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Crossroads: Modern Interactive Intersections and Accessible Pedestrian Signals

Janet M. Barlow and Lukas Franck

Abstract: This article discusses the interactive nature of modern actuated intersections and the effect of that interface on pedestrians who are visually impaired. Information is provided about accessible pedestrian signals (APS), the role of blindness professionals in APS installation decisions, and techniques for crossing streets with APS.

Today's traffic signals are often interactive in design, responding to the volume and actions of both vehicles and pedestrians. The operating characteristics and order of phases of the signals at these traffic-actuated intersections may also change, depending on the time of day or day of the week. Pedestrians who are blind do not have routine access to pedestrian signal information and hence need to determine increasingly complex signal patterns through nonvisual techniques alone. Although the Americans with Disabilities Act (ADA) requires facilities and programs of state and local governments to be "accessible to and usable by" individuals with disabilities in the United States (U.S. Department of Justice, U.S. DOJ, 1991), the interface between pedestrians and the computerized controllers of intersections that operate the signals is often both poorly designed and inaccessible to pedestrians who are blind in the United States.

At interactive actuated intersections, pedestrians are expected to press a button that tells the intersection controller (a type of computer) to allow sufficient time for a pedestrian to cross the street. At a wide street with low volumes of traffic on side streets, the pedestrian timing can be as much as 20 seconds more than the time allowed for vehicles (Barlow, Franck, Bentzen, & Sauerburger, 2001; McKinley, 2001). The

expectation of interaction between pedestrians and signals is commonly misunderstood even by sighted pedestrians, resulting in pedestrian pushbuttons that are accompanied by paragraphs of instructions (see Figure 1). As can be seen on the sign in the photograph in Figure 1, pedestrians are supposed to begin crossing during the walk interval, which is symbolized by the white "walking man" symbol. During the flashing Don't Walk signal, shown by an orange flashing hand, the instruction is: "Don't start; finish crossing if started." During the solid or "steady" orange hand symbol, pedestrians are supposed to have cleared the crosswalk. Pedestrians are instructed to push the button for a Walk signal. In most states, it is illegal to begin crossing without a Walk signal if pedestrian signals are present (National Committee on Uniform Traffic Laws and Ordinances, 2000).

In surveys of orientation and mobility (O&M) instructors and pedestrians who are blind, the respondents have reported difficulty with several tasks that are specifically related to signals: knowing when to begin to cross, determining whether there is a pushbutton to activate a pedestrian signal, and finding and using the pushbutton (Bentzen, Barlow, & Franck, 2000; Carroll & Bentzen, 1999). Several studies have corroborated the results of the surveys (Barlow, Bentzen, & Bond, 2005; Crandall, Bentzen, & Myers, 1998; Marston & Golledge, 2000; Williams, Van Houten, Ferraro, & Blasch, 2005), and some have investigated the use of accessible pedestrian signals (APS) to solve some of the problems (Crandall et al., 1998; Marston & Golledge, 2000; Williams et al., 2005).

Recent research at complex intersections in three cities (Barlow et al., 2005) found that pedestrians who were blind began crossing during the walk interval on only 48.6% of the crossings and completed crossings after the onset of perpendicular traffic on 26.9% of the crossings. The mean latency in beginning crossing (the time between the onset of the Walk signal or near-side parallel traffic and the participant beginning to cross) was 6.41 seconds. When Williams et al. (2005) compared a receiver-based APS (handheld), pushbutton-integrated APS, and typical visual pedestrian signals, they found that the mean latency for blind participants in starting crossing without an APS was more than 5 seconds. Walk signals are typically only 4 to 7 seconds long, although the flashing Don't Walk signal, or clearance interval, is timed to allow the

completion of the crossing if a person begins to cross during the Walk signal.

Marston and Golledge (2000) compared crossings by participants who were blind with and without APS. Without an APS, almost half (48%) the participants attempted to cross during the steady Don't Walk signal, a time recorded as unsafe by the researchers. With access to the pedestrian signal information provided by APS, no participant started crossing at an unsafe time. In similar research (Crandall et al., 1998), 20 experienced pedestrians who were blind crossed at four intersections (80 crossings) in downtown San Francisco, both without and with APS. The intersection signal phases were pretimed (the same in every cycle), and the use of pushbuttons was not required. At crossings without APS, the participants requested assistance in knowing the onset of the walk interval on 24% of the crossings, and for crossings on which they independently initiated the crossings, the participants began crossing during the Walk signal on 66% of the crossings. With an APS, 99% of those who began crossing independently began during the Walk signal. Williams et al. (2005) also assessed the total number of signal cycles that the participants missed before they crossed. Without an APS, the mean waiting time was almost 2 full cycles (1.91), whereas with either type of APS, the mean waiting time was just over a half a cycle (0.51).

These survey and experimental results dovetail with the experiences of practitioners and, as a result, some practitioners have become advocates for APS. At many locations, traffic sounds still provide adequate information, but they may do so only at some times of the day or under certain conditions. Moreover, traffic engineers have stated that approximately 90% to 95% of intersections are currently actuated, which means that the timing at the intersection is constantly changing to accommodate the traffic (vehicular and pedestrian) that is present, and pedestrians must use pedestrian pushbuttons to receive pedestrian timing (D. Fullerton, personal communication; March 9, 2005; J. Hereford, personal communication, March 8, 2005).

Traditionally, both O&M instructors and many individuals who are blind have had mixed feelings about audible traffic signals. For some people who are blind, the old-style, loud, audible signals that sounded on every

cycle of the traffic signal interfered with their ability to judge traffic independently and conjured up degrading stereotypes. O&M instructors generally have believed that the skills they teach are sufficient to cope with all traffic situations. However, the challenges posed by modern interactive, actuated intersections, the demographic shift in the number of people who have moved to autocentric suburbs, quieter cars, and the aging blind population have degraded the effectiveness of traditional techniques in many situations. Meanwhile, there have been advances in the technology of APS that may make them more acceptable to O&M instructors and people who are blind. Modern APS provide the same information that is provided by visual pedestrian signals in both quiet audible and vibrotactile formats and respond to levels of ambient noise, so they are not unnecessarily loud.

Traffic engineers refer to the *Manual on Uniform Traffic Control Devices* (MUTCD) for specific guidance on where and how vehicular and pedestrian signals should be installed. Since 2000, guidance on the installation of APS has also been included. The 2003 edition of the MUTCD (Federal Highway Administration, FHWA, 2003) includes two sections on APS. In Part 4, Section E.06, engineers are specifically encouraged to consult with pedestrians who are blind and O&M instructors when considering installations of APS. Before they provide such consultation, O&M instructors, other blindness professionals, and consumers who are blind should understand the typical functioning of actuated intersections and pedestrian signals, as described by Barlow et al. (2001) and Barlow and Franck (1999), know what kinds of APS are available, and understand the features of the APS. Vision professionals who are involved in such consultation need to be aware of their role in installation decisions, regulations pertaining to the installation of APS, and potential problems and solutions.

Types and features of APS

The MUTCD defines an APS as "a device that communicates information about pedestrian timing in nonvisual format such as audible tones, verbal messages, and/or vibrating surfaces" (FHWA, 2003; Section 4A.01). Four types of APS are currently available in the United States: pedhead-mounted, pushbutton-integrated, receiver-based, and

vibrotactile only. Of these APS, the most familiar to the average consumer and professional are the pedhead-mounted devices, mentioned earlier, that use speakers that are attached to the pedestrian signals. These APS can make a variety of sounds, but commonly use birdcalls. There have been objections to this type of APS because they are often loud, and the birdcall sounds have been found to be easily confused with the calls of real birds (Bentzen et al., 2000; Uslan, Peck, & Waddell, 1988).

Pushbutton-integrated APS are less common in the United States, but are the standard in much of Europe and in Australia. These devices rely upon relative proximity to the departure point, rather than upon different sounds, to clarify which street is being signaled. A good location for the pushbutton is important, and these APS can be quiet, since they are generally immediately adjacent to the crosswalk. All sounds come from the pushbutton and pushbutton housing, and they typically include a pushbutton locator tone in addition to an audible Walk signal indication. The pushbutton locator tone repeats constantly, at one-second intervals, to tell pedestrians that there is a pushbutton and to help them locate and use the pushbutton. Tactile arrows are also a standard feature to help blind pedestrians determine which street the device serves (see Figure 2 and Figure 3). The arrow typically vibrates during the walk interval to communicate information on the Walk signal to pedestrians who cannot hear or who want to confirm information from the audible signal tactilely.

Signals that indicate the beginning of the walk interval exclusively through vibration are also found in Europe and occasionally in the United States. Their location immediately adjacent to the crosswalk and near the curb is critical to their use, since users have to be touching the device to detect the Walk indication.

Receiver-based technologies provide information that is transmitted to handheld personal receivers. They have been used to a limited degree in the United States and to a greater extent in Japan. These receivers are also highly directional, providing information on the location of the target curb from the departure curb. They may also be programmed to provide orientation information as users approach the crossing.

Until 2000, when some language on APS standards and guidance was

added to the MUTCD (FHWA, 2003), there were no national standards for APS in the United States. The MUTCD language is general, allowing the use of any of the types of APS just described. The U.S. Access Board is in the process of developing accessibility guidelines that apply to street crossings and include language on the APS. The *Draft Guidelines for Accessible Public Rights-of-Way* (U.S. Access Board, 2002) recommend the installation of APS at all new or reconstructed intersections and provide more specific recommendations and requirements for APS features. Although they have not been finalized as standards, they are considered the best guidance at this time (Institute of Transportation Engineers, 2004).

The U.S. Access Board's recommendations

The *Draft Guidelines* call for the use of pushbutton-integrated signals that provide audible and vibrotactile indications during the walk interval. Most pedhead-mounted devices do not provide a vibrotactile indication of the walk interval and do not meet the requirements of the *Draft Guidelines*, although one manufacturer has a vibrotactile pushbutton as an option. Vibrotactile-only devices were not recommended because they require an unrealistically precise location and do not provide audible information; receiver-based devices were not recommended because the information is not available to those who do not have a receiver.

The *Draft Guidelines* call for further improvements in the pedestrian interface in the United States by requiring push-button locator tones, tactile arrows at pushbuttons, and compensation for ambient sound. Both the locator tone and the Walk indication should be audible only 6-12 feet from the pushbutton unless there is special activation of a louder signal feature. The U.S. Access Board (2002) also made specific recommendations regarding the location of APS. The location of an installation can affect the choice of the Walk indication or the need for other APS features that clarify which signal is sounding.

Locations of installations

Installation in the proper location in relation to the crosswalk can be important for any type of APS. Recent research, the *Draft Guidelines*,

and MUTCD all recommend that each APS device should be on a separate pole, located no more than 10 feet from the curb line (but closer, if possible) and as close as possible to the line of the associated crosswalk that is the farthest from the center of the intersection (Ashmead, Wall, Bentzen, & Barlow, 2004; FHWA, 2003; Scott, Myers, Barlow, & Bentzen, in press; U.S. Access Board, 2002). Two APS on a corner should be at least 10 feet apart, according to the *Draft Guidelines* and MUTCD, so pedestrians can easily distinguish which device is emitting a sound (see Figure 4).

Walk indications

The recommended audible Walk signal indication is a fast-ticking or beeping percussive sound at 8 to 10 repetitions per second or a verbal message (U.S. Access Board, 2002). To clarify, the Walk signal indication should be the same tone as the locator tone at a faster repetition rate, another tone at a faster repetition rate, or a verbal message.

Recent research has provided further guidance on recommended Walk signal indications. Scott et al. (in press) recommended that two APS that are installed in the separated locations on a corner could and should have the same Walk signal indication. They found that using the same sound for both APS was not confusing when the APS were separated and each was located close to the crosswalk that it signaled. When there were two APS on a single pole, using two different tones to indicate which crosswalk had the walk interval, such as the commonly used cuckoo and chirp, was found to provide ambiguous information that may result in pedestrians crossing with the wrong signal, as other research and surveys have corroborated (Ashmead et al., 2004; Bentzen et al., 2000; Carroll & Bentzen, 1999; Uslan et al., 1988). In that situation, the use of verbal messages resulted in a slight delay in pedestrians' response, but a significantly higher percentage of correct decisions (Scott et al., in press). These results support the use of verbal messages if APS cannot be installed in the recommended locations but a single tone where two APS on a corner are separated and each is located beside the crosswalk it serves. Recommended language for verbal messages has been developed and has been recommended for inclusion in the MUTCD sections on APS (Bentzen, Barlow, & Franck, 2004).

Other features

In addition to the locator tone, tactile arrow, and audible and vibrotactile Walk indication, APS may have additional features, such as braille labels, actuation indicators, and optional features that are called by an extended button press (holding the pushbutton in for a minimum of one second). Optional features may include audible beaconing, a longer time to cross, or pushbutton information messages (U.S. Access Board, 2002). Audible beaconing is a louder signal that is intended to be heard from across the street to provide directional guidance. The louder signal may come from the Walk indication speakers on the APS or from different speakers. The pushbutton information message is a speech message that provides additional information, such as the name of the street that the pushbutton controls and other information on the geometry of the intersection or signalization. Further details and information about features and their use, installation locations, and APS manufacturers can be found in *Accessible Pedestrian Signals: Synthesis and Guide to Best Practice* (Barlow, Bentzen, & Tabor, 2003).

Involvement by professionals: Implications for practice

Implications of the ADA

As was mentioned earlier, the implementing regulations of the ADA require facilities and programs of state and local governments to be accessible. In a letter to the authors dated May 24, 2005, Elizabeth Stewart, deputy general counsel of the U.S. Access Board, clarified the application of the ADA to situations in which the final regulations do not address a particular type of facility (for example, APS or street crossings):

> The DOJ ADA regulations require that each facility constructed by, or on behalf of, or for the use of a public entity shall be designed and constructed in such manner that the facility is readily accessible to and usable by individuals with disabilities. With respect to an altered facility, the regulations provide that the alteration shall, to the maximum extent feasible, be altered in such manner that the altered portion of the facility is "readily accessible to and usable by individuals with disabilities." This means that the facility "can be approached, entered, and used by individuals with disabilities easily and conveniently."

> However, even if there are not specific design or construction standards which address a particular element, … the ADA still applies because the nondiscrimination mandate of Title II is not dependent on the publication of design guidelines for a specific facility type or for specific elements within a facility.

In addition to the general nondiscrimination clause of the ADA, there is a more specific requirement for effective communication. Citing the ADA, a 2004 FHWA publication specifically mentioned an APS as a means to communicate information: "Implementing regulations for Title II of the ADA, which covers state and local governments, also address 'communications and information access,' requiring 'effective communications' with persons with disabilities. In the sidewalk/street crossing environment, this would include accessible pedestrian signals, markings and signage" (FHWA, 2004, p. 1). As was noted earlier, the ADA regulations for implementation specifically require "the public entity to take such steps as may be necessary to ensure that communications with … members of the public with disabilities are as effective as communications with others" (U.S. DOJ, 1991, Subpart E: Communications, 35.160 General, a). Where there are pedestrian signals, this requirement can be used to support the installation of APS to provide access to the signal information.

Particularly since the MUTCD recommends that traffic engineers consult with them, blindness professionals are sometimes asked by cities, counties, or other jurisdictions to help decide whether an APS is appropriate at an intersection. There can be civil rights implications in making such decisions, since the ADA is a civil rights law. Professionals who consult on the APS should educate themselves on the ADA and its application to such decisions.

Installation issues

When APS are being installed as part of a completely rebuilt intersection, new wiring, conduits, and poles can easily be added in compliance with the *Draft Guidelines* (U.S. Access Board, 2002). However, in adding APS to an intersection as a retrofit, the ADA allows variations from the new construction guidelines, when it is technically infeasible to meet those guidelines (U.S. DOJ, 1991). There are often decisions and

sometimes compromises to be made regarding the placement of poles, walk messages, volume, and additional features when the entire corner is not being rebuilt. These decisions are those in which blindness professionals and consumers who understand the APS features and their use may particularly need to be involved.

In evaluating numerous installations of pushbutton-integrated APS, we have consistently seen some common installation problems. These are new types of devices, and there is a "learning curve" for the installers. Traffic signal technicians are used to installing traffic signals and are aware of the requirements for locating and aiming signals. However, those signals deal with light, not sound. Signal technicians have little experience adjusting sound levels or aligning tactile arrows, and may have limited awareness of small details that affect the proper functioning of APS and the use of APS by blind pedestrians. Pedestrians who are blind, O&M instructors, and blindness professionals who know how APS should operate can often provide useful feedback after the installation of APS.

During an evaluation of APS installations, it is important to consider the functioning of APS in a number of areas. These areas include the placement and location of the APS in relation to crosswalks, synchronization of the APS with the Walk signal, alignment of tactile arrows, the repetition rate and volume of pushbutton locator tones, the messages and volume of audible Walk indications, pushbutton information messages, and optional features.

Information and assistance

O&M instructors and consumers who are blind can work collaboratively with traffic engineers to plan for the provision of appropriate accessible features at an intersection. Although the cost of installing APS is a small fraction of the cost of installing a signalized intersection, funding for retrofits may be limited. Advocates in some cities have been able to help the traffic engineering department obtain funding for requested modifications.

The Orientation and Mobility Division of the Association for Education

and Rehabilitation of the Blind and Visually Impaired (AER) has an Environmental Access Committee made up of regional representatives who are available to assist individuals who need current information on APS. The tasks of these representatives include developing expertise in access issues; keeping O&M instructors informed of regulations, new technology, publications, and resources; linking with traffic engineers to offer them expertise in O&M; and helping O&M instructors and consumers make requests to engineers and public works officials that are consistent with standards and technology. A list of representatives can be found on the AER web site <www.aerbvi.org>.

Suggested techniques in using APS

It is particularly important to recognize that the APS information is supplemental to traffic and environmental cues and provides information only about the status of the signal. The APS Walk signal indication indicates that the Walk signal is on, not that it is safe to cross--cars can still be turning across the crosswalk or driving through a red light. The APS Walk signal sound can be compared to the "on your mark" instruction at the beginning of a race. It means that the signal has changed; however, it is still important to "get set" (assess the traffic) and then begin to cross ("go").

The only place in the O&M literature where specific techniques are suggested for crossing at an intersection using an APS is a section in a draft curriculum on the APS that was developed for Easter Seals Project ACTION (2003). On the basis of our experience and of the Project ACTION draft, the following techniques are suggested:

- Approach the intersection and stop at the curb or curb ramp or street edge, maintaining initial alignment; check alignment for crossing by listening to traffic. Even if a pushbutton locator tone is noticed during approach, continue to the curb or edge of the street first.

- Determine the starting location for crossing and identify tactile cues to use to realign after pressing the pushbutton because, after pushing the button, there may be no time to listen to parallel traffic

and realign before the next Walk signal.

- Listen and evaluate the intersection. Determine traffic patterns and the geometry of the intersection and listen for a pushbutton locator tone or a tone or spoken Walk indication. (It is important that students or clients understand and can recognize the difference. between a pushbutton locator tone and typical Walk indications.)

- Search for a pushbutton using a systematic pattern. Even where there is a pushbutton locator tone, a systematic search pattern is needed to maintain orientation. Because dog guides are trained to avoid obstacles, they may be reluctant to approach poles that support pedestrian pushbuttons. It may be more efficient for the handler to use a cane to search initially before teaching the dog to locate the pole.

- Once the APS is located, explore the device and its functioning, including locating the tactile arrow to confirm that the arrow is pointing in the direction of the street being crossed.

- Hold the pushbutton down for more than three seconds to see if more information is provided.

- Listen to the APS and traffic for a full cycle to make sure that the tones or speech correspond with the traffic information.

- Press the pushbutton and return to the predetermined spot at the curb, realign, and prepare to cross.

- When the Walk indication is heard, confirm that traffic on the perpendicular street is stopping or stopped and listen for initial parallel traffic movements when available.

- Cross the street using typical alignment techniques (paying attention to traffic, maintaining a straight line of travel, and so forth) and continue to listen for turning cars. In many cases, cars can turn right and left across the crosswalk during the pedestrian phase. Although drivers are supposed to yield to pedestrians, they often do not.

- Be aware that a locator tone on the destination curb may provide

additional wayfinding information.

- If a tone or speech Walk indication is audible on every cycle, the intersection signals are probably pretimed (fixed timed) without a pedestrian pushbutton, so listen through a cycle to confirm the sounds and the street they apply to and then cross using traffic sounds to confirm the APS information.

Conclusion

Extensive changes have taken place in traffic and infrastructure technology since the founding of the O&M profession (McKinley, 2001). Many of these changes may not be obvious to drivers and pedestrians, who may only notice that the traffic patterns they had taken for granted are subtly different and less predictable. O&M instructors may find that these changes affect their clients and the skills they teach. We hope that this article has provided some insights into techniques that will prove useful at modern actuated intersections. Many blind pedestrians who received their O&M training at some point in the past may experience a change in traffic patterns and may be unaware of the variability of actuated intersections or appropriate techniques for crossing at intersections with protected left-turn phasing (Barlow et al., 2005; Frieswyk, 2005). As stated earlier, most intersections outside downtown areas are now traffic actuated. Professionals should consider that consumers may need to upgrade their skills and understanding of the functioning of modern intersections and learn how to take advantage of APS technologies to provide access to the signal information to cross updated interactive intersections with efficiency and confidence.

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Janet M. Barlow, M.Ed., COMS, *research associate, Accessible Design for the Blind, 440 Hardendorf Avenue, NE, Atlanta, GA 30307; e-mail: <jmbarlow@accessforblind.org>.* ***Lukas Franck, M.A., COMS,*** *supervisor, Community Instruction, The Seeing Eye, P.O. Box 375, Morristown, NJ 07963; e-mail: <lfranck@seeingeye.org>.*

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