

**Research Report
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USE OF AUDIBLE PEDESTRIAN SIGNALS

by

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EXECUTIVE SUMMARY

Audible pedestrian signals are a device used to provide additional traffic control at signalized intersections to aid visually impaired pedestrians. An objective of this study was to determine the status of the use of this device and investigate possible guidelines for possible future installations of audible pedestrian signals in Kentucky. Another specific objective was to investigate the need for such signals at a number of intersections at the University of Kentucky.

The study showed that audible pedestrian signals can be used to supplement the standard pedestrian signals. However, their use must be limited to intersections with a demonstrated need and a standard method of use must be adopted. To provide uniformity, the same device should be used for any new installations in Kentucky as has been used in the past.

When guidelines are provided in the MUTCD, the signals must be adapted to conform to those standards. In the interim, a list of guidelines was given for locations where an audible pedestrian signal should be considered. Also given are some interim guidelines for the installation of these signals.

Conclusions were reached that audible signals should be added to one approach at three intersections at the University of Kentucky. Use of the audible signal must be coordinated through groups representing the visually impaired so that proper training is provided. Any new installations should be monitored with any necessary changes made to the guidelines for where they should be considered and how they should be installed.

1.0 INTRODUCTION

There has been concern over the need for additional traffic controls at signalized intersections to aid visually impaired pedestrians. Audible pedestrian signals are one type of device used for this purpose. Audible signals emit various types of sounds to aid the visually impaired in crossing the street. They have been used, in varying degrees, in many cities across the United States. There has been a limited use of audible signals in Kentucky with requests for expanded use of this signal. However, to date this device has not been recognized as a standard device in the Manual on Uniform Traffic Control Devices (MUTCD) which is incorporated in Kentucky's traffic laws.

An objective of this study was to determine the status of the use of this device and investigate the use of guidelines for possible future installations of audible pedestrian signals in Kentucky. Another specific objective was to investigate the need for such signals at a number of intersections at the University of Kentucky.

2.0 BACKGROUND

This study was started as a result of requests made for the installation of audible pedestrian signals at several intersections in Lexington at the University of Kentucky campus and at an intersection in Frankfort. There has been a reluctance by the Kentucky Transportation Cabinet to install audible pedestrian signals at locations where turning vehicles would cross the pedestrian crosswalk.

One reason for the hesitancy has been the lack of a recognized national standard concerning where such a signal should be used or the method of installing the signal. Potential liability questions may arise when installing traffic control devices that have not been recognized as a standard device. An audible signal is not specifically mentioned in the current version of the MUTCD which has been incorporated in KRS 189.337 under Kentucky's traffic laws.

A second reason for the reluctance to install the audible signal is that the typical audible signal does not provide an audible clearance interval for the visually impaired. The audible signal is only typically provided during the WALK indication with no audible signal during the flashing DONT WALK indication. The MUTCD requires (Section 4D-7) that a pedestrian clearance interval shall always be provided where pedestrian indications are used and shall consist of a flashing

DONT WALK indication. This requirement may be met for visually impaired pedestrians without providing an audible clearance interval since the time for the flashing DONT WALK indication is available for all pedestrians.

The possibility of prohibiting turns on red and installing audible signals has been mentioned. However, any expanded use of audible signals has been delayed until an adoption of relevant standards.

The Americans with Disabilities Act (ADA) Transportation Work Group has submitted guidelines to the Transportation Cabinet to follow when considering the installation of audible signals. The guidelines consist of the 12 evaluation factors developed in San Diego. The ADA Transportation Work Group recommended a process where a committee made up of a person with a visual loss, a mobility instructor, and an engineer with the Transportation Cabinet evaluate the need at specific locations.

The current status of audible signals relative to the MUTCD was investigated. The MUTCD is currently being revised but the new version will not be published for some time. It appears that audible pedestrian signals will be included in an updated version of the MUTCD. It is anticipated that standards will be provided in an upcoming version of the MUTCD dealing with how to use audible signals but there is no indication that warrants will be provided for where to use this device. The interpretation given was that the current MUTCD does not prohibit the use of audible pedestrian signals. Audible signals would be considered as a supplement to the typical pedestrian signal. The time needed for a clearance interval for visually impaired pedestrians would be provided by the flashing DONT WALK indication. Using this interpretation, an audible clearance interval would not be required when an audible WALK indication is provided. After the requirements of the MUTCD are met with the standard pedestrian signal, additional information is provided to the visually impaired through the audible signal.

3.0 CURRENT USE IN AREA

In Kentucky, audible pedestrian signals are currently installed in Louisville, Lexington, and Frankfort. The only installations by the Transportation Cabinet are one in Frankfort and three in Lexington (two at the University of Kentucky and one at a seniors center). There are several (12 to 15) in Louisville which have been installed by the city. Most of the Louisville signals are placed near the Kentucky School for the Blind and the University of Louisville. Others are near a vocational school and a community center.

All of the audible signals currently used in Kentucky are the type using different bird sounds for the different directions of travel. The audible tone is provided only during the WALK indication. Push buttons are provided to actuate the pedestrian signal. At some of the Louisville intersections, a special curb marking (yellow with a raised portion) was provided. Turn prohibitions signs were noted at several of the intersections.

The installations were made in response to requests and study. Louisville conducts a 12-hour traffic count and pedestrian count. The pedestrian count classifies into categories including the visually impaired, wheelchair use, elderly, and children.

The use of audible signals in Cincinnati was also investigated. There are about 20 to 25 intersections with audible signals in Cincinnati with about one intersection added each year. The city works with various associations when deciding where to place these devices. A study of the intersection is conducted but intersections are no longer rated as was done when the program started. Ratings were originally done to identify the intersections with the most need with no specific level identified as the point where an audible signal should be installed. The intersection must be near a specific destination or generator with use of more than one visually impaired pedestrian per day. Typically no more than five visually impaired pedestrians will use any given intersection so pedestrian counts are not conducted. Turn prohibitions are considered but are not typically used. The Sonalert device is used. It provides a different tone for the north-south and east-west directions. A constant tone is provided during the WALK indication with an intermittent tone provided during the DONT WALK indication. This provides an audible clearance interval. All pedestrian buttons are placed at the same location on the pole (about two to four feet from the handicapped ramp) with the pole placed at a standard location when possible.

4.0 LITERATURE REVIEW

A review of the literature was conducted as part of the study. Summaries of some of the relevant articles in this area are given in the Appendix. Various types of audible signals have been installed in the United States for over 40 years with this type of signal used in over 100 cities nationwide. Surveys have been conducted to determine opinions on the use of this signal. The results have shown that most groups favor their use. The opposition has had concerns about: the effect of the signals on the independence of the visually impaired, providing a false sense of security, noise problems, the lack of standards, and the ability to properly use the signal. The limited amount of comparisons of accident data before and after

installations of audible signals have not found any significant differences.

Two types of devices have been used. The most common type of device is made by Nagoya Electric works. This unit emits a cuckoo sound for the north-south direction and a chirp sound for the east-west direction. The other device, which is used most often in the eastern United States, is a Mallory Sonalert buzzer which typically consists of a constant tone for east-west crossings and a buzzer sound for north-south crossings. In almost all installations, the signals only sound during the walk phase. The exception is in Cincinnati where a Sonalert unit is used which has been adapted so that a constant sound is given during the WALK signal and an intermittent sound is given during the flashing DONT WALK indication.

No detailed warrants have been developed for the use of audible pedestrian signals. There have been no reports which have recommended specific criteria above which audible signals should be used. The most detailed guidelines were developed in San Diego. A list of five basic considerations and 12 evaluation factors are used as a ranking system. The basic considerations are as follows:

1. Intersection must be signalized.
2. Audible signals must be susceptible to retrofitting.
3. Audible signals should be equipped with pedestrian signal actuations.
4. Location must be suitable to installation of audible signals in terms of land use, noise level, and neighborhood acceptance.
5. There must be a demonstrated need for the audible signal device.

The evaluation factors concerned intersection safety, pedestrian usage, traffic conditions, and mobility evaluation. Each of 12 factors were given a score from zero to five with the total used to rank an intersection for its need for an audible pedestrian signal. The following factors are considered.

1. pedestrian accident record,
2. intersection configuration,
3. width of crossing,
4. vehicle speed,
5. proximity to facilities for visually impaired,
6. proximity to public facilities,
7. number of transit stops and/or routes,
8. passenger usage,
9. heavy traffic flow,
10. light traffic flow,
11. uneven traffic flow,
12. mobility evaluation.

There have been no national standards developed for the installation of this device. The criteria which has been used in several cities was first developed in Huntington Beach, California. The following 12 criteria have been used.

1. Must not be annoying to the average pedestrian or resident.
2. Must have noise levels measured at an intersection from 10 to 120 decibels.
3. Must be low cost.
4. Must have upper and lower volume limits.
5. Simple, low-cost installation is required.
6. Must require minimal maintenance, if any, in a harsh environment.
7. Must be mechanically adjustable as to direction.
8. Should not require any extra wiring to the cabinet.
9. Should not in any way interfere with normal signal operation.
10. Must only operate when the WALK indication is displayed.
11. Must have a different, easily distinguishable sound for each direction.
12. Should operate either by pedestrian actuation, time clock, or both.

5.0 INTERSECTION CHARACTERISTICS

Requests had been made by various groups and individuals associated with the visually impaired to place audible pedestrian signals at three intersections at the University of Kentucky campus. These intersections are: 1) Rose Street and Washington Avenue, 2) Rose Street and Columbia Avenue, and 3) Euclid Avenue and Martin Luther King Boulevard.

All three of these intersections are "T-type" intersections with three approaches. This is one type of intersection identified by the literature as a candidate for audible signals. This type of intersection is a problem because the sounds of parallel traffic are used by the visually impaired to cross streets. The sound of an idling vehicle and then the noise as it accelerates across the intersection can be used. The lack of parallel traffic and the turning movements at "T-type" intersections present a problem.

Both of the intersections on Rose Street have protected/permissive left turn phasing. There are no other intersections between Washington Avenue and Columbia Avenue which have a traffic signal. The distance between the two intersections is slightly under 1,000 feet. There is a bus stop located between the intersections. The bus stop is located close to the Columbia Avenue intersection. Rose Street has a width of 40 feet with both side streets 25 feet in width. Between Washington Avenue and Columbia Avenue, Rose Street has two lanes separated by

an 8-foot nonmountable median. There is a separate left turn lane on the approach from which turns can be made to the side street. There are marked 4-foot wide bicycle lanes on both sides of Rose Street. Both Washington Avenue and Columbia Avenue are two lane streets with no turning lanes. Signs note that Rose Street is in a school zone with a reduced regulatory speed limit of 25 mph on Monday through Friday from 8 am to 4 pm. Signs also prohibit turns on red at the two intersections during this same time period. Both intersections have pedestrian signals with push button actuation. The Faculty Center is located on Rose Street adjacent to Columbia Avenue.

Euclid Avenue is a two lane road. There is no separate turning lane or left turn phase for traffic turning onto Martin Luther King Boulevard. The width of Euclid Avenue is about 34 feet east of the intersection and 53 feet west of the intersection. Parking is allowed on the north side of Euclid Avenue west of the intersection. Turns on red are prohibited at all times. Pedestrian signals are provided and are actuated with push buttons. The Martin Luther King Boulevard approach is 36 feet in width at the intersection with separate left and right turn lanes. Dormitories are located in the northwest quadrant of the intersection with the Student Center located immediately south of the intersection. A bus stop is located on Euclid Avenue west of the intersection. The speed limit on Euclid Avenue is 30 mph.

Traffic volume information was reviewed. Counts showing 24 hour volumes through the intersections were 20,500 at Rose Street and Washington Avenue, 17,400 at Euclid Avenue and Martin Luther King Boulevard, and 16,200 at Rose Street and Columbia Avenue. These counts were taken between 1991 and 1993.

6.0 PEDESTRIAN VOLUME

Pedestrian volume counts were made at the three proposed intersections at the University of Kentucky. The counts were conducted between 8 am and 4 pm and were summarized hourly with totals for each approach and subcategories of obviously visually impaired pedestrians (using guide dog or cane), pedestrians in wheelchairs, and pedestrians classified as elderly or a child. The number of pedestrians crossing in the crosswalk were divided into two categories. These were crossing during the the WALK or flashing DONT WALK indications and those crossing during the steady DONT WALK indication. Pedestrians crossing near the intersection, but not at the crosswalk, were also counted since this is a common occurrence at these intersections.

Available information indicates there are currently four totally visually impaired students at the University of Kentucky. In addition, there are other

visually impaired persons who may not be identified by the pedestrian count. Only one visually impaired pedestrian was counted at the two Rose Street intersections. It was learned that they were told, by a mobility specialist, not to use these intersections because of the problem with crossing Rose Street. There was a small number of visually impaired pedestrians (five) counted at the Euclid Avenue intersection. This is primarily related to a nearby dormitory.

A total of 1,831 pedestrians were counted at the Euclid Avenue and Martin Luther King (MLK) Boulevard intersection during the eight hour period. Three crossing areas were counted (crossing Euclid Avenue on the west and east side of MLK and crossing MLK). Most of the pedestrians (59 percent) were observed crossing Euclid Avenue west of MLK. This was the crosswalk used by all five of the visually impaired pedestrians. Fifteen percent did not cross at the crosswalk while 55 percent used the crosswalk during a steady DONT WALK indication. The WALK indication was only displayed if the push button detector was used. Three pedestrians using wheelchairs were observed with two crossing Euclid west of MLK. Five pedestrians were classified as children with seven classified as elderly.

A total of 2,216 pedestrians were counted at the Rose Street and Columbia Avenue intersection. The majority of the pedestrians (71 percent) were crossing Rose Street on the south side of Columbia Avenue with most (68 percent) crossing at the crosswalk. Most of the pedestrians who used the crosswalk on Rose Street crossed during the steady DONT WALK indication. There was a large volume of pedestrians (23 percent) crossing Columbia Avenue with most using the crosswalk and crossing during the WALK or flashing DONT WALK indications. One visually impaired pedestrian was observed (crossing Columbia Avenue). Three pedestrians using wheelchairs were observed. No pedestrians were classified as children with six classified as elderly.

A total of 4,669 pedestrians were counted at the Rose Street and Washington Avenue intersection. The majority of the pedestrians (61 percent) were crossing Rose Street on the north side of Washington Avenue with the large majority (82 percent) of the pedestrians on this crossing not using the crosswalk. There is a raised median on this side of the intersection which is used as a refuge during the crossing maneuver. Most of the remaining pedestrians (33 percent) used the crossing on Rose Street on the south side of Washington Avenue with only about three percent not using the crosswalk. No visually impaired pedestrians were observed at this intersection. Two pedestrians using wheelchairs were observed with two pedestrians classified as children and three classified as elderly.

7.0 ACCIDENT DATA

Accident data were obtained at the intersections under consideration as well as at intersections currently having an audible signal. All pedestrian accident data in Fayette County for the three-year period of 1993 through 1995 were reviewed. Only one pedestrian accident was identified as occurring at any of these intersections over this three-year period. This was a 1993 accident at Rose Street and Columbia Avenue. This analysis shows that, while the large pedestrian volume indicates the potential for pedestrian and motor vehicle conflicts, there has not been any documented accident problem at any of these intersections.

The latest statewide summary of Kentucky traffic accident data showed there was 654 pedestrian/motor vehicle accidents in Fayette County in the five-year period of 1991 through 1995. Fayette County had a relatively high annual pedestrian accident rate (accidents per 10,000 population) compared to all other counties in the state although there were three counties in its population category with a higher rate (Kenton, Jefferson, and Campbell). When cities were considered, Louisville had a substantially higher rate than Lexington. The highest pedestrian accident rates were in Newport and Covington.

8.0 CONCLUSIONS

The study showed that audible pedestrian signals can be a useful device to provide additional information to the standard visual pedestrian signal. However, their use must be limited to intersections with a demonstrated need. Also, a standard method of use must be adopted.

Audible pedestrian signals can only be used as a supplement to the standard pedestrian signals. They can only be used where there are existing pedestrian signals which are actuated by a push button. When used in this manner, they provide additional information for the visually impaired and are not in violation of the MUTCD. While an audible clearance interval is not provided in the device currently used in Kentucky, the clearance interval is provided through the standard pedestrian signal. The audible signal serves to supplement the WALK indication which provides an audible cue for the start of the cycle. This is particularly important at intersections where parallel flow does not provide this information (such as a "T" intersection).

In order to provide guidance in the interim, prior to inclusion of the audible signal in the MUTCD, the following guidelines are given for intersections where the use of audible pedestrian signals should be considered.

- a. the intersection must have a traffic signal with a pedestrian signal,
- b. the pedestrian signal must be equipped with push button pedestrian detectors,
- c. there must be a demonstrated need for the audible signal (such as proximity to facilities used by the visually impaired),
- d. there should be a formal written request for the audible signal by a group or individual representing the visually impaired,
- e. the intersection presents a problem for the visually impaired (i.e. "T" intersection, uneven traffic flow),
- f. there should be a commitment by a group representing the visually impaired that training will be provided to any visually impaired pedestrian which may use this intersection,
- g. noise from the audible signal does not present a problem to adjacent residences or businesses, and
- h. should be considered at mid-block signals installed for pedestrians.

Using these guidelines, the investigation results in the conclusion that it would be logical to add an audible pedestrian signal at the Euclid Avenue and Martin Luther King intersection. This is a "T" intersection and is adjacent to student housing for the visually impaired and the student center. Pedestrian counts have documented usage by the visually impaired at this intersection.

These guidelines also indicated that an audible signal should also be considered for at least one of the two Rose Street intersections. The need is related to the difficulty in crossing Rose Street at these "T" intersections. The Rose Street and Columbia Avenue intersection would appear to provide the best current alternative if only one intersection is selected because it is located closer to a bus stop and adjacent to the Faculty Center. However, a demand will be generated at the Rose Street and Washington Avenue after the new library is opened. Therefore, it would be logical to install audible signals at both of these "T" intersections.

"No turn on red" signs should be maintained at these intersections. Consideration should be given to using the audible signals on only one crosswalk across the major street (Euclid Avenue and Rose Street) at each intersection with no signal needed on the cross street. This would eliminate possible confusion with different sounds for crossing in different directions. The recommended crosswalk would be on the west side of the Euclid Avenue and Martin Luther King Boulevard intersection, the north side of the Rose Street and Columbia Avenue intersection,

and the south side of the Rose Street and Washington Avenue intersection. This would eliminate the conflict between the visually impaired and left turning vehicles from the side street. Use of the audible signal must be coordinated through groups representing the visually impaired so that proper training is provided.

To provide uniformity, the same audible device should be used for the new installations as has been used in the past. The possible addition of an audible clearance interval may be considered in the future. As an interim measure prior to standards from the MUTCD, the following guidelines should be considered when audible pedestrian signals are installed. The signals must be adapted to conform to future standards provided in the MUTCD.

- a. the audible signal should only be activated when a push button pedestrian detector is activated,
- b. there should be a method of adjusting the noise level, such as by time of day,
- c. the push button detectors should be located at a standard location so that they can be located as easily as possible by the visually impaired (the use of a device to aid in the location of the detectors should be considered),
- d. the audible signal should operate when the WALK indication is displayed,
- e. consideration should be given to providing the maximum allowed length of the WALK interval (using MUTCD guidelines) to provide the maximum audible length,
- f. different sound must be used for different directions,
- g. when installed at a "T" intersection, the audible signal should not be used on the main street approach where there is a conflict between pedestrians and left turning vehicles from the side street, and
- h. turns on red should be prohibited at the intersection.

The effects of the installation of any new audible pedestrian signals on the volume of visually impaired pedestrians and any resulting problems are unknown. Any new installations should be monitored with any necessary changes made to the preceding lists of guidelines for when these signals should be considered and how they should be installed.

APPENDIX

SUMMARY OF LITERATURE REVIEW

Brabyn, L.A. and Brabyn, J.A.; "An Evaluation of Talking Signs for the Blind," Human Factors, Vol. 25, No. 1, February 1983.

This study evaluated the effectiveness of an electronic navigational system. The system consists of signs that transmit an infrared signal along with a hand held receiver that decodes the signal into speech output. The test concluded that the electronic navigational system was more effective than raised print labeling.

Daviess, E.; "Signals for Blind Pedestrians," Traffic Engineering and Control, Vol. 16, No. 4, April 1975.

A research project dealing with signals for the blind in Australia found that conveying information to blind pedestrians can be achieved by audible or tactile means. There does not appear to be a preference among the blind between audible and tactile devices. An example is a device referred to as "pelicans" which have a piezo-electric sound generator with an intensity between 80 and 120 dB at one meter.

A device used in Sweden is an audible ticker within the push button signal activator which pinpoints its location and increases in frequency from 75 per minute to 750 per minute during the walk period. In Japan, a pattern of braille tiles is installed on the pavement near the crossings and studs are installed along the edge of the crossings.

"Evaluation of Audible Pedestrian Traffic Signals," San Diego Association of Government, December 1988.

This study had three components: 1) an analysis of equipment used, 2) description how the signals are used and evaluated by the visually impaired, and 3) determining their impact on pedestrian accidents.

The two most common signal devices used are the Sonalert buzzer and Nagoya audio signal. The Nagoya signal is used widely in the western United States and almost exclusively in California and was chosen for a detailed analysis. This unit emits bird sounds consisting of a cuckoo sound for the north-south direction and a chirp sound for the east-west direction. The east-west chirp was found to be more easily heard in traffic than the north-south cuckoo. Results

showed the sounds were not highly directional and precise aiming of the units was unnecessary. The older visually impaired and the younger sighted test subjects detected the sound of the signals more readily than the older sighted subjects.

A survey found that more than three-quarters of the organizations which serve the visually impaired, with a position on audible signals, support their use. The opposition of the National Federation of the Blind was noted. More than 80 percent of these organizations have had experience with the signals and two-thirds of those found it positive. Several respondents commented that the signals should be located only at intersections with an unusual configuration or uneven traffic flow. Several respondents also commented that the signals should be installed at three leg or offset intersections and where there is little parallel traffic to provide cues for crossing. It was noted that instruction on the proper use of the signals is required.

A survey of mobility instructors showed that their clients generally liked the feeling of safety which using the audible signal gave them. Problems in using the signals included locating the pole with the push button and realigning at the curb once the signal is actuated. The pole should be located as close as possible to the corner. A tactile marker on the edge of the curb at the pedestrian crosswalk would help cane users realign for crossing.

A survey of educational agencies found that high school students were trained to use the signals in areas where the students frequently travel, after they can travel using traffic sound cues. College students and faculty were supportive of having audible signals at campus intersections. Instructors felt the signals were most useful where traffic cues are not adequate, such as at 3-leg intersections or at intersections with very light traffic on one street.

A survey of cities in North America showed that about half had audible signals at only one or two intersections. The state with the most signals was California with the largest number in San Diego. Most signals are installed in business districts, at colleges with programs for disabled students, and at service centers for persons with vision impairments and for senior citizens. Several California cities have received complaints about noise caused by the signals from nearby residents and businesses. Some cities have installed timers to turn off the signals at a certain time each night. Several cities have had the signals vandalized.

Only five cities were identified which had any criteria or policy statements for determining where the signals should be installed. The criteria for use was an identified need by visually impaired or elderly persons and proximity to facilities serving or being used of these groups. The equipment must emit a directional sound with the sound typically emitted only during the WALK indication. One city

also had a sound during the flashing DONT WALK indication. There should be no sound during the steady DONT WALK indication. There must be different sounds for north-south and east-west directions. The equipment should be reasonably priced with a low maintenance cost, have the ability to accommodate certain noise levels with adjustable volume levels, and not interfere with traffic signal operation. The sound should not be annoying to persons nearby. The intersection must be signalized with pedestrian actuated buttons present and the signals capable of being retrofitted. Other location considerations are the compatibility of the surrounding land, the accident experience, intersection configuration, vehicle speed, and traffic flow.

The only city in which specific numerical guidelines were listed was San Diego where points were assigned for several variables. The variables included accident records, intersection configuration, width of crossing, vehicle speed, proximity to facilities for the blind, proximity to facilities utilized by all pedestrians, access to public transit, traffic flow (heavy, light, or uneven), and mobility and miscellaneous factors. An intersection was given a rating for comparison purposes. A threshold level at which an audible signal was needed was not identified.

Pedestrian traffic accidents were reviewed at 60 intersections before and following installations of audible pedestrian traffic signals. Results showed there was no difference in the numbers of accidents before and after installation of the signals.

Goode, J. A.; "Innovative Pedestrian Signals and Crossing," Federal Highway Administration, 1996.

The goal of this paper was to find new devices used at pedestrian crossings along with their costs, effectiveness, and warrants. Audible pedestrian signals were one type of device evaluated. They are usually placed at locations where visually impaired people travel extensively such as near agencies serving the visually impaired, government offices, shopping, transit, or tourist centers, and at complex intersections. No specific warrants for their use has been developed.

Concerns include possible noise pollution, disturbing area residents and businesses, ambient noise masking the audible sound, confusion of the audible sound with another sound, and instilling a false sense of security such that pedestrians will not pay attention to other important traffic cues.

Other innovative pedestrian devices were discussed. They included a hand-

held transponder to use to find the signal pole, a guide strip to guide the pedestrian to the signal pole, a touch post to initiate the detection sequence, a device used by a visually impaired pedestrian which would increase the time for the walk interval, and detection devices to detect slow pedestrians in the crosswalk and adjust the time for the walk interval.

McKay, B.; "Audible Pedestrian Signals, Ohio Institute of Transportation Engineers, September 1984.

This report describes the initial use of audible pedestrian signals in Cincinnati. Since visually impaired persons are taught to cross the street at traffic signals by listening to the sounds of stopping, starting, and moving traffic, right-angled cross intersections with two-phase signals were not considered for initial locations. Acute-angled intersections, offset intersections, intersections with pedestrian refuge islands, and intersections with protected left-turn phases were initially considered. At these intersections, there is a need to know when and where to begin crossing as well as an audible device at the far side of the crosswalk to provide a homing target.

A design using a steady, constant tone during the WALK indication, a pulsating tone during the flashing DONT WALK, and silence during the steady DONT WALK was used. A buzzer was used for the east-west crosswalks. There were minor complaints about noise. A refinement to minimize the noise would be to operate the device with a push button.

The conclusions were that audible pedestrian indications can be useful in specialized applications and that it is important to have a pedestrian clearance indication.

Oliver, M.B.; Fegan, J.C.; and Ardekani, S.A.; "Audible Pedestrian Signals-Current Practices and Future Needs," ITE Journal, June 1990.

The objectives of the study were to document the types of devices in use and recommend conditions under which the installation of such devices are advisable. It focused on documenting the current practices concerning the manufacture, installation, and operation of audible pedestrian signals. A survey was sent to organizations for the visually impaired, city traffic engineers, audible pedestrian

signal manufacturers, and orientation and mobility specialists. Of the 69 respondents, 36 supported audible signals, 13 were opposed, and 20 had no opinion. Those in favor emphasized the utility of the signals in areas with unusual geometrics or short cycle lengths. Those opposed were concerned with reliability and the dependency that they may cause among the visually impaired.

Many of the automatic devices emit different sounds to indicate which direction to cross and how much time is available for crossing. The two most popular emit a buzzer or a birdcall sound. The signal used most frequently in the eastern United States is a general-purpose buzzer. The cost to implement this device can vary from \$500 at a semiactuated intersection to \$8000 at a pretimed controlled site since a new controller must be installed. The signal most frequently used in the western United States emits a "peep-peep" tone for the east-west direction and a "cuckoo" tone for the north-south crossings. Total costs for the products, materials, and labor range from \$3,700 to \$4,500.

San Diego developed a quantitative ranking system for the installation of audible signals. Basic considerations are that: 1) the intersection is signalized, 2) the audible signals be susceptible to retrofitting, 3) the audible signals be equipped with pedestrian actuations, 4) the location is suitable in terms of land use, noise level, and neighborhood acceptance, and 5) there is a demonstrated need. There are four groups of evaluation factors in the areas of intersection safety, pedestrian usage, traffic conditions, and mobility evaluation with 12 factors identified. These factors are: 1) pedestrian accident record, 2) intersection configuration, 3) width of crossing, 4) vehicle speed, 5) proximity to facilities for visually impaired, 6) proximity to public facilities, 7) number of transit stops, 8) passenger usage, 9) heavy traffic flow, 10) light traffic flow, 11) uneven traffic flow, and 12) mobility evaluation.

The first known criteria for the operation of audible pedestrian signals was developed in Huntington Beach and has been adopted by many other cities. A list of 12 suggested criteria follows: 1) must not be annoying, 2) noise levels at intersection from 10 to 120 decibels, 3) low cost, 4) upper and lower volume limits, 5) simple, low-cost installation, 6) minimal maintenance, 7) mechanically adjustable as to direction, 8) not require any extra wiring to the cabinet, 9) not interfere with normal signal operation, 10) operate only when the WALK indication is displayed, 11) have a different, easily distinguishable sound for each direction, and 12) operate either by pedestrian actuation, time clock, or both.

The conclusion was that audible pedestrian signals are feasible but only at certain complex or confusing intersections that are frequented by the visually impaired.

Oliver, B. O., "Audible Pedestrian Signals: A Feasibility Study," Federal Highway Administration, Report FHWA-RD-89-205, February 1989.

This report represents an effort to determine the feasibility of audible pedestrian signals. These signals are devices which give auditory cues to help the visually impaired cross safely at difficult intersections. Surveys were sent to over 100 organizations, audible signal manufacturers, and cities who have knowledge of the devices, and responses were analyzed. The devices were found to be feasible but only at certain complex and confusing intersections. Twelve criteria for the installation of the devices were developed as were twelve criteria for the operation of the devices. Buzzers, constant tones, bird calls, and voice signals were examined by obtaining information from traffic engineers who had experience with each sound. It was determined that intermittent tones were the most effective for human localization. For the most widely used devices, cost data were developed for the products, installation, and maintenance. A partial listing of the U.S. and foreign cities which have the devices was compiled along with a partial listing of audible signal manufacturers. The problems the visually impaired face as well as their suggested solutions were listed.

Installation and evaluation criteria were developed in San Diego to provide a method of establishing a priority listing. There is not a certain level above which an audible signal is warranted. Basic considerations were that the signal must be signalized, must be subject to retrofitting, should be equipped with pedestrian signal actuations, must have suitable land use, noise level, and neighborhood acceptance, and must have a demonstrated need. A team consisting of a traffic engineer, a mobility instructor, and a visually impaired person rates candidate intersections based on twelve evaluation factors. These factors are pedestrian accident records, intersection configuration, width of crossing, vehicle speed, proximity to facilities for the blind, proximity to facilities used by all pedestrians, number of transit routes and stops, number of transit passengers, heavy traffic flow, light traffic flow, uneven traffic flow, and mobility factors.

There was a discussion of the twelve installation criteria suggested by Huntington Beach. 1) The signal must not be annoying to the average pedestrian or resident. An annoying signal would elicit the resentment of both the impaired and sighted with the visually impaired identified with this signal. 2) Noise levels should be between 10 and 120 dB. Levels less than 10 dB will not command attention with those in the 120 dB range annoying. 3) It must be low cost to enable cities to afford the devices. 4) They must have adjustable upper and lower volume limits to account for the variation in traffic noise levels between peak and non-peak hours. 5) A simple, low-cost installation is required to encourage use. 6) The device

must require minimal or no maintenance in order to gain the confidence of the pedestrian. 7) The signal must be mechanically adjustable as to direction to allow for lower sound levels and to provide the pedestrian with a sound from his initial corner as well as a sound to home in to from the destination corner. 8) It should not require any extra wiring to the cabinet, although some wiring may be required to provide a clearance interval. 9) It should not interfere with the normal vehicle signal operation or a malfunction could interfere with the entire intersection signal operation. 10) The criteria concerning operation only during the WALK interval has been debated since this does not provide an audible clearance interval. 11) It must have a different, easily distinguished sound for each direction so there will not be confusion concerning which crossing is clear. Different manufacturers use different types of sounds. 12) The device should operate either by pedestrian actuation, time clock, or both so it would not be heard continuously throughout the day and would not disturb nearby residents during times of low traffic noise.

Oliver, M. B.; "Guidelines for Audible Pedestrian Signals," Public Roads, Vol. 53. No. 2, September 1989.

Over 100 cities have installed audible pedestrian signals. San Diego developed criteria for installation. Basic considerations included that the intersection is signalized, hardware is capable of retrofitting, audible signal is equipped with pedestrian actuators, location is suitable in terms of land use, noise level, and neighborhood acceptance, and there is a demonstrated need. The specific factors dealt with pedestrian accident records, intersection configuration, width of crossing, vehicle speed, proximity to facilities for the blind or visually impaired, proximity to key facilities utilized by all pedestrians, number of transit stops, passenger usage, heavy traffic flow, light traffic flow, uneven traffic flow, and mobility evaluation.

The two most popular audible devices in the United States use either a buzzer or a bird call sound. The most frequently used signal in the eastern United States is the Mallory Sonalert buzzer. Cincinnati uses the Sonalert device in a system which consists of a constant tone for east-west crossings and a buzzer sound for north-south crossings. During the WALK indication, a constant tone or buzzer sound is given. During the pedestrian clearance interval, a sound pulses in cadence with the flashing DONT WALK indicator. The sound is emitted only upon demand.

The audible signal used most frequently in the western United States is manufactured by Nagoya Electric Works. The tone for the east-west direction is "peep-peep" while the north-south tone is "cuckoo".

Tageldin, S.; "Talking Signs Signal Transportation Future," PTI Prism, Winter 1994/95.

San Francisco is using remote infrared signs that "talk" to the visually impaired giving travel guidance. The typical audible signal given a sound that does not give pedestrians precise information on their location. The Talking Sign consists of a transmitter that broadcasts recorded voice messages over infrared beams and a receiver that converts those infrared signals back into speech. This device has been used at 14 street crossings in downtown San Francisco which is the only city in North America currently using this system. It delivers two types of detailed messages. The first fixed message of no more than 30 seconds identifies the pedestrian's location, position, and direction. The second message, updated every five seconds, indicates the fluctuating status of the traffic signal at a given crosswalk. The new generation of Talking Signs will not only direct pedestrians when they reach an intersection but will transmit the message as a pedestrian goes up a sidewalk indicating the corner that is being approached.

Templer, J.; "Provisions for Elderly and Handicapped Pedestrians: Vol. I Executive Summary," Federal Highway Administration, FHWA-RD-79-1, January 1979.

Blind subjects were used to determine if they would have a problem with detecting curb ramps. The overwhelming majority of the blind subjects had little difficulty in detecting the ramps and accurately determining the top and the bottom of the ramps. It was noted that a lip, or step, at the bottom of the ramp should not be provided. Where the junction between the curb ramp and the street or walkway is not obvious in that the gradient differential is 1:20 (or less steep), then the ramp should be finished with a surface that is detectable by the blind.

One type of active environmental cue that has been suggested is the use of detectable, special walkway surfaces to inform or alert visually impaired pedestrians. In those locations where a detectable walkway surface can be used to provide warnings or general navigational information, at least a 48 inch length of the walkway should be treated. Either a resilient material should be considered or strips of thermoplastic 6-inch wide and set 6 inches apart across the walkway. If an exposed aggregate such as pea gravel is to be formed in the walkway, this should not be made so rough that it will affect adversely the passage of people in wheelchairs and other handicapped pedestrians.

Uslan, M. M.; Peck, A. F.; and Waddell, W.; "Audible Traffic Signals: How Useful Are They?", ITE Journal, September 1988.

This paper reports a controlled study of 27 blind persons who attempted to cross three intersections equipped with audible pedestrian signals and one without. The intersections represented differing degrees of complexity.

The subjects experienced difficulty in finding the pedestrian pole at street corners. This was most difficult for the subjects who used guide dogs. Tactile guide strips were installed at two intersections and were used by a minority of the subjects. Some were confused by the tactile strips and were guided to the wrong pole. For many reasons, many subjects did not succeed in crossing the streets. Most failures were related to the problem of locating the correct pedestrian pole and button.

Subjects crossed the street in less time at intersections with audible signals. Interviews showed that the subjects and instructors felt the audible signals were more of a help than a hindrance. They recommended installation of these signals in their community, but only at intersections that are difficult to cross. Examples would be: "T" type intersections, intersections with left-turn or right-turn storage lanes, intersections where there is periodically light traffic, intersections with wide streets, and intersections with confusing traffic patterns.

While audible signals provide an extra measure of safety, they have the drawback of requiring intensified listening at complex intersections. The key to overcoming this drawback is pedestrian education and training through instruction and practice.

Wilson, D. G., "The Effects of Installing an Audible Signal for Pedestrians at a Light-Controlled Junction," Transport and Road Research Laboratory, 1980.

A before and after study at an intersection with an audible signal reduced pedestrian reaction times. The figures applied to all pedestrians and not just the visually impaired due to their small number in the population. The time taken to cross the road by pedestrians initiating their crossing in the walk phase decreased by five percent. Pedestrian delay after the onset of the walk phase decreased by over 20 percent. For those starting to cross during the walk phase a significant reduction was obtained in the proportion failing to complete their crossing before the vehicle indications began.