing nearby residents.
- Based on the accident data from nine California cities, the audible signals have not yet made a clear impact on pedestrian accident rates at the intersections studied despite generally favorable user responses to such signals.
- For some of the intersections studied, the audible signal appeared to lessen the frequency of inappropriate pedestrian crossings.
- The driver/vehicle was at fault in nearly two-thirds of the accidents so audible signals would not have helped in such cases.
- The pedestrian was at fault in just over one-third of the accidents following APTS installation. These accidents occurred either in the year of APTS installation or during the following year. No pedestrian-caused accidents occurred in the second full year following APTS installation. It appears that APTS may be beneficial to all pedestrians once they become familiar with them. Therefore, public educational programs regarding APTS should accompany their installation.
- Because fewer persons under age 17 were involved in accidents following APTS installation, audible signals may especially help young people to cross streets more safely.
- There is substantial support for audible signals from the surveyed organizations and from professional that provide training services to visually impaired pedestrians.
- Many blind persons, once properly trained, find the audible signals useful in helping them to cross streets safely and with greater confidence. However, a minority of respondents do not want audible signals and believe that they would not be useful to blind pedestrians.
- Programs should be established at senior citizen centers and other similar agencies to instruct older adults, who are developing vision impairments as part of the aging process, in pedestrian safety and how to use audible signals.
- Some visually impaired persons had difficulty finding the traffic light pole and push button that activated the WALK light. Standardizing the location of such poles and their push buttons at corners of intersections would therefore be helpful.

Additional research is needed to address several unanswered questions: What is the impact of the Sonalert and other types of audible signals on pedestrian accident rates? Although the number of pedestrian accidents at the intersections studied did not change, did the installation of APTS reduce the pedestrian accident rate if vehicular and pedestrian traffic volume changes were taken into account? Would expanding the traffic accident rates beyond the 2 years following APTS installation establish a clearer trend as to their impact on pedestrian traffic safety?

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