Accessible Pedestrian Signals

Work performed under contract by:

Billie Louise Bentzen, Ph.D.
Lee S. Tabor, AIA
Accessible Design for the Blind
P.O. Box 1212
Berlin, MA 01503
978-838-2307 voice / faxb
bentzen@ma.ultranet.com

August 1998

U.S. Access Board •1331 F Street, NW • Suite 1000 • Washington, DC 20004-1111

800-872-2253 (Voice) • 800-993-2822 (TTY) • 202-272-5447 (Fax)

info@access-board.gov (e-mail) • http://www.access-board.gov (Website)

Contents

Accessible Pedestrian Signals

Introduction

The Transportation Equity Act for the 21st Century — TEA-21, the successor to ISTEA — directs that pedestrian safety considerations, including the installation of audible traffic signals, where appropriate, be included in new transportation plans and projects [Sec. 1202(g)(2)]. The bill was signed into law by the President on June 9, 1998.

Accessibility

The Americans with Disabilities Act (ADA) requires access to the public right-of-way for people with disabilities. Access to traffic and signal information is an important feature of accessible sidewalks and street crossings for pedestrians who have vision impairments. While most intersections pose little difficulty for independent travelers who are blind or have low vision, there are some situations in which the information provided by an accessible pedestrian signal is necessary for independent and safe crossing.

How persons who are blind cross streets

Techniques and cues used in crossing streets are diverse and vary by location and individual. Many visually impaired pedestrians have trained with an Orientation and Mobility Specialist who has an undergraduate or graduate degree in teaching travel skills to persons who have visual impairments. In the most common technique utilized for crossing at signalized intersections, pedestrians who are blind begin to cross the street when there is a surge of traffic parallel to their direction of travel.

Vehicular sounds are often sufficient to determine the onset of the WALK interval and the direction of the crosswalk. However, there are some intersection geometries, acoustic conditions, and traffic control systems which make it very difficult for persons who are visually impaired to obtain the cues necessary to cross streets independently and safely. Accessible traffic signal technologies can be helpful to pedestrians in these situations.

Value of accessible pedestrian signals

Accessible pedestrian signals (APS) that provide audible and/or vibrotactile information coinciding with visual pedestrian signals let pedestrians who are blind know precisely when the WALK interval begins. This information is useful in analyzing an intersection and preparing to cross. Pedestrians who know when the crossing interval begins will be able to start a crossing before turning cars enter the intersection and can complete a crossing with less delay. Audible signals can also provide directional guidance, which is particularly useful at non-perpendicular intersections and at wide multi-lane crossings.

The redundant information conveyed by audible pedestrian signals increases the attention of all pedestrians to turning traffic and may contribute to a reduction in pedestrian-vehicular conflicts and crashes at signalized intersections (R. Van Houten, Malenfant, J. Van Houten & Retting, 1997). It is widely believed in many European countries, where the use of audible pedestrian signals has been more extensive than in the U.S., that the presence of audible pedestrian signals increases the speed at which most pedestrians initiate their crossings, thereby decreasing the necessary length of the pedestrian interval. Audible pedestrian signals may also increase the safety of persons with cognitive disabilities.

History of APS in the U.S.

Federal and model code accessibility standards in the U.S. do not yet include scoping or technical provisions for APS or other means of communicating visible signal information to pedestrians who have vision impairments. Regulators have been reluctant to standardize on any current device or system until more research and development is done on applications of emerging intelligent transportation systems and related communications technologies.

Although audible crossing indicators have been available for over 25 years, they have not been well received by traffic planners in the United States. This is probably attributable to two factors: one is noise pollution and consequent community opposition; the other is disagreement among blind people on the need for and effectiveness of audible pedestrian signals.

However, changes in traffic control and signaling design and practice today have greatly disadvantaged blind pedestrians who wish to travel independently. The Department of Justice has recognized that APS may be necessary at some locations in order to provide access for a pedestrian who is blind to the "program" of pedestrian circulation provided by a jurisdiction.

Information Requirements at Intersections

Introduction

Travel along regular routes and on regular schedules is routine for most blind pedestrians. However, independent travel to unfamiliar destinations is a more complex undertaking, requiring access to information on the pedestrian and street environment at decision points along the route. Most blind pedestrians will be able to cross streets safely and independently if they have access to the same range of information available to pedestrians who are fully sighted.

Detecting the street

The first information needed by the pedestrian who is blind is "Have I arrived at a street?" Before the advent of curb ramps, depressed corners, and built-up intersections, the presence of a curb was an unambiguous cue to the sidewalk/street edge. In the absence of a curb, even experienced blind pedestrians using an unfamiliar intersection with a curb ramp have a high probability of entering the street before they are aware of leaving the sidewalk (Bentzen & Barlow, 1995; Hauger, Rigby, Safewright, & McAuley, 1996). Blind travelers whose path of travel coincides with a single curb ramp at the apex of a corner — a diagonal curb ramp — may inadvertently enter the stream of parallel traffic (Hauger et al., 1996) without being aware of the sidewalk/street boundary.

In some countries (including Japan, England, and Australia), surfaces which are highly detectable under foot or detectable by the use of a long cane, provide definitive information to pedestrians who are blind that they have arrived at a curb ramp. The International Standards Organization (ISO) is proposing a standardized truncated dome surface for use as a warning of the sidewalk/street boundary ahead. It is similar to the detectable warning surface specified in the *ADA Accessibility Guidelines* (ADAAG) 4.29.2 for use on the edges of transit platforms.

Information Requirements at Intersections (continued)

Identifying the street

The next information needed for decision-making at unfamiliar intersections is: "Which street is this?" This information is seldom provided in any accessible format. Pedestrians who are visually impaired develop a mental map and keep track of where they are within that map, usually by counting blocks and street crossings. Where necessary ¾ and available ¾ assistance may be sought from other pedestrians.

Analyzing intersection geometry

The next information needed is: "What is the geometry of this intersection?" Important pieces of information which are obvious to pedestrians having full vision, but which may not be possible for pedestrians who are blind to determine by listening to traffic patterns, are the following:

- Is my destination curb straight in front of me, or must I angle to the left or right to reach it?
- How many streets intersect here?
- How wide is this street?
- Should I expect to encounter any islands or medians as I cross this street?
- Am I standing within the crosswalk?

Incorrect or missing information for any of these questions may result in missing the destination curb or median.

Analyzing the traffic control system

Next, pedestrians need to identify the type of traffic control system at this intersection:

- Is this a signalized intersection?
- Do I need to push a button to actuate the walk interval? If so, where is the button?
- Is the button close enough to the crosswalk that I will have time to position myself correctly at the crosswalk, facing my destination curb, before the onset of the walk interval?
- Which button controls the walk interval for the street I want to cross?
- Does it stop traffic on one street, or all traffic?
- Do cars still turn during the walk interval?
- Is there a second button I must push that is on a median?
- Will there be a surge of parallel traffic telling me the walk interval has begun? Will I be able to hear it over other, concurrent traffic sounds?

Missing information for any of these questions may result in failing to use pedestrian push buttons and crossing at times other than the pedestrian phase. In research conducted for the San Diego Association of Governments (1988), blind pedestrians had significant difficulties finding the push button and realigning at the curb for crossing. On 50% of trials in research conducted in San Francisco (Crandall, Bentzen and Myers, 1998), blind pedestrians crossing at four unfamiliar fixed timed signalized intersections that did not have APS were not able to obtain sufficient information from traffic sounds and other cues to identify whether an intersection was signalized or had stop signs.

Identifying the crossing interval

After determining the geometry of the intersection and aligning so they are facing towards the destination curb ¾ and having determined that an intersection is signalized and pushing a button, where necessary ¾ pedestrians who are blind need to know: "When does the WALK interval begin?" In the absence of APS, pedestrians who are blind use the surge of traffic on the street beside them (parallel traffic) to indicate that they have the WALK interval. On 34% of trials in research cited above (Crandall et al. 1998), participants who were blind did not have sufficient information to begin their crossings during the WALK interval and initiated a crossing out of phase.

Too little traffic may be as information-poor as too much. Sometimes there is no surge of parallel traffic, such as at intersections where all traffic stops during the pedestrian phase, mid-block crosswalks, and intersections where ¾ or when ¾ there is little or no traffic on the parallel street. Useful rush hour traffic noises may be absent in the evening or even at lunch hour. Sometimes streets are so wide or in such noisy environments that the surge of parallel traffic cannot be heard. Where there is split phase timing to permit left turns, the surge of left turning cars may be mistaken as indicating the onset of the WALK interval and blind pedestrians may cross into the paths of left turning vehicles.

Starting the crossing

Being able to start a crossing soon after the onset of the parallel traffic surge requires fast decision-making. And distinguishing between a surge of parallel traffic indicating the onset of the WALK interval and a single car turning right on red after stopping requires good listening and good spatial thinking. A majority of persons who are visually impaired are over the age of 65, by which time they may be experiencing age-related hearing loss and delayed reaction times. They often require a few seconds to be certain of the parallel traffic surge, and therefore may not start soon enough to clear the street within the clearance interval. Pedestrians who have low vision may use visual cues to identify and avoid vehicles within close range. However, pedestrians who are blind must proceed more cautiously. This often means ceding the right of way to a vehicle stream that, once established, may not offer a pedestrian gap until another cycle has been called.

Maintaining crossing alignment

Once the pedestrian who is blind has begun to cross the street, the next question is: "Am I headed straight towards my destination curb?" Traffic going straight ahead on the parallel street provides helpful auditory guidance to many persons if it is present. However, abundant turning traffic makes it difficult to hear traffic going straight, and difficult to use its sound to maintain a straight line of travel. When traffic is absent, blind pedestrians have no guidance from vehicular sounds either for determining the onset of the WALK interval or to maintain alignment while crossing the street. The wider the street, the more severe the consequences of even slight veers from the crosswalk area.

Accessible Traffic Signal Technologies

Types of signals providing WALK and DON'T WALK information

A number of technologies exist which provide WALK and DON'T WALK information. These APS provide information that is audible, vibrotactile, or both.

The matrix entitled "Accessible Pedestrian Signals: Product Functional Characteristics" on page 33 shows the functional characteristics of each product. Manufacturer information is given on page 34. All products produce a sound, vibration, or both, during the walk interval. Beyond this, there is great variation in the functional characteristics of different products, with some providing information throughout the signal cycle. A few devices have audio output that varies, by message or repeat frequency, as the pedestrian cycle changes from WALK to DON'T START to DON'T WALK.

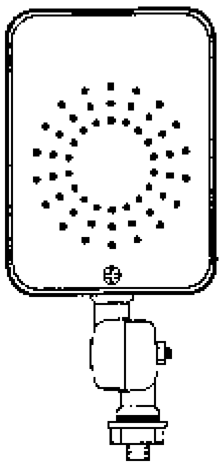
Currently available products are of three design types, categorized by the location from which the audible or vibrotactile cue is given:

- Speakers mounted in, on or near the visible ped-head;
- Transmitters mounted in or on ped-heads; and
- Sound generator and vibrating hardware which are integrated into the push button at or near the curb.

Like visible pedestrian signals, devices that use audible speakers and/or vibrating hardware will provide cues at both ends of a crossing when the pedestrian interval is actuated. Transmitter/receiver systems respond to individual use, and so will 'read' only the transmitter that is being scanned.

Speakers mounted in, on, or near ped-heads

Products that have speakers mounted in, on, or near ped-heads emit a sound such as a bell, buzz, tone or birdcall (typically cuckoo and chirp) during the WALK interval. (Examples: IDC, Mallory, Novax, STN Atlas, and Wilcox) If such a signal is loud enough to be heard across the street, if the tone is highly localizable, and if the speaker is carefully oriented, the signal also functions as an audible beacon, providing guidance for going straight across the street.



IDC

If the tone is not highly localizable or the speaker is not carefully oriented, such a signal may give ambiguous information about which street has the WALK interval, and may give false information about the direction of the crosswalk. A tone that is loud enough to be heard across the street may be perceived as obnoxious by other persons in the vicinity and may mask traffic sounds which provide critical safety information.

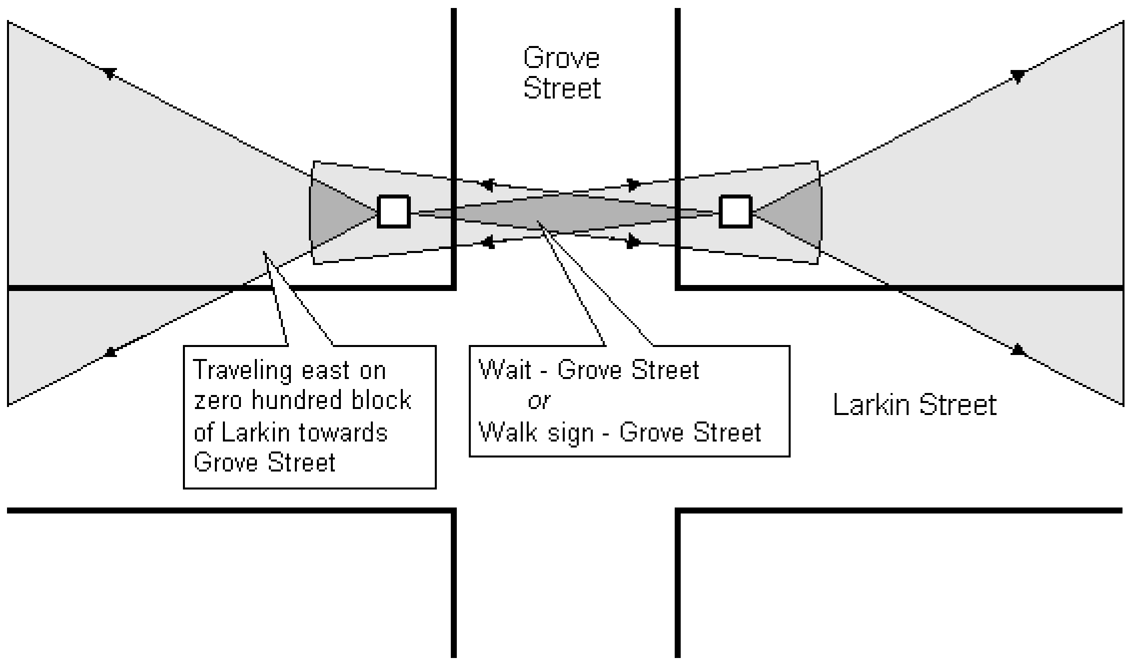
Tones that alternate from one side of the crossing to the other have been shown to enable blind pedestrians to cross more directly and quickly. They are also less likely to mask traffic sounds.

Transmitters at the ped-head

Infrared or LED transmitters located at the ped-head can transmit a speech message to hand-held receivers (Examples: Talking Signs, Relume). Messages may identify the location and direction of travel of the pedestrian, give the name of the street to be crossed, and provide real time information about WALK and DON'T WALK intervals. It is essential that the information regarding the light cycle be received only when the user is standing at the crosswalk with the receiver aimed at the transmitter on the opposite curb, or the information can be ambiguous.

For example, the Talking Signs system installed at several intersections in San Francisco transmits a message that includes the name of the street on which the pedestrian is traveling, the direction of travel, the block the pedestrian is on, and the name of the intersecting street he/she is approaching. Standing within the limits of the crosswalk at the intersection, the pedestrian can pick up a repeating message stating the name of the street and the status of the cycle. For example, "Wait ¾ Grove Street," or "Walk sign ¾ Grove Street." To ensure safety, a pedestrian must receive the same message for the same traffic condition at every crossing equipped with transmitters.

A transmitted system can convey more ¾ and more precise — information about individual intersections than any other APS. It can be adapted for vibrotactile use by deaf-blind pedestrians and may be engineered for output in other languages. It is excellent for atypical intersections where there are more than four crosswalks, and when direct signals, such as tones, may overlap and therefore be unclear or misleading. There is no noise pollution with such a system ¾ the information is only received by individuals when they desire it ¾ but it does not benefit other pedestrians at the same crossing. Such systems require users to obtain, carry, maintain and use receivers, which raises issues of distribution and availability to non-residents. However, the increasing use of personal pagers, cellular telephones, and other mobile digital communications devices suggests that personal telecommunications equipment will be commonplace in the near future.



A bird's eye view of Talking Signs® infrared transmitter system for intersections

Pedestrian hears voice message from hand-held receiver

The above illustration shows how the Talking Signs infrared transmitter delivers messages to the pedestrian who is carrying a receiver.

Wide beam tells:

- Direction of travel ¾ "traveling east"
- Present location ¾ "on zero hundred block of Larkin"
- Intersecting street ¾ "towards Grove Street"

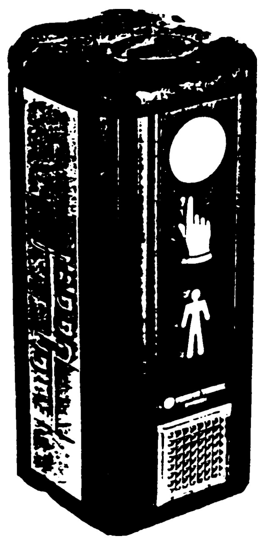
Narrow beam tells:

- Crossing condition and intersecting street ¾
  "wait ¾ Grove Street""walk sign ¾ Grove Street"
- Safe crosswalk zone

Accessible Traffic Signal Technologies (continued)

Sound generator and vibrating hardware integrated into the push button

A third type of APS, which has been standard in Australia and Sweden for many years, is fully integrated into the pedestrian push button assembly (Examples: Campbell/Panich, Georgetown, Polara Engineering, Prisma Teknik). Some provide vibratory information only; others augment vibro-tactile hardware with a quiet, slowly repeating, tick, click, or tone to identify the location of the push button during the DON'T WALK and pedestrian clearance intervals, and a faster tick, click, or tone to identify the WALK interval.



Prisma Teknik

Audible push button locating signals are heard only from the near vicinity of the push button. They let pedestrians know that the intersection is one that requires pedestrian actuation to call a WALK interval. The tick/click/tone also signals where to find the push button. The locator tone coming from the push button assembly during the DON'T WALK and clearance intervals becomes a louder and faster tone during the WALK interval. Tones coming from the push button are often found to be less objectionable in quiet settings than the tones coming from the ped-head.

Most APS devices that are integrated into the push button incorporate a raised (tactile) directional arrow. Some manufacturers offer options for additional tactile information that describes street crossing and traffic signal characteristics in braille or raised diagrams.

Sound generator and vibrating hardware integrated into the push button (continued)

Vibrating devices may be particularly applicable at intersections with medians, where a full crossing requires pedestrians to wait at the median for a subsequent cycle. Since the sounds of multiple audible signals may overlap in such settings, they are not recommended because of the possibility of conveying conflicting information. Vibrotactile signals may also be more suitable at intersections with channelized turning lanes, where audible tones cannot provide precise enough information about which crossing is being indicated by the signal.

Vibrotactile information requires physical contact with the signal hardware. The pedestrian must locate the button and understand the meaning of the vibrating signal obtained by resting the hand on the housing of the device. It is essential that vibrotactile signals be close enough to the curb ramp, near the curb line, so that blind pedestrians can be aligned and prepared for crossing while still keeping a hand on the signal.

Characteristics of Accessible Pedestrian Signals

Information characteristics

The most important information provided during the WALK interval is: "When does the crossing interval begin?" The audible or vibrotactile answer to this question:

- must be readily perceived from where pedestrians begin their crossings;
- must clearly convey that it is time to walk; and
- must be unambiguous with regard to which street has the WALK interval.

It should be no louder than necessary.

Volume control

Most audible pedestrian signals have volume control that is automatically responsive to ambient (background) sound. A louder tone will be produced when vehicle and other noise at an intersection is high, as during rush hour or construction; a quieter sound will be produced during night-time hours. This is especially helpful in residential neighborhoods. Some signals can also be pre-set for varying volume within particular ranges. Most signals with automatic volume control have a minimum limit placed at about 30 dB and a maximum limit at about 90 dB.

A signal that is 5 dB above ambient sound as perceived at the departure curb, is normally considered loud enough to inform pedestrians who are blind that the WALK interval has begun.

At regularly shaped four-way intersections, the signal does not need to be heard across the intersection, since the speakers at the departure and arrival curbs will both operate upon button actuation. A signal which is unnecessarily loud will not only be perceived as a neighborhood nuisance, but it may also mask the sounds of turning vehicles. In Australia, the WALK tone is adjusted to be heard for about one-third of the width of the crossing.

Localizable tones

Where intersections are complex, and particularly at crosswalks which have turns or which are angled relative to the departure sidewalk, pedestrians who are blind may need information to help them head for their destination curb. This requires that an audible signal be highly localizable. The most localizable tones are ones which are discontinuous and which are of mixed or changing frequencies. Tones ranging from 500 Hz to 1000 Hz, with higher harmonics, are highly localizable for most pedestrians, including those having age-related hearing loss (Hulscher, 1976; San Diego Associa-tion of Governments, 1988). Most audible pedestrian signals available in the U.S. are now pulsed, and most are either mixed frequencies or changing frequencies such as those resembling birdcalls.

For these signals to be highly localizable, their speakers should be oriented in line with the relevant crosswalk. If the tone is not highly localizable and the speaker is not carefully oriented, the signal may give ambiguous information about which street has the WALK interval, and ambiguous information for going straight across the street.

In a typical installation, speakers are actuated simultaneously on both the corner where the pedestrian is standing and the destination corner. It is therefore sometimes difficult for blind pedestrians to determine the direction of the audible pedestrian signal on the destination corner, even if the tone is highly localizable, because the tone coming from the destination corner is masked by the sound on the corner from which the pedestrian is starting the crossing.

Alternating signal

Research in Montreal (Hall, Rabelle, & Zabihaylo, 1994) has identified the characteristics of a particularly highly localizable signal. Orientation and mobility specialists collaborated with an acoustical engineer to develop a melodic tone which alternated back and forth across the street.

Blind pedestrians crossed straighter and faster with the alternating system than with a system in which the tones broadcast in unison from both ends of the crosswalk. The melody, comprised of highly localizable frequencies, must be loud enough to be heard across the intersection. The researchers recommend the use of this signal for only one crosswalk at an intersection. Pedestrians crossing perpendicular to the crosswalk having the alternating signal must interpolate the opposing WALK interval by listening to and analyzing several signal cycles.

Characteristics of Accessible Pedestrian Signals (continued)

Differentiating audible tones

Novax Industries

Some audible pedestrian signals utilize two different tones that are associated with two different crossing directions. The most common tones are sounds like "cuckoo" and "chirp." The repeating cuckoo sound is normally used for north/south crosswalks, and the repeating chirp is normally used for east/west crosswalks. This is the recommended signal in California and Canada.

Pedestrians report that mockingbirds and catbirds may mimic the “cuckoo” and “chirp” where the signal is broadcast at every pedestrian interval. Useful tones must be unique and distinctive and not easily mistaken for other messages common in the street environment, like the warning sound of a backing vehicle.

Some APS products have the capability of producing more than two different tones to accommodate intersections having more than two intersecting streets. However, it is difficult to interpret the use of additional tones without specific instruction. Unfamiliar or non-standard tones will not be useful to pedestrians who are not familiar with a given intersection.

Associating tones with direction of travel

For the two different sounds to be useful, users must remember which sound goes with which direction, and know their direction of travel. At intersections that are not aligned according to the primary compass coordinates, information from paired audible tones may be ambiguous except to frequent users of those intersections.

In areas where the street system is curvilinear or otherwise irregular, it may not be apparent to a blind pedestrian that a heading has changed. In fact, pedestrians may not know the compass orientation of a route of travel. In research in San Diego (San Diego Association of Governments, 1988), blind pedestrians were often unable to associate a given sound with a particular travel direction.

Broadcast voice messages

Some systems have the capability of presenting recorded speech messages telling the name of the street and the status of the signal cycle (Examples: Campbell/Panich, Novax, Prisma Teknik). In locations where they have been tried, including Seattle and Philadelphia, there has been difficulty making the speech information loud enough to be intelligible over traffic sounds. However, such messages ¾ if heard ¾ clearly communicate to all pedestrians which street has the WALK interval.

Research in Clearwater, Florida (Van Houten et al., 1997) with prototype speech message technology indicates that voice messages can be used to increase the attention of all pedestrians to turning vehicles and to decrease pedestrian/motor vehicle conflicts at signalized intersections.

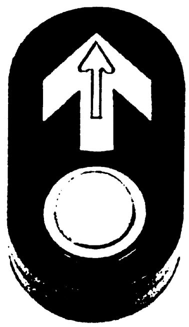
When the pedestrian push button was pressed, the message was "Please wait for walk signal."

The message "Look for turning vehicles while crossing [street name]" began 200 msec before WALK signals were illuminated.

The signal also gave participants who were blind precise information about the onset of the WALK interval and which street had the WALK interval.

Audible push button locating signal

Pedestrians with vision impairments must spend extra time analyzing traffic patterns in order to identify intersections where actuation is required. Then they must locate the push button for the crossing they wish to make. Locating the push button is a major problem for blind pedestrians (San Diego Association of Governments, 1988).



Campbell / Panich

At pedestrian actuated intersections, it is extremely helpful to have a quiet tone coming from the vicinity of the push button. This audible push button locator tone informs pedestrians of the need to use the push button to actuate the WALK interval and signals the location of the push button.

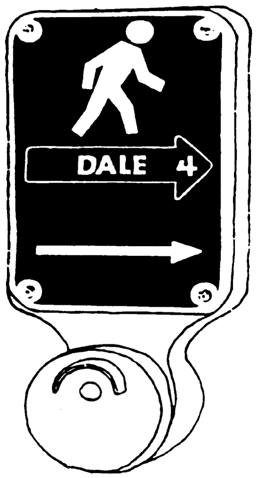
Audible push button locating signals typically sound during the DON'T WALK interval and the clearance interval. They have a slowly repeating tone or ticking sound which is adjusted to be heard no more than 6 to 12 feet (2 to 4 meters) from the push buttons that serve each end of the crosswalk.

In available products (Examples: Campbell/Panich, Prisma Teknik, STN Atlas), the sound has automatic level control. The locator tone informs pedestrians of the need to push a button, and provides an audible cue to the destination corner.

Walk onset tone

A brief burst of high frequency sound, rapidly decaying to a 500 Hz WALK tone, is used by one manufacturer (Campbell/Panich) to alert pedestrians to the exact onset of the WALK interval. This may encourage faster initiation of crossing, decreasing the likelihood of conflict between pedestrians and turning vehicles. If crossings are initiated faster, the intersection is likely to be cleared faster.

Vibrating WALK signal



Polara Engineering

In some signals, the push button, a second button on the bottom of the push button housing, the entire push button housing, or a raised arrow on the housing vibrates during the WALK interval and, in some cases, during the clearance and DON'T WALK intervals (Examples: Campbell/Panich, Georgetown, Polara Engineering, Prisma Teknik). The vibrating signals may or may not be combined with audible signals. In signals having both types of information, the vibration is synchronous with the pulsing of the audible signal (slow during DON'T WALK, and faster during WALK).

The vibratory information feature lets pedestrians who are deaf-blind know when the WALK interval is in effect. A vibration-only signal introduces no noise pollution, but it does not provide information to other pedestrians, who will not be aware of or use the vibratory feature. However, vibrotactile signals may be the APS of choice at medians, slip lanes, and other locations where audible signal messages might overlap to convey conflicting information.

Location is very important for vibratory-only signals. If the push button is not located in a good place from which to start the associated crossing, blind pedestrians must feel the WALK signal and then find a good starting location and align correctly after its onset. This may take more than the time allotted in sequencing programs to initiate a crossing. At a crowded corner, it may be difficult for pedestrians who are blind to make their way up to the button.

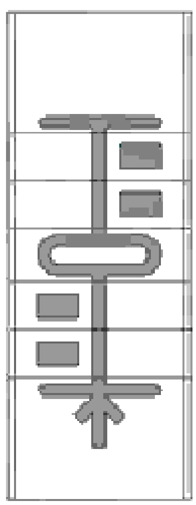
Characteristics of Accessible Pedestrian Signals (continued)

Actuation indicator

Either a light, a tone, or both may indicate to pedestrians that their actuation request has been received (Examples: Campbell/Panich, Prisma Teknik). The indicator assures pedestrians that the device is working, thereby encouraging pedestrians to wait until the onset of the WALK interval. A light is helpful to persons with low vision, but persons who are blind require a tone.

Tactile information

A raised arrow on the push button housing helps users know which street is controlled by a push button. It is of minimal assistance in aligning for a crossing, however. The arrows that work best for persons who are blind are ones that have a relatively long shaft and are oriented so that they can be read with the hand held in a horizontal position. Arrows should have good visual contrast with their background so that all users, including those having low vision, will see them readily.



Prisma Teknik

One signal (manufactured by Polara Engineering) provides the name of the associated street in braille and raised type on a large, vibrating, tactile arrow placed above the push button. A Scandinavian push button-integrated signal (manufactured by Prisma Teknik) can incorporate a raised schematic map showing what will be encountered as the pedestrian negotiates the crosswalk controlled by that push button. Map information includes:

- the number of lanes to be crossed;
- whether these are vehicular or bicycle lanes or trolley tracks;
- which direction traffic will be coming from in each lane; and
- whether there is a median.

A California manufacturer (Polara Engineering) is working on a system of tactile symbols which will provide information such as the shape of the intersection, and whether turning traffic is permitted during the WALK interval.

Separate actuation of the audible signal

Several jurisdictions report the use of special actuating buttons or systems for accessible signals that are subsidiary to the standard pedestrian button. Devices may actuate an audible or vibrotactile signal only in response to a specific call.

Two devices (Georgetown and Novax) can be optionally equipped such that a pedestrian must push and hold the button for an additional period of time in order to actuate the audible feature. Other systems rely on a separate actuating button, which may have a braille label.

Blind pedestrians who don't wish to add noise to the environment or to call attention to themselves can actuate the WALK interval without actuating the accessible signal. Pedestrians who are not aware of local practice may not be able to call the accessible signal.

Determining When to Install APS

Introduction

In some countries APS are required wherever new pedestrian signals are installed. In the U.S., however, APS have been viewed as an individual accommodation, installed upon request along a specific route of travel.

It is likely that the recent passage of the Transportation Equity Act for the 21st Century (TEA-21), the successor to ISTEA, will stimulate increased attention to APS as a standard pedestrian safety feature. The Department of Transportation will develop guidance on a wide range of pedestrian and bicycle issues, including APS. Transportation standards, documents, manuals, and good practice recommen-dations will be updated over the next few years to reflect this broader view. The Institute of Transportation Engineers has established a committee on accessible intersections charged to develop a toolbox of resources that traffic engineers can use to make information at intersections available to pedestrians with vision impairments.

Since pedestrians who are blind have sufficient acoustic infor-mation for crossing many streets safely, how are engineers to decide which signalized intersections shall have APS?

A number of U.S. jurisdictions have well-articulated systems for determining whether an APS is warranted. Each involves participation of one or more representatives of at least three groups of experts: traffic engineers, orientation and mobility specialists, and pedestrians who are blind. Additional infor-mation may be obtained from transportation agencies listed under "Sources of Information" on page 35.

San Diego and Los Angeles have highly structured rating scales and require a minimum number of points to warrant installation of APS. The process used in Portland, Oregon is less structured.

APS need evaluation factors

Factors that these and other jurisdictions consider in evaluating signalized intersections to determine whether APS are warranted include:

- proximity to a facility for persons who are blind;
- proximity to alternate crossings, proximity to transit stops, and proximity to key facilities used by all pedestrians;
- intersection configuration and width of street;
- vehicle speed;
- traffic volume (both heavy and light);
- pedestrian accident records;
- demonstrated need or user request;
- presence of pedestrian push buttons;
- surrounding land use and neighborhood acceptance; and
- existence of a signal which is susceptible to retrofitting.

Cost of evaluation versus standard implementation

At least one small city has determined that the expense of evaluating intersections for APS installation is likely to be higher than simply integrating APS in the pedestrian signal, where one is provided. Corvallis, Oregon has provided APS at all signalized intersections. They have found that audible prompts get pedestrians moving faster and are particularly useful in advising persons with cognitive disabilities when to cross the street. If APS are to be installed at all signalized intersections, it is important that signals from one intersection cannot be heard at other intersections.

Determining When to Install APS (continued)

Summary

While point ratings based upon factors outlined above may be useful in evaluating priorities for the installation of APS at specific locations, it should be kept in mind that state and local governments may be held legally liable if a person who is blind or visually impaired is injured as a result of the absence of APS, particularly if there has been a request for APS at the relevant intersection.

Furthermore, the information provided by APS may be necessary at any time, along any route, to residents, occasional travelers, and visitors. Thus, warranting schemes should place only limited emphasis on factors related to frequency or likelihood of use. Of greater importance are factors related to determining whether sufficient acoustic information exists ¾ at all times ¾ to permit safe crossing at a particular intersection.

Too little traffic is as great a problem for pedestrians who are blind as is too much traffic. Blind pedestrians must be able to hear a surge of traffic parallel to their direction of travel in order to know when the WALK interval begins.

Intersections that may require evaluation for APS installation include those with:

- very wide crossings;
- secondary streets having little traffic;
- non-orthogonal or skewed crossings;
- T-shaped intersections;
- high volumes of turning vehicles;
- split-phase signal timing; and
- noisy locations.

Where these conditions occur, it may be impossible for a pedestrian who is blind to determine the onset of the WALK interval by listening for the onset of parallel traffic or to obtain usable orientation and directional information about the crossing from the cues that are available.

Standards and technical provisions

In many countries, APS technology is specified in regulations. The most prescriptive standard seems to be that of Australia, which is met by the Audio Tactile Push Button with a locator tone manufactured by Bob Panich Consultancy. Canada's standard is much less prescriptive, and is similar to that of the state of California. Signals manufactured by Intersection Development Corp., Mallory, Novax Industries, and Wilcox Sales meet these specifications.

The International Standards Organization (ISO) has recently developed a draft standard "Technical aids for vision and vision and hearing impaired persons, Acoustic and tactile signals for traffic lights"; signals manufactured by Bob Panich Consultancy, Prisma Teknik and STN Atlas meet the criteria of the current draft. See "Sources of Information" on page 35 to obtain standards.

Push buttoncriteria

Pedestrians who have vision impairments need to know if an intersection is designed to require pedestrian actuation of the WALK cycle. This information can be provided by an accessible push button. The most important characteristics of accessible push buttons are:

- a locating tone if actuation requires use of a push button;
- a faster, repeating tone during WALK; and
- a tactile arrow to indicate which crosswalk is governed by the push button.

Desirable optional characteristics include:

- a change tone at the onset of WALK;
- a vibration on WALK;
- audible and visible actuation indicators; and
- a tactile map, symbols, or text providing intersection information.

Broadcast audible signal criteria

The most important functional characteristics of APS which broadcast audible information on the status of the signal cycle from the ped-head are:

- a highly localizable sound;
- an unambiguous indication of which street has the WALK interval; and
- a sound volume responsive to ambient sound.

Desirable optional characteristics include:

- alternating tones; and
- a different tone for opposing crossings.

Transmitted audible signal criteria

The most important considerations for APS which transmit personal messages are:

- an unambiguous message set;
- signal status messages which can be heard only within the crosswalk; and
- a proactive system for distributing receivers to residents and visitors.

Desirable optional characteristics include:

- naming the intersecting street in the signal messages; and
- providing additional location information that can be picked up as the traveler approaches the intersection.

Vibrotactile signal criteria

Vibrotactile signals must be installed within the width of the crosswalk near the curb line of the sidewalk so that users can rest a hand on the signal while simultaneously being aligned and prepared to cross.

Precise orientation of speakers and transmitters

Precise orientation is critical. If a speaker or transmitter is oriented even a few degrees out of alignment with the associated crosswalk, pedestrians may inadvertently travel out of the crosswalk. Audible signals should be mounted within the crosswalk; where two speakers are used on the same corner, they should be horizontally separated by at least 10 feet (3 meters).

Sound level

The sound level of the speakers should be carefully set. Sound should be between 30 dB minimum and 90 dB maximum. At no time should sound be more than 5 dB above ambient sound. At crosswalks where pedestrians who are blind need to know only the onset of WALK, sound pressure levels should be measured from the corner. At crosswalks where directional guidance is needed, such as at very wide streets, or at irregular or complex intersections, sound pressure level (dB) should be measured from the middle of the street.

Location of push buttons

Push buttons must be installed as near the crosswalk as possible, preferably on the sidewalk within the width of the crosswalk connection. Vibration-only devices should be installed within the width of the crosswalk near the curb line of the sidewalk. Where push buttons emit tones, paired devices signaling perpendicular crossings should be separated as much as crosswalk location permits. Tactile signage can be used to identify which crossing is controlled. Because all pedestrians will use the push button at an actuated crossing, the device should be located in close proximity to the top landing of the curb ramp serving that crossing and within accessible reach range for use from a wheelchair.

Pedestrian Detection Technology

Introduction

Pedestrian detection technology can be of particular benefit to persons who are blind if the system incorporates audible and/or tactile crossing information. Systems that replace pedestrian actuation with automatic sensing to trigger a WALK cycle should provide APS to signal the crossing interval, since the cycle will not otherwise provide sufficient cues for analysis by a blind user.

PUFFIN crossing

An excellent example of the use of detection technology is the "Pedestrian User-Friendly Intelligent (PUFFIN) crossing in use in England since 1993 (Department of Transport, 1993). PUFFIN crossings, with equipment manufactured by Microsense Systems, Ltd., employ pedestrian detectors for both the pedestrian waiting area and the crosswalk.

In PUFFIN crossings, visual WALK/DON'T WALK indicators are located on the same end of the crosswalk as the waiting pedestrian. They are oriented perpendicular to the street at the right edge of the crosswalk so that the pedestrian can simultaneously watch the ped-head and the approaching traffic in the nearest lane. Because the ped-heads can be viewed close up, pedestrians who have low vision are often able to see the visual signals. The visual pedestrian signals show either a green man indicating that the pedestrian may start crossing, or a red man indicating that the pedestrian should not start crossing. There is no intermediate or ambiguous flashing symbol.

Pedestrian Detection Technology (continued)

Waiting area detectors

Waiting area detectors may be either pressure mats with piezo-electric sensors, infrared or microwave detectors mounted on the signal pole, or video cameras serving remote sensor software. After a pedestrian has pressed a push button to actuate the WALK interval, detectors confirm the presence of pedestrians standing near the crossing. If the pedestrian disappears before the onset of the walk interval, the call for the pedestrian phase is canceled. Pedestrians who are vision-impaired must be able to locate the push button, the waiting area, and the crosswalk if such detectors are to be effective. In these and in similar systems that rely wholly on sensors to actuate the pedestrian phase, APS will be necessary to signal the onset of the WALK interval.

Crosswalk detectors

Crosswalk detectors are infrared sensors that respond to pedestrians moving in the crosswalk. As long as a pedestrian is detected in the crosswalk, a preset extension is added to the pedestrian clearance interval, enabling later-starting or slower moving pedestrians to clear the intersection before vehicular traffic resumes.

Similar pedestrian detection technologies are in use in the Netherlands, Australia and New Zealand, where they also improve safety and efficiency of street crossings for pedestrians who have vision impairments.

Accessible Pedestrian Signals

Product Functional Characteristics

	Campbell / Panich	Georgetown	Intersection Devel.	Mallory [3]	Novax Industries	Polara Engineering	Prisma Teknik	Relume	STN Atlas	Talking Signs	Wilcox Sales
Type											
Ped-head mounted											
Speaker			●	●	●				●		●
Transmitter								●		●	
Push button integrated	●	●				●[4]	●				
Audible WALK Signal											
Characteristics											
Voice	○				○		○	●[7]		●[9]	
Bell					○						
Buzzer		○			○						
Bird calls	○		●	○	●						●
Ticker					○				●		
Tones	●			○	○	○	●		●		
Sound Volume											
Fixed				●							
Variable - installer					●		●				●
Variable - automatic	●		●		●		●		●		○
Variable - user										●	
At user request		○[2]			○[2]						
Audible Locating Signal	●	○				○	●	●[8]	●	●[10]	
Walk Onset Tone	●[1]										
Vibrating WALK Signal	●	●				●	○				
Actuation Indicator											
Light	○						●				
Tone							●				
Tactile Information											
Arrow	●	●				●	●				
Street geometry						○	○[6]				
Street Name						●[5]				●[11]	

NOTES:

1. High frequency burst tone
2. Audible only when button is depressed at least 3 seconds
3. Component
4. Retrofits existing push button
5. Braille & raised print
6. Crosswalk map
7. Voice says "Proceed with caution"
8. Voice says "Don't walk"
9. Voice says "Walk sign" & street name
10. Voice says "Wait" & street name
11. Audible street name thruout WALK

KEY:

● = Standard feature

○ = Optional feature

APS Product Sources

Bob Panich Consultancy Pty. Ltd.
48 Church Street, P.O. Box 360
Ryde NSW 2112, Australia
Voice: 61 2 9809 6499
Fax: 61 2 9809 6962
Email: panich@enternet.com.au
Website: people.enternet.com.au/~panich
Product: Audio Tactile PB

Dick Campbell Company
1486 Northwest 70th Street
Seattle, Washington 98117
Voice: (206) 782-1991
Fax: (206) 782-2092
Email: dickcampbell@seanet.com
Product: Audio Tactile PB

Georgetown Electric, Ltd.
2507 West Second Street
Wilmington, Delaware 19805
Voice: (302) 652-4835
Fax: (302) 652-6447
Product: VIPB

Intersection Development Corporation
9300 E. Hall Rd.
Downey, Calif. 90241
Voice: (800) 733-7872 or (562) 923-9600
Fax: (562) 923-7555
Website: www.idc-traffic.com
Product: APS-10

Mallory, North American Capacitor Co.
P. O. Box 1284
Indianapolis, Indiana 46206-1284
Voice: (317) 273-0090
Fax: (317) 273-2400
Product: VSB 110

NOVAX Industries Corporation
658 Derwent Way
New Westminster, BC V3M5P8 Canada
Voice: (604) 525-5644
Fax: (604) 525-2739
Website: www.novax.com
Product: DS-100

Polara Engineering, Inc.
4115 Artesia Avenue
Fullerton, California 92833-2520
Voice: (714) 521-0900
Fax: (714) 522-8001
Email: polaraeng@aol.com
Product: TPA

Prisma Teknik AB
P.O. Box 5, S-543 21
TIBRO, Sweden
Voice: 46 504 150 40
Fax: 46 504 141 41
Email: info@prismateknik.se
Website: www.prismateknik.com
Product: Prisma TS

Relume Corporation
64 Park St.
Troy, Michigan 48083
Voice: (248) 585-2640 or
(888) 7RELUME
Fax: (248) 585-1909

STN Atlas Elektronik GmbH
Behringstrasse 120D 22763
Hamburg, Germany
Voice: 49 40 88 25 2155
Fax: 49 40 88 25 4111
Product: AUDIAM

Talking Signs, Inc.
812 North Boulevard
Baton Rouge, Lousiana 70802
Voice: (888) 825-5746
(504) 344-2812
Fax: (504) 344-2811
Email: ward@talkingsigns.com

Wilcox Sales Company
1738 Finecroft Drive
Claremont, California 91711-2411
Voice: (909) 624-6674
Fax: (909) 624-8207
Product: PS/A 10

Sources of Information

California Department of Transportation
Traffic Manual Metrics, Rev. 1996
1120 North Street
Sacramento, California 95814
Voice: (916) 654-5267 or
(916) 654-2852

City of Los Angeles, California
Adaptive Device Study Worksheet
Brian Gallagher, PE
Department of Transportation
City of Los Angeles
221 Figueroa Street, Suite 300
Los Angeles, California 90012
Voice: (213) 580-5398

City of Portland, Oregon
Guidelines for Installing Audible Pedestrian Traffic Signals
Linda Ginenthal
Community Traffic Safety Program
City of Portland
Office of Transportation
1120 SW Fifth Avenue, Room 730
Portland, Oregon 97204
Voice: (503) 823-5266
LINDA@syseng.ci.portland.or.us

City of San Diego, California
Audible Pedestrian Traffic Signals for the Blind, Intersection Evaluation Procedure
Patricia Sieglen
Disability Services Coordinator
City of San Diego
1200 Third Avenue, Suite 924
San Diego, California 92101
Voice: (619) 236-5979
Fax: (619) 236-5596

Department of Transport
Network Management and
Driver Information Division
St. Christopher House
Southwark, London
England SE1 0TE

International Standards Organization
Secretariat of ISO/TC 173/WG6
Mr. Gerald Kuso
Österreichisches Normungsinstitut
Heinistrasse 38
A-1020 Wien, Austria
Voice: (43) 1 213 00 714
Fax: (43) 1 213 00 722

Microsense Systems, Ltd.
Meon House, 10 Barnes Wallis Road
Segensworth, Fareham, Hampshire
England, PO15 5TT
Voice: (44) 1489 571979
Fax: (44) 1489 575616

Standards Australia
Pedestrian Push-button Assemblies
1 The Crescent, Homebush 2140
(PO Box 1055, Strathfield 2135)
Australia
Voice: (61) 2 9746 4600
Fax: (61) 2 9746 3333

Transportation Association of Canada
TAC Manual of Uniform Traffic Control Devices, 1994
2323 St. Laureat Boulevard
Ottawa, Ontario K1G 4J8 Canada
Voice: (613) 736-1350
Fax: (613) 736-1395
Email: secretariat@tac-atc.ca
Website: www.tac-atc.ca/

Sources of Information (continued)

U.S. Architectural and Transportation
Barriers Compliance Board
(the Access Board)

1331 F Street NW, #1000
Washington, DC 20004-1111
Voice: (202) 272-5434;
Technical Assistance Line:
(800) 872-2253
TTY: (202) 272-5449;
Technical Assistance Line:
(800) 993-2822
Fax: (202) 272-5447
Email: info@access-board.gov
Website: www.access-board.gov

References

Bentzen, B.L. & Barlow, J.B. (1995). Impact of curb ramps on safety of persons who are blind. *Journal of Visual Impairment and Blindness*. **89**, 319-328.

Crandall, W., Bentzen, B., & Myers, L. (1998). *Smith-Kettlewell Research on the use of Talking Signs® at light controlled street crossings.* Smith-Kettlewell Rehabilitation Engineering Research Center, San Francisco. Report to National Institute on Disability and Rehabilitation Research.

Department of Transport (1993). *The use of PUFFIN pedestrian crossings.* London: Department of Transport, Network Management and Driver Information Division.

Hall, G., Rabelle, A. & Zabihaylo, C. (1994). *Audible traffic signals: A new definition.* Montreal: Montreal Association for the Blind.

Hauger, S., Rigby, J., Safewright, M & McAuley, W. (1996). Detectable warning surfaces at curb ramps. *Journal of Visual Impairment and Blindness.* **90**, 512-525.

Hulscher, F. (1976). Traffic signal facilities for blind pedestrians. *Australian Road Research Board Proceedings.* **8**, 13-26.

San Diego Association of Governments (1988). *Evaluation of audible pedestrian traffic signals.*

Van Houten, R., Malenfant, J., Van Houten, J. & Retting, R. (1997). *Using auditory pedestrian signals to reduce pedestrian and vehicle conflicts. Transportation Research Record No. 1578.* Washington, DC: National Academy Press.

Specifying Audible Pedestrian Signal Locator Tones

Billie Louise Bentzen, Ph.D.*, Janet Barlow, M.Ed, Douglas Gubbé**

The problems

- Blind pedestrians don't know whther they need to push a button to request a WALK phase
- Blind pedestrians have trouble finding push buttons

Potential solution

Use a **push button locator tone** –
a quiet repeating tone or ticking sound coming from the push button

A push button locator tone:

- Sounds throughout the clearance and DON'T WALK intervals
- Informs the approaching blind pedestrian that button press is needed
- Indicates location of the button
- Widely used in Europe and Asia for 30 years

The Research

Objectives

- Determine repetition rate for locator tone that enables fastest location of the push button by blind pedestrians – compare .5, 1.0 and 1.5 Hz pulse rates
- Investigate effect of loudnes of locator tone on speed of location of push button

Participants

42 persons who had insufficient vision to locate poles

Procedure (conducted along busy 6-lane artery in Los Angeles, February 14, 1999)

- Locate push button pole from distances of 6 feet to 12 feet
- Rate the preference for locator tones repeating at different rates (.5, 1.0, and 1.5 Hz)

Results (all significant at .05 level)

- 1.0 and 1.5 Hz pulse rate resulted in equal pole location speed; faster than .5 Hz
- 1.5 Hz repetition rate tone was preferred above the 1.0 Hz and .5 Hz repetition rate tones; the latter two also differing from one another
- Tone 2 dB above ambient sound resulted in faster pole location than tones at 5 dB and 10 dB above ambient sound. (5 and 10 dB were equal)

Conclusion

- Locator tone repetition rate should be standardized at 1.0 Hz
- Additional research should be done on effect of ambient sound compensation on localization of the push button

*Accessible Design for the Blind, Berlin, Massachusetts

**NOVAX Industries Corp., New Westminster, British Columbia