

**AUDIBLE PEDESTRIAN SIGNALS:
A FEASIBILITY STUDY**

by

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(ABSTRACT)

This report represents a concentrated effort that determines 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 out 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 are listed. Topics for further study include the use of hand-held devices which activate sound signals at intersections and the development of tone schemes for 4-leg and multi-leg intersections which are not north-south and east-west. An additional topic for future study is the development of tone schemes for traffic circles.

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5. INTRODUCTORY SECTION

There has been much controversy over the use of audible pedestrian signals. These signals are devices which click, buzz, whistle, beep, or chirp with the intent of aiding the visually impaired in crossing the street. Some individuals and organizations are strongly in favor of the signals while others are strongly opposed. It is the purpose of this study to determine the feasibility of audible pedestrian signals. Results were obtained by interviewing and surveying the visually impaired, traffic engineers, audible signal manufacturers, and organizations of and for the blind and by examining existing audible signal sites.

Factors which may contribute to the infeasibility of the signals and which were reviewed are noise complaints, cost, and lack of acceptance by the visually impaired community.

Criteria for their installation and operation were developed. Uniformity is necessary for at least two reasons. First, it is necessary as an aid to the traffic engineer. A set of uniform criteria, which leave room for the judgement of the traffic engineer, will make his/her job much easier when faced with the question of whether or not

to install the signals. Second, the visually impaired will have a sense of independence when crossing the street. For example, knowing that a buzzer sound indicates that the east-west direction is safe to cross whether in Washington, D.C., or San Diego, California, creates a much greater sense of confidence when walking.

An additional objective was to determine the best type of sound for the signals. Voice applications, intermittent tones, pure tones, and bird calls were examined and recommendations were made concerning the best sound.

Audible devices at signalized intersections have been in use for at least 40 years. Portland, Oregon had one installed in 1948, but the signals have not become popular in the United States until fairly recently [4]. At least 100 cities nationwide have the signals installed. Worldwide use of the signals varies considerably. Australia, Scotland, Japan, New Zealand, and Sweden are far more advanced in their use of the devices. The Melbourne City Council in Australia was among the first to install buzzers at one signal location in 1959 [4]. Edinburgh, Scotland has successfully used voice messages to aid at crossings since 1980 [39]. Japan had developed 21 musical tunes to help at

crossings in addition to chiming, whistling, and imitation bird sounds. New Zealand has the only national standard which makes a specific provision for pedestrian signals for the visually impaired (NZS.5431:1973) [4]. Sweden has audible signals at 80-90% of their signalized crossings [25].

In contrast, East Germany is opposed to such facilities, as it is believed that it is the duty of every citizen to assist visually impaired pedestrians who are clearly identified [4].

Audible pedestrian signals were specifically designed to help the visually impaired; any benefits to sighted pedestrians are a bonus. A question which arises is "What is the definition of a visually impaired person?" Visual impairment may range from being color blind, to having low vision, to being legally blind. The above three visual impairment terms are defined as follows: A color blind person has defective color perception, independent of the capacity for distinguishing light, shade, and form. A low vision person has a corrected visual acuity of no more than (20/70) or an angle of vision of no more than 20 degrees. A legally blind person has a corrected visual acuity of (20/200) and/or an angle of vision less than 20 degrees in the better eye [10].

6. REVIEW OF LITERATURE

Several methods were employed to determine (1) what is known about audible pedestrian signals, (2) where they have been used, and (3) how both the visually impaired and the general public have responded to them. Initial sources of information were employees of the Federal Highway Administration who had corresponded with visually impaired persons, traffic engineers, and audible signal manufacturers concerning the audible devices. The correspondences accumulated by these individuals were an excellent starting point. Many of the cities which use the signals were mentioned in these letters as were audible signal manufacturers and earlier research papers.

A further source of information was the Department of Transportation library which conducted a Transportation Research Information Services (TRIS) search using the key words "pedestrian," "traffic," and "signal." The literature identified by the search was examined and much information was obtained. Research articles reviewed and their authors are included on the following page:

- o "Audible Pedestrian Traffic Signals: Report and Recommendations" Prepared by the Committee for the Removal of Architectural Barriers (CRAB) for the City of San Diego.
- o "Audible Pedestrian Signals for the Blind: Intersection Evaluation Procedure" prepared by the City of San Diego.
- o "The Effects of Installing an Audible Signal for Pedestrians at a Light-Controlled Junction" by D.G. Wilson.
- o "Traffic Signal Facilities for Blind Pedestrians" by F.R. Hulscher.
- o "A Study of Audible Signals for the Visually Handicapped in Salt Lake City" prepared by P.D. Kiser.
- o "Audible Traffic Signals and the Blind Pedestrian" by Mark Uslan.
- o "Audible Pedestrian Traffic Signals," by Nan Valerio of the San Diego Association of Governments. August 1986.
- o "Development of an Audio-Tactile Signal to Assist the Blind at Pedestrian Crossings" by Louis A. Challis & Associates.

Articles and books mentioned in the bibliographies of these and other papers were further sources of information as were private letter and telephone communications.

An additional reference was the Institute of Transportation Engineers' (ITE) issue paper entitled "Audible Pedestrian Signals." In 1983, the ITE was enlisted to obtain information on audible signals by its Virginia members because of a bill that was introduced requiring the devices at all signalized pedestrian crossings in Virginia. Though the bill never passed, the ITE compiled a 58-page booklet of past correspondence concerning the signals.

7. MATERIALS AND METHODS

In addition to the material found in the literature review, information for this report was gathered from five other sources: (1) the visually impaired, (2) organizations for the visually impaired, (3) city traffic engineers in municipalities having the signals, (4) audible pedestrian signal manufacturers, and (5) specialists in related fields such as audiology. Initial contact with these sources was made through a mail survey conducted through the Civil Engineering Department at Virginia Polytechnic Institute and State University [See the Appendix on page 118 for a copy of the questionnaires]. There were numerous follow up and face-to-face conversations with the above persons. The various costs and benefits of the audible signals were taken from the responses, and conclusions were drawn.

It had to be initially determined what persons or groups were to be surveyed. The literature review indicated that there were five main types of persons or organizations involved: (1) city traffic engineers, (2) audible signal manufacturers, (3) organizations of the blind, (4) the visually impaired, and (5) specialists in related fields. Examples of surveys sent to city traffic engineers, organizations of the blind, and audible signal

manufacturers are presented in the Appendix beginning on page 118. The questions asked the visually impaired in personal interviews are not included since the discussions were informal. The surveys sent to various specialists are not included because many surveys were distributed, and the questions were tailored to the specialty. For example, the questions asked an audiologist focused on the best tone and frequency for human localization while questions asked the Lothian Regional Council in Scotland focused on a key operated audible system.

City Traffic Engineers:

The city traffic engineers were asked 10 questions which pertained to criteria used to install the signals, cost per signal, community response to the devices, response of visually impaired organizations to the devices, sounds used, and before/after accident rates. Remaining questions pertained to the benefits and drawbacks of and alternatives to the signals. A sample questionnaire is included in Appendix section 12.1.1.

Audible Pedestrian Signal Manufacturers:

The eight questions asked of the audible signal manufacturers were almost identical to those asked the traffic engineers. Though the manufacturers were not asked about community response, the reaction of the visually impaired organizations, or the accident rates, they were asked to name the cities which used their audible system. Appendix section 12.1.3 contains an example survey.

Organizations of and for the Visually Impaired:

A concern was that some of the visually impaired might be sensitive to the crossing device issue. Four subjective questions were devised with the intent of letting the visually impaired express their feelings and opinions. The questions asked follow:

1. What is your reaction to audible signals?
2. Do you feel that the signals are or would be helpful? (Why or Why not?)
3. (If Applicable) What sounds are or would be most effective for you? (i.e., bells, gongs, voices, buzzers, bird calls, or other)
4. What alternative or additional crossing aids (if any) would you like to have installed? (Please List)

The survey was limited to the groups mentioned in the review and in personal correspondences between the author, traffic engineers, visually impaired organizations, and the general public. As responses were received, other organizations suggested by the respondents were also surveyed.

Meetings in the Washington, D.C. area with handicapped organizations, visually impaired persons, and orientation and mobility instructors from schools for the visually impaired provided further insight into the study. The number of members interviewed from each organization follows: Tyler School (8), the Columbia Lighthouse for the Blind (5), National Capitol Citizens with Low Vision (11), the Maryland School for the Blind (1), American Foundation of the Blind (1), Architectural and Transportation Barriers Compliance Board (1), and the NOVA Council of the Blind (11). The responses given during these meetings provided input for the Attitudes Towards Audible Crossing Devices section on page 36 and the Intersection Problems Encountered by the Visually Impaired section on page 131. The comments received included suggestions for additional intersection safety improvements.

8. RESULTS

One hundred twenty-four questionnaires were sent to organizations for the visually impaired, traffic engineers, audible signal manufacturers, and specialists. The distribution of the surveys was as follows: organizations for the blind (70), city traffic engineers (41), specialists in related fields (9), and audible signal manufacturers (4). Since five of the surveys sent to the organizations for the visually impaired were returned because of no forwarding address, a maximum of 119 responses could have been received. Since sixty-nine of the possible 119 responses were received, a response rate of 58% was achieved. This is a good response for mail surveys of this type.

The comments received were mostly positive since 36 of the 69 responses were in support of the audible devices. Twenty of the comments expressed indifference; they noted some of the benefits of the devices and some of the drawbacks but were non-committal in either supporting or opposing the devices. Though the remaining 13 negative responses were in the minority, the comments received were more lengthy than those received from the proponents of the devices as is shown in the Attitudes Toward Audible Crossing Devices section on page 36.

9. DISCUSSION

9.1 AUDIBLE PEDESTRIAN SIGNALS

There are myriad audible signal devices, all of which are either pedestrian activated or automatic. Pedestrian activated signals are connected to the pedestrian push button which is connected to the signal controller. Once the button is pressed and the appropriate phase for pedestrian traffic occurs, a sound is emitted which alerts the persons waiting to cross the street. Automatic signals are activated by the cycle change at pre-timed traffic intersections and not by pressing a button. Many of the automatic devices emit different sounds to indicate both the direction and available time for crossing [28]. The following is a listing and description of some of the audible pedestrian devices and techniques being used both in the United States and abroad.

9.1.1 UNITED STATES

9.1.1.1 BELLS

In 1951, Philadelphia initiated an audible system using bells. The bell was attached above the signal head and rang one time for safety and two times as a warning that traffic

was moving. The superintendent of the Home for the Blind, R. Earl Barret, in conjunction with Philadelphia traffic engineers is credited with the invention [51]. This particular system is no longer used in Philadelphia.

9.1.1.2 BUZZERS

In the 1970's Sono Guide was invented by Alfred C. Erikson of Michigan City, Indiana and tested by Southern Illinois University scientists. It translates the **Walk** and **Don't Walk** signals into high-pitched noises which tell the visually impaired when and when not to cross. The box resembles a square speaker and is the same size as the pedestrian crossing signals with which it is synchronized [52].

John J. Benneth, the Assistant Director of the Traffic and Transportation Committee in Portland, Oregon writes of a device in Portland which was developed for crossing a busy, high-speed arterial highway. The device, which is still in use, consists of a progressive system of buzzers operating in conjunction with regular traffic installations on several intersections of 82nd Ave. Pedestrian **Walk/Don't Walk** signals are installed at the corner, and when a visually

impaired person presses a button on the box provided at each crossing, the buzzer will sound if the **Walk** signal is on. If the **Don't Walk** signal is on, the pedestrian must continue to press the button until the **Walk** indication shows again before the buzzer will sound.

Connecticut cities such as Hartford and Mansfield use audible signals only in conjunction with exclusive **Walk** phases and not with concurrent **Walk/Vehicle** phases in its traffic signal designs. The Connecticut Department of Transportation tried various devices which were mounted inside of the **Walk** signal housing but found the Edward's Adaptahorn model 876-N5 to be the most effective for its needs because of the device's flexibility, long life, minimal maintenance, and adjustable sound output [17].

Only one Adaptahorn is needed per intersection and that is installed in the center of the intersection and attached to one of the traffic signal indications. The device works in parallel with the visual **Walk/Don't Walk** indications in that it is steady during the **Walk** period and intermittent during the **Don't Walk** clearance period. One tone is used, and it is similar in sound to the horns used to signal intermission at a basketball game. The volume does not

automatically adjust to the ambient noise but can be manually adjusted from 78 to 103 dB to accommodate the needs at each intersection. Though the units cost approximately \$80 each, additional costs are dependent on the type of traffic controller being modified and the availability of spare wires. An average cost for labor, materials, and equipment is \$1450 (1988\$). The devices have been used since 1973 and have been well received by the visually impaired in the area [17].

The most frequently used signal in the eastern United States is the Mallory Sonalert buzzer [63]. The Sonalert devices that cities use most frequently are the SC 110E and the SC 110Q. Each Sonalert model has its own frequency (tone) which cannot be changed. Models are available to provide frequencies from 1900 to 4500 Hz. For equal sound pressure, the 1900 Hz signals sound softer and more pleasant than the 2900 and the 4500 Hz signals [45]. The Sonalert buzzers are general purpose buzzers and were not designed specifically for use as audible pedestrian signals. Two advantages they present are their cost (about \$10-20 apiece) and the fact that they can be purchased through any electronic components distributor [63].

The City of Cincinnati, Ohio has had more than five years of experience with the Mallory devices. On May 24, 1983 a cooperative effort between the Cincinnati Public Works Department, the Greater Cincinnati Coalition of People with Disabilities, the National Federation of the Blind, the American Council of the Blind, and the Bell Telephone Pioneers resulted in the installation of Cincinnati's first audible signal which is located at Fifth and Vine Streets. The system consists of a constant tone for east-west crossings which is provided by the Mallory SC 110E and a buzzer sound for north-south crossings which is provided by the SC 110Q [8].

The audible device emits no sound during the **Don't Walk** phase. During the **Walk** signal, the device emits either the constant tone or the buzzer sound depending on which crossing is clear. The third mode of the signal consists of a pulsating sound which indicates the pedestrian clearance interval [8].

The Mallory devices used in Cincinnati are installed by drilling a silver dollar-sized hole into the pedestrian signal head and placing the unit therein. The unit is wired directly to the **Walk** phase in the controller.

Through the unique wiring of the device, the sound pulses in cadence with the flashing **Don't Walk** indication (60 times per minute) during the pedestrian clearance interval.[20]

The purpose of the pulsing tone is three-fold:

1. To simulate closely to the visually impaired pedestrian what the sighted pedestrian observes.
2. To give the visually impaired an audible target to walk towards.
3. To indicate to the visually impaired on the crosswalk that they have adequate time to complete their maneuver while those still on the sidewalk do not [20].

Since Cincinnati only installs the devices at crossings which have pedestrian actuation (push buttons), the sound is emitted only upon demand.

The cost of implementing the Mallory devices varies according to the number of units needed and the installation and maintenance requirements. Eight of the 10 to 20 dollar units are required at a standard 4-leg intersection. Installation costs are contingent upon the type of

controller at the candidate intersection. At semi-actuated intersections, the installation costs are less than \$500 (1988\$). In contrast, the costs at pre-timed controller sites are from \$7000 to \$8000 (1988\$) because a new controller must be installed and additional wiring performed. Cincinnati traffic engineers have found the Mallory devices to be highly reliable and to require low maintenance costs. Cities such as Cincinnati which have large engineering and electrical departments have an economic advantage when it comes to installing the devices because they can perform the work themselves. The Cincinnati Engineering Division periodically meets with representatives of the visually impaired and installs approximately 3 new signals each year based on recommendations from this group [20].

9.1.1.3 BIRD CALLS

The audible signal most frequently used in the western United States is manufactured by Nagoya Electric Works, Nagoya, Japan and imported by Traconex of Santa Clara, California [63]. The devices are 126 mm high, 94.5 mm wide, 126 mm deep and weigh 6.6 kg. The output is 90 dB

per watt at one meter and is self-switching to one of two adjustable output levels depending on ambient noise conditions. The tone for the east-west direction is Peep-Peep while the north-south tone is Cuckoo. The devices cost about \$400 each (1988\$); a standard four-leg intersection can be effectively equipped with four units but optimal results are achieved with eight. An advantage of using eight units is that the volume level on each unit does not have to be set at high levels because the sound need only be heard over half of the crossing. It takes about 20 minutes to install the signals, and they can be used in conjunction with all standard pedestrian signals [53].

Salt Lake City, Utah has been using the Traconex/Nagoya bird call device since 1978. They currently have 24 locations equipped with audible units. The city's engineers encountered a unique problem when they installed the audible signals: their signals (tones) were installed for the opposite directions as later suggested by the manufacturers. According to Salt Lake City, some time after they had installed their signals, they discovered that the manufacturers utilized a scheme opposite to theirs. The city approached the local Federal Highway Administration

(FHWA) office about their dilemma, but since the FHWA currently does not consider audible signals to be traffic control devices but rather auxiliary devices [27], it had no standards to offer the engineers. Discussions with the local organizations for the blind revealed that they were satisfied with the current sound scheme. Two other factors which led to the city's not changing the sound scheme were that reversing the tones not only would cost additional money for labor but also would create crossing hazards to the visually impaired who were used to the original scheme [41].

The product cost of 8 units at a 4-leg intersection is \$3200 (1988\$). Installation performed by the Salt Lake City signal division crews varied between 32 and 64 man-hours and cost \$16 per man-hour. Miscellaneous materials ranged between \$20 to \$300 per intersection. Total costs for the products, materials, and labor ranged from \$3,700 to \$4,500 [41].

9.1.1.4 VOICE APPLICATIONS

The first application of a talking signal in the United States took place in New York City at 5th Avenue and 42nd

Street on December 3, 1959 [3]. The message was lengthy and probably caused pedestrians to leave the curb later because they listened to the entire message. The actual three-part message follows:

"BE CAREFUL: The flashing **Don't Walk** signal indicates it is now too late to leave the curb. If you are in the roadway, cross quickly to the other side of the street...
Don't Walk...Remember, jaywalking is now against the law. You not only risk getting killed, but getting a summons as well. Of the 17,500 jaywalker casualties last year, 2,600 were killed or injured while crossing against the red light. So obey the law and DON'T JAYWALK!!...You always protect yourself and others when you remember to CROSS AT THE GREEN...NOT IN BETWEEN!"
 [The **Don't Walk** paragraph repeats itself and the **Walk** message comes on next.]
"Walk...The green pedestrian signal on 5th Avenue now indicates **Walk**...You can cross the avenue with safety and ease. Crossing at the corner with the light in your favor will safeguard your life...BE CAREFUL! The **Walk** signal will soon flash red"[3].

The signal was developed through a cooperative effort between New York City's traffic engineers and the Arnold Company of Brooklyn. The signals were not successful and were removed [3].

The most recent voice application of an audible signal in the United States is the Talking Sign which was designed by William Loughborough and implemented at the Smith-

Kettlewell Eye Research Foundation in San Francisco. The Talking Sign concept is based on an inexpensive, voice-modulated, infrared transmitter whose message is heard through a pocket-size receiver which is carried by the pedestrian, speaks the signs' messages and indicates the direction of their source [13].

The transmitters currently available operate from AC power lines. Prototype models under development operate by solar power and/or batteries and, when they come into production, installation and maintenance will cost the same as for any other electrical sign, according to Loughborough. The message can vary in length from two to thirty seconds depending on the capacity of the device used. The voice is recorded on and stored in a silicon memory chip which allows for a clear message when the receiver is pointed at the transmitter. The receiver utilizes a sensitive light detector-demodulator and contains a speaker which emits the message. The receivers are durable, inexpensive, dependable, and small enough to be carried in a pocket [13].

The system's performance and utility has been tested at institutions such as the San Diego Community College and the Los Angeles Braille Institute, and the user comments

were overwhelmingly favorable. When typical voice messages were presented to native English speakers, 98.7% understood the messages clearly. Tests to determine if there is a reduction in time from using the system showed that 71% of the blind subjects took less time to reach the target locations using the Talking Signs than those using the raised-print labels [13].

The talking system was tested for reliability and effectiveness at the San Diego Community College, and operated reliably both indoors and outdoors. In addition, it was found to be a valuable orientation aid to new students at the beginning of the school term. No vandalism was reported [13].

Available transmitters cost about \$50 each but will cost much less if purchased in large quantities. The receivers cost about \$150 each but will also become much cheaper if purchased in sufficient quantities. According to Loughborough, the sytem may also be used to help the visually impaired to locate business establishments as they are walking down the street. For about \$25, individual stores or residences could place the appropriate hardware outside of their door, and the visually impaired could

locate the various establishments by scanning with their receiver. A traffic intersection utilizing the Talking Sign system is to be installed by Mr. Loughborough in San Francisco in the near future [13].

There are several advantages to using the Talking Sign system. First, the system does not have to be universally implemented to be useful. Visually impaired pedestrians could benefit greatly by having the devices installed only at difficult crossing locations. A second advantage is that they do not pollute the audible environment any more than would reading the sign out loud, and this would occur only when in use [13]. Thirdly, the system could benefit the visually impaired at traffic circles, intersections having streets which are not east-west and north-south, and multi-leg intersections. Instead of having to develop separate tone schemes for crossing each leg of the above three examples, the system would tell the sight limited pedestrian where he is and where he is going. At present, however, the system has not been tried at a traffic intersection. As previously stated, an intersection in San Francisco is to be equipped with the talking system in the near future. Once installed, hidden defects or shortcomings may not be

revealed until the prototype has been in place for several months.

Additional American devices that are still in the conceptual stage come under the generic title of remote auditory indicators. This system works on the same concept as remote-controlled televisions and toys and consists of (1) a remote control unit which is carried by the pedestrian and (2) a series of speakers which are located at each corner of the candidate intersection. When the control is pressed, an auditory voice cue is broadcast from the speakers, and all pedestrians may be alerted of the changing signal. In 1981, it was estimated that the receiver/speakers would cost about \$5/unit if they were purchased in quantities greater than 100 [61]. Such reduced prices could be easily obtained by encouraging the visually impaired groups to mass purchase the devices. It must be mentioned that these devices were conceptualized for indoor rail rapid transit stations and not for traffic intersections and that they must be upgraded for outside applications.

9.1.2 EXPERIENCE ABROAD

9.1.2.1 BELLS

Several fatal accidents to the blind in Gedera, Israel (south of Tel Aviv) in 1963 prompted research on and installation of audible signals in that area. The installation consists of two-way signal heads, one on each side of the road at the pedestrian crossing. Each signal head has only the amber and red lenses. The amber flashes continuously, alerting drivers to the crossing and allowing the pedestrians to cross. The visually disabled pedestrian activates the audible signal by inserting and turning a special key in a lock which is mounted on the post. The turning key activates a series of events beginning with the flashing amber changing to a steady amber for four seconds. The light then shows the red indication and, after six seconds, a bell rings twice cuing the visually handicapped that it is safe to cross. After an adequate crossing time of twenty seconds, the bell stops ringing. The red light remains for six additional seconds to help those who still may be in the crosswalk. The solid amber signal then reappears and changes to flashing amber after three seconds. The above timing is not fixed as each phase can be changed

as deemed necessary by engineering judgement. In 1963, more than 150 keys were distributed to the visually impaired of Gedera, and the responses have been quite favorable [68].

9.1.2.2 INTERMITTENT TONES

A device was developed in Finland which on red pedestrian lights gives an intermittent **Beb Beb Beb....** sound, a common sound to indicate danger on emergency vehicles. On the green pedestrian phases, a steady continuous **Beeee....** sound signifies that the danger is over. There are eight units at a standard four-leg intersection (two per corner). As a person stands at a corner, he will be able to hear two units at the same time. When one of the units indicates **Don't Walk**, the other indicates **Walk**. The unit has three features which were especially developed to minimize noise pollution: (1) a manual volume adjuster; (2) an automatic volume adjuster which regulates according to ambient noise; and (3) a sound director which directs most of the device's sound toward the street. The sound director also helps the visually impaired pedestrian to home in on the **Walk** signal from the opposite corner as he/she is walking. The devices have performed

quite well in Europe, especially with regard to the safety of children. The sound is discreet and is audible only within a thirty-foot radius from the intersection. The discreet sound keeps the visually handicapped from feeling that they are singled out [26].

9.1.2.3 MISCELLANEOUS TONES

The Japanese, pioneers in the field of audible pedestrian signals, have made advances in the development of distinctive and effective tones. They have introduced devices which use chiming, whistling, and bird sounds as well as 21 different musical tunes. Their traffic authorities have now realized that pedestrians may be confused by the large varieties of sounds and have taken steps to reduce the number of tones. Though the number of tones is being reduced, the number of Japanese Metropolitan Governments using the signals remains high. As of February 1975, 29 of the 47 Japanese Metropolitan and Prefectural Governments use the signals making a total of 265 installations [4].

9.1.2.4 AUDIO-TACTILE DEVICES

In Holland, T.E.C.b.v. manufactures a device known as the T.E.C. Rattle/Ticker model BS5-50 which allows the visually impaired to cross the road safely at signalized pedestrian crossings. Special attention has been given to noise considerations for people living nearby in that though the unit has a maximum sound level of 70 dB, the model can be adjusted manually to suit the surroundings [18].

The Rattle/Ticker produces a clearly audible rattling sound with a ticking rate of approximately 800 per minute during both the solid and flashing **Walk** phases. When the indication is **Don't Walk** the sound rhythm changes to a slow ticking rate of approximately 70 per minute. It is possible to set up the system so that the ticking/rattling sound will only be produced when the pedestrian activates a push button on the pole. In such cases, upon the completion of a cycle, the acoustical signal will switch off automatically after about ten seconds. Continuous operation of the signal has the advantage of allowing the visually handicapped to orient him/herself on the crossing. The 120 x 60 x 85 mm unit is installed inside the pole and has optimal protection against vandalism [18]. Installation is fast and simple via the

service hatch in the pole. Wiring is done directly to the traffic signal. Eight signals are needed at a standard four-leg intersection with the cost per signal being about \$100 (1986\$) {650 Danish Kroner, DKK} [14]. The Rattle/Ticker is based on an electro-magnetic relay tapping against a metal case. Advantages of the mechanical clicking sound include help in localization, detection amongst traffic noise, and least annoyance to the community. In addition, the system has a sensory feature which is most helpful to the deaf-blind: the **Walk** and **Don't Walk** phases can be felt by vibrations when the device is in operation [5].

Dansk Signal Industri a/s of Denmark has a device which works on the same principle as the Rattle/Ticker. The unit needs a special mounting bracket and requires its own power supply. The sound emitted is an electronic sound controlled by the micro processor which measures the local environmental noise and automatically regulates the output so that the signal is heard under all normal circumstances. This prevents the unit from becoming a nuisance to local residents or businesses. In addition to the sound output, further information is provided to the visually impaired in

the form of a tactile arrow which is located on the top of the unit. The information is given by the raised knobs placed on the arrow. For example, an arrow with one knob situated at the end and in the direction of the crossing indicates that there is no median for refuge in the center of the road. An arrow with a knob at the end and another knob situated approximately 1 centimeter from the end knob indicates that there is a refuge in the center of the road. An arrow with a knob situated at both ends is used for units pointing in the direction of the crossing. The unit has built-in safeguards which ensure that should a fault occur, the unit will not give the **Walk** indication. The cost of this unit is approximately \$1200 (1986\$) {DKK 8000} [14].

Aldridge Traffic Systems (ATS) of Australia improved upon the desirable features of previous audio-tactile devices and now manufactures the Audio Tactile Pedestrian Detector (ATPD). The system comprises two separate units: (1) a post-mounted weatherproof box which accommodates the electronic control circuitry, power supply, and ambient noise monitor microphone, and (2) an Aldridge audio-tactile push button assembly. The push button assembly houses the tactile transducer and the audio signal transmitter [1].

ATPD produces two distinct types of audio signals and two distinct tactile pulse rates. The four functions follow:

1. The audible locating signal is continuously present for the duration of time the associated pedestrian traffic signal is in the **Don't Walk** condition. This serves to assist pedestrians with sight impairment to locate the push button assembly thereby permitting use of both the audio and tactile indication facilities available. The tone is approximately 1000 Hz with a slow repetition rate of 0.52 Hz [1].

2. The crossing signal comprises two tone audible signals with different tones. The first is a tone that immediately peaks and then decays followed by a rapidly pulsing tone of a fixed frequency. The tone has an initial burst of 2 KHz decaying in frequency to 500 Hz. The second, a pulse tone, is approximately 500 Hz with a fast repetition rate of 8.3 Hz. This sequence ensures positive identification by pedestrians with sight impairments and also serves to enhance the pedestrian **Walk** indication to all pedestrians at the traffic signal installation [1].

3. During the **Don't Walk** condition, a tactile signal pulses at the same rate as the corresponding audio signal (0.52 Hz), thereby giving a second sensory confirmation of the **Don't Walk** condition [1].

4. During the **Walk** interval, the tactile indication pulse rate (8.3 Hz) operates coincident with the distinctive audible **Walk** signal pulse [1].

The ATPD automatically adjusts its noise levels to ambient noise. Under all traffic conditions, the tones can be heard up to a distance of three feet from the signal. Under quieter conditions (night and early morning), the sounds can be heard up to a distance of nine feet. ATPD costs about \$400 per installation. The visually impaired in Australia apparently approve of this system as there are currently over 3000 installations in the seven Australian states [49].

9.1.2.5 VOICE APPLICATIONS

A great deal of work has been done in developing voice signals overseas, particularly in Japan and Scotland. In

the early 1980's, the Saitama, Japan Prefectural Police introduced a demonstrator audible signal unit which utilized a voice application. The device combines an ordinary signal and a micro-chip based sound synthesizer of the sort used in talking vending machines. When the pedestrian push button is pressed, the traffic light switches to the yellow mode, a chime sounds and a female voice speaks the following sentence in Japanese: "Please Do Not Cross Yet" [65]. After a few seconds have elapsed, the light turns green and another voice indicates that it is now safe to cross [65].

Shandwick Place in Edinburgh, Scotland has been the site of another voice signal experiment since November, 1980. The product, known as the Talking Pelican System, works as follows: When the **Walk** appears, a spoken message indicates that the signals have changed. On one-half of the crossing, a male voice gives the message: "Traffic Going To {Location} Has Been Signalled To Stop" [39]. On the other half a female voice gives the message: "Traffic Coming From {Location} Has Been Signalled To Stop"[39].

Two seconds is added to the **Walk** interval so that people new to the crossing will still have time to start crossing after listening to the message [39].

The voices are projected from directional all-weather loudspeakers mounted on top of the signal poles. A time switch is incorporated to lower the volume at night. The naturally spoken messages are placed onto a semiconductor chip; this is not a synthesized version of the required message, so it may be recorded using local accents, dialects, or languages if this will benefit the municipality [39].

Costs also vary for the system. A time-clock system is \$3000 (1988\$) and its installation is about \$300. The set of four loudspeakers for installation is \$300-400. The message recordings range from \$100-200, depending on who supplies and records the tape. A comprehensive maintenance contract costs \$200-250 the first year and about \$400 in subsequent years. Ordinary signal cable can be used to connect the speakers from the poles to terminal blocks [39].

Coeval Products Ltd. has been licensed by the Lothian Regional Council to further develop, manufacture, market, and install the Talking Pelican System [39]. A Pelican crossing is a British term referring to a mid-block Zebra crossing (pedestrian crossing striped with paint) with a pedestrian actuated **Walking Man/Standing Man** visual signal [58].

9.2 ATTITUDES TOWARDS AUDIBLE CROSSING DEVICES

9.2.1 VISUALLY IMPAIRED

9.2.1.1 POSITIVE

Salt Lake City, Utah has received numerous positive comments concerning their installation of audible pedestrian signals. In fact, their most encouraging comments came from visually impaired persons who were hesitant to travel downtown before the devices were in place. After the city installed the devices, the sight impaired felt more confident about being in the downtown area and were able to take advantage of social activities and shopping opportunities [6].

A totally blind person in Cincinnati made two key statements pertaining to the benefits of the signals. First, he said that the devices let one know when it is safe to cross. Second, the audible signal provides a beacon to head towards [66].

The Student Committee of the Braille Institute of America says that its members feel the audio crossing signals should be considered no more special for the visually impaired than the **Walk** and **Don't Walk** signals are for the general public [24].

The following responses come from visually impaired individuals who were interviewed by the author either in person or through the mail survey:

- o The devices assist not only the visually impaired but also those who need a little help when trying to cross busy streets.
- o There is a need for them at unusual intersections.
- o The audible cue is good both for the visually impaired and the dogs which guide them.
- o Audible traffic signals can be very helpful to blind persons in an independent travel situation, especially in areas of heavy traffic.
- o The devices are favorable at selected major traffic light intersections.
- o The audible signals are favorable only in crowded areas and those with twisting and confusing intersections.
- o The devices helped greatly at an angled intersection in Las Vegas.
- o Audible units are needed at short cycles so that pedestrians can get into the crosswalk as soon as possible.

9.2.1.2 NEGATIVE

The National Federation of the Blind (NFB) is totally opposed to audible signals. They explain that when the blind are correctly trained in the use of the long white

cane, and believe in the philosophy which teaches self-confidence, the blind do travel safely, and have been traveling safely for many years. They feel that audible traffic signals, tactile surface tiles, and other devices are not at all necessary, teach dependency, and give the public the erroneous idea that the blind cannot function without them [35].

According to Main Roads magazine, there is a certain mistrust by visually impaired pedestrians of mechanical devices at signal-controlled intersections for at least two reasons: fear of malfunction, and questions as to their own ability to identify the proper signal when two are on a corner [49].

Ramona Walhof of the NFB points out that blind or visually impaired are taught to travel independently using common sense, listening to traffic, and traveling with a long white cane or guide dog. She adds that the very success in training these thousands of pedestrians should indicate that no changes are needed at intersections. Walhof further states that it would be cheaper to improve training and other services to the blind in areas where services are poor and that any unnecessary bells, buzzers,

or tactile devices will cause sighted persons to think that the blind cannot travel without them [44].

Robert Acosta, President of the NFB of California, takes the position that it would be very expensive to place these devices at every major thoroughfare. He would rather see these funds spent on the obtaining of jobs for blind people. Acosta also brings up the problem of contributory negligence. Many civil codes (ex. Section 54 of the California Civil Code) protect a blind person should he inadvertently stray from the crosswalk in violation of everyday traffic rules. Should a blind pedestrian/vehicle accident occur, he adds, a motorist may argue that the pedestrian should have been using the acoustic signal at that particular corner. Acosta states that audible traffic signals should be an optional matter which the blind person may or may not choose to use depending on his proficiency in mobility [11].

Ted Young, in his article "On Traffic Signals," argues that the blind and visually impaired have been traveling successfully and safely throughout history without such props and aids. He states that unless one can prove that traffic conditions have radically changed or that something

has caused the visually impaired as a whole to deteriorate or become less able, it is difficult to build a case for the necessity of such devices. Young emphasizes that given proper mobility training, a visually impaired person can safely cross any street without such gimmicks [67].

Young [67] explains that a blind person crosses the street by listening to audible cues such as traffic flow; when the traffic is moving in a parallel direction as opposed to a perpendicular direction, it is safe to cross. He questions how a tone is more reliable than the proven methods of listening to traffic flow because if a person cannot be trained to analyze traffic flow despite the best efforts of rehabilitation or because of other handicaps, it is questionable whether a traffic signal can help that person to cross any street safely or independently. According to Young, if a person's only handicap is blindness and if that person has been properly trained, a tone at an intersection will not be of much additional help. There are already noises from jackhammers, traffic, and building construction; additional noises are not needed, says Young. Another of his reasons for opposition to the devices is that the general public may wonder what additional devices the visually impaired require to do everyday tasks.

Additional negative responses have come from the personal interviews and the mail surveys and are listed below:

- o Loud signals will make visually impaired pedestrians feel conspicuous [38].
- o It is difficult to determine the direction in which the signals are telling pedestrians to cross.
- o The devices may be subject to mechanical failure [46].
- o The signals may give a false sense of security [46].
- o Tone may be masked by traffic.
- o Tone may be confused with other traffic noise.
- o Deaf-blind persons will not be aided by an acoustic device alone.
- o Without prior instruction, there is no way of knowing which signal indicates which direction.
- o There is no uniformity among the devices.

9.2.2 GENERAL PUBLIC

9.2.2.1 POSITIVE

Salt Lake City, Utah received a large number of positive comments about the signals. Many of the responses came from sighted persons who felt that the devices alerted them that the signal had changed, and that it was safe to

cross. Persons with low vision problems who were not legally blind comprised a large percentage of this group [6].

Wherever they have been installed, the acceptance has been gratifying according to Frank Girardot of Traconex. He adds that neither rain, heat, cold, nor volcano dust seems to affect the signals and that the devices are apparently not attractive to vandals [23].

9.2.2.2 NEGATIVE

The negative responses voiced by the general public focused mainly on the noise aspect of the signals. Some feel that the sounds may cause noise complaints from persons in adjacent offices, hotels and residences. Others are of the opinion that the audible signals are noise pollutants simply because they add to the level of noise on the streets.

9.2.3 PUBLIC OFFICIALS

9.2.3.1 POSITIVE

The City of Cincinnati, Ohio reports that audible pedestrian signals are particularly helpful at intersections

that are non-orthogonal because they help the visually impaired to find the ends and alignment of the crosswalks [33].

In Peoria, Illinois, the traffic engineers have reported that the devices improve the alertness of sighted pedestrians as well as the visually impaired [12].

The Sacramento, California traffic engineers noted that conversing pedestrians waiting to cross are clued to the fact that the signal has changed. A further observation was that audible signals are attention getting for both fully sighted and visually impaired pedestrians who are not attentive to the visual **Walk** signal [36].

Daydreaming sighted pedestrians will come to attention and be less likely to miss the **Walk** indication according to observations by the Edmonton, Alberta engineering department. In addition, the department reports, the audible cues will be of great benefit at intersections with long cycle lengths and short **Walk** phases [22].

9.2.3.2 NEGATIVE

San Francisco traffic engineers have experience with at least five drawbacks of the audible pedestrian signals.

First, they have received noise complaints from people in adjacent offices, motels, and residences. Second, there is no way of knowing without foreknowledge which sound is directed toward which crossing as there is no uniformity. Third, they do not believe the devices could withstand the vandalism present on U.S. streets. Fourth, there would probably be objections to the sounds even if they were attenuated. Finally, they believe that there is no clear definition (perhaps one is not possible) of the needs and wishes of the visually impaired pedestrian [16].

The sounds may give the visually impaired a false sense of security; they may tune out traffic clues that may override the audible signal which indicates that it is safe to walk [47]. For example, a driver in an emotional situation such as being late to work or going to the hospital may very well run a red light if they think that the intersection is clear. Current audible devices do not clue the pedestrian to such dangerous circumstances. In addition, they can be confused with other sounds at intersections such as trucks moving in reverse.

Audible devices have an inherent drawback: at complex junctions where it is too difficult to cross, audible

signals require additional listening tasks which, in turn, add to the difficulty of crossing the street. The key to overcoming this drawback is pedestrian education and training. For the blind pedestrian, the full advantage of audible signals can only be realized with instruction and practice in their use [62].

The City of San Diego states that audible traffic signals cannot assure the visually impaired pedestrian that it is safe to cross. [It must be emphasized that visual traffic signals cannot assure a safe crossing.] San Diego's Policy Number 200-16 enumerates four conditions under which the audible devices would not be of much help:

1. Vehicles may still be clearing the intersection when the audible signal starts.
2. Impatient drivers may fail to stop at the red signal indication.
3. Right turning motorists may look to the left and start moving their vehicle to the right without looking for pedestrians on the right.
4. Vehicles may have the signal which allows them to turn left, or right at the same time that the pedestrians have the **Walk** indication [2].

9.2.4 ORIENTATION AND MOBILITY SPECIALISTS

9.2.4.1 POSITIVE

The orientation and mobility specialists at the Carroll Center for the Blind express at least two favorable opinions concerning audible signals. The first is that the units should be considered at atypical signalized intersections where it may be difficult to safely cross by relying on traditional orientation and mobility skills. The second is that audible signals may be necessary at certain busy and complex intersections in that there may be no other way for the visually handicapped to cross [15].

9.2.4.2 NEGATIVE

One specialist at the Carroll Center states that traditional methods have proven to be reliable and make a traveler more aware, alert, and safe. He goes on to say that the visually impaired could develop a false sense of security in that the device may mislead a person into thinking that the coast is clear [15].

Arthur O'Neill another mobility specialist at the Carroll Center disagrees with the use of audible signals for three reasons:

1. They are not consistent from one system to another.
2. They may be annoying to those who live or work nearby.
3. They are not universally used and create a dependency problem (if effective) since they are not used at all complex intersections [37].

Leon Thamer of the Braille Institute states that it is the goal of his organization to increase the independence of the visually impaired rather than to contribute to the dependence on aids [42].

9.3 COMMENTS REGARDING NEGATIVE RESPONSES

OBJECTION 1:

Visually impaired persons have been traveling safely for years without such devices. It is hard to justify such a device unless there have been radical changes in the sight impaired population, and the traffic environment.

RESPONSE 1:

It is true that many visually impaired have been traveling safely for years, but it is also true that many have become recluses and do not venture out. Audible signals increase the confidence of and expand the opportunities to the visually handicapped community by helping them to cross under complex circumstances. Situations have changed in the roadway environment in the past years. Cities are larger; there are more vehicles and drivers on the road at any given time; and drivers appear to be both more impatient and more unaware of white cane laws which require motorists to stop when a visually impaired person with a white cane is crossing the road.

OBJECTION 2:

The devices may be subject to mechanical failure.

RESPONSE 2:

The two devices most popular in the United States, the Mallory Sonalert and the Traconex Audio Signal, have had few mechanical problems. According to Peter Fischer of Traconex, of the 2500 devices they have sold, less than 10 have had problems [21]. The Sonalert devices have an expected life of 5 years [45] but have been known to work well past the 5 year mark. The ones in Washington, D.C. have been working for over 10 years.

OBJECTION 3:

It would be very expensive to provide the devices at every traffic intersection.

RESPONSE 3:

It would not be economically feasible to have them at every intersection and the visually impaired do not want them everywhere. The Basic Considerations and the Evaluation Factors (See the Discussion of Criteria Section on page 60) are designed to single out the intersections most worthy of an audible signal. Having an evaluation team

which is composed of a traffic engineer, an orientation and mobility specialist, and a visually impaired person also helps to better determine the most critical intersections.

OBJECTION 4:

If the devices are loud, they will make the visually impaired feel conspicuous.

RESPONSE 4:

Observations of the devices in the Washington, D.C. area reveal that the signals are not loud. The Traconex model has a volume adjuster which is self-switching to one of two output levels based on ambient noise conditions. The Mallory SC 110E has a sound pressure level at two feet that varies from 55 to 65 dB which is in the "Soft" loudness category. The SC 110Q varies from 68 to 80 dB which is in the "Medium" loudness category.

OBJECTION 5:

It is difficult to determine the direction in which the devices are signaling the pedestrians to cross.

RESPONSE 5:

This objection was only valid before suggested sound patterns were recommended for the east-west and north-south crossings. (See Operating Criterion Number Eleven, page 95)

OBJECTION 6:

Tone may be masked by traffic.

RESPONSE 6:

The chirps, constant tones, peeps, and cuckoo sounds are quite distinct and are not significantly masked by traffic. In addition, since traffic noise is generally below 500 Hz, signals which are between 500-1000 Hz should minimize the possibility of masking [30].

OBJECTION 7:

The tone may be confused with other traffic noise.

RESPONSE 7:

An intermittent pulse may be confused with emergency sirens, but a sound which has a constant frequency of 750 Hz should minimize this occurrence [29]. The back up alarms on trucks are within the same frequency range (700-2800 Hz) and sound pressure level range (80-110 dB) of audible signal [19]. An audible signal which is more sporadic may be of great benefit in distinguishing between trucks moving in reverse and audible crossing aids [30]. One example would be to have one long beep, pause, three short beeps, pause, one long beep.

OBJECTION 8:

Audible signals may give a false sense of security.

RESPONSE 8:

The devices may indeed lead the visually impaired to let down their guard when they hear the tone. However, the devices are not meant to be a substitute for orientation and mobility skills but rather a supplement to them. Their purpose is twofold: (1) to indicate that the **Walk** phase has begun and (2) to serve as an audible beacon for orientation.

OBJECTION 9:

The devices will cause noise complaints from persons in adjacent offices, hotels, and residences.

RESPONSE 9:

The devices are not loud, and most are in the soft to medium sound loudness category. In addition, one of the operating criteria suggests that the devices either be operated by time clock, pedestrian push button, or both so that the devices will not be a disturbance during off-peak traffic hours (See Operating Criteria Number Twelve on page 97).

9.4 JUSTIFICATION

The introduction of new traffic control facilities is contingent upon the improvement of safety and the reduction of delay. As far as safety is concerned, the visually impaired are cautious at intersections and would rather wait at the corner for a cycle or two than venture carelessly into an intersection. Many visually impaired avoid the confusing intersections altogether and take alternate routes. Consequently, the visually impaired are rarely involved in serious traffic accidents---at least accident reports do not categorize each incident by the degree of visual acuity of those involved. There is not enough accident data concerning the visually impaired to justify the use of special signals which would benefit only the visually handicapped pedestrians. Since there is a lack of accident data, there is a corresponding difficulty in establishing a sound economic argument for the installation of audible pedestrian signals [4].

For a new device to be successful and accepted, it must be beneficial to more than one segment of society. Children, older persons, the handicapped, and the average pedestrian should somehow benefit from the signals.

Children do not pay close attention at intersections and often run into the street when they think it is safe to cross whether the **Walk** indication is showing or not. An audible cue at complex or busy intersections will help them to be more alert at the dangerous sites. Older adults may travel at least one foot per second slower than the figure used by traffic engineers in the computation of crossing times under normal conditions. Combined data from 1979 to 1980 indicates that 27.3 percent of all pedestrian fatalities involved persons over the age of 65 [50].

Acoustic signals will serve as an aid to older adults in initiating and completing their street crossings more quickly and thereby reducing the probability of being hit. A handicapped pedestrian, depending on his/her impairment, may walk slower than the rate of the unimpaired pedestrian. A prompt which would let them begin crossing sooner would certainly improve their chances of an incident-free crossing [4].

The reduction in pedestrian reaction times at intersections equipped with acoustic signals has been the key finding in research undertaken by the Transport and Road Research Laboratory (TRRL) in England. D.G. Wilson of the

TRRL has performed a before/after study at an audible intersection at South-end-on-Sea in Berkshire, England which supports the reduction in reaction time statement. Three notable findings were observed by Wilson [64]:

1. The time taken to cross the road by pedestrians initiating their crossing in the **Walk** phase decreased by 5 percent.
2. Pedestrian delay after the onset of the **Walk** phase decreased by over 20 percent.
3. 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.

It should be noted that these figures were obtained for all pedestrians and not just for the visually handicapped. The improvements to the visually impaired could not be singled out due to the small number of visually impaired in the population [64].

Many persons often daydream or do not pay close attention at intersections and lose a few seconds of their

Walk phase. The problem is compounded during peak hours when the pedestrian phase may be shortened to allow for more vehicle movement. In such cases, the daydreaming pedestrian may miss the **Walk** phase altogether. Should the late pedestrian decide to cross, he will run a much higher risk of being hit. R.V. Leith, a traffic engineer for the city of Auckland, New Zealand, estimates that acoustic signals may reduce the lost time at the start of the pedestrian phase by as much as 2-3 second [4].

A request that provisions for the handicapped be designed into a specific project is frequently met with a counter request to prove that there are enough handicapped people to justify the effort and added costs [56]. There are indeed enough visually handicapped to justify that they be provided for at certain complex, confusing, or high volume intersections. Over 11.4 million persons in the United States have some form of visual impairment. One-million are termed low vision and an additional 400,000 are totally blind, and the remaining 10 million are also affected in everyday life by their visual disability. An estimated 59 percent of blind and low vision persons have multiple impairments. Of the multiply impaired, 65 percent are hard-of-hearing or deaf.[54]

Employment possibilities are a further justification for audible signals. William P. McCahill, Executive Secretary of the President's Committee on Employment of the Handicapped in 1969, states that getting back and forth to work was just as important to a handicapped person as convincing an employer of his work skills. Most businesses are favorable to hiring the handicapped providing that they can perform their job satisfactorily as well as get to work on time. When a visually impaired person cannot get to his or her job with ease or move about satisfactorily, he will not be able to make a decent living for himself and his or her family. As improvements are made at intersections, the visually handicapped will find a new freedom and a new mobility [55]. The reason that the employment issue is so significant is that many visually limited persons may not apply for jobs in high volume, complex areas because of the degree of difficulty in getting to work. Even though the individuals are qualified for the jobs and the jobs may be higher paying, they choose not to apply for safety reasons [40].

While it may be true to some extent that the visually impaired may become dependent on the devices and that the

public will think that they cannot travel without them, it must be realized that the mobility skills of the visually impaired vary considerably. The differences in success may be attributed to one or several of the following reasons: differences in experience, differences in age, and additional handicapping or disabling conditions [34].

Visually impaired persons are reminded of their handicap when they cannot accomplish certain tasks because of their impairment. One of the more difficult tasks is crossing streets at offset, acute-angle, multi-leg, or awkward intersections. Crossing such awkward intersections in unfamiliar environments can be even more of a problem.

The installation of traffic control devices can alleviate some of these difficulties [5]. Personal interviews with the blind, visually impaired, and orientation and mobility specialists reveal that visually impaired pedestrians sincerely desire to be independent. No one likes to constantly ask for assistance in completing a daily task, and visually impaired persons are no exception. Asking whether the **Walk** indication is displayed or asking for assistance in crossing the street inevitably draws unwanted attention to the disability. Audible cues will

eliminate this problem and will enhance both the independence and confidence of the visually impaired pedestrian.

9.5 CRITERIA FOR INSTALLATION AND OPERATION

Installation criteria are used to determine whether there is a need for an audible signal at candidate intersections and if so, what is the priority of each intersection. Once the priority of each candidate is determined, the operating criteria are employed to make the most effective use of the devices.

9.5.1 INSTALLATION

It has been the state policy of Vermont since the early 1980's to include audible signals in all new traffic signal installations that have pedestrian heads. Generally they are installed, tested, and then disconnected unless needed or requested by local officials [32]. It is not known if other states or cities have such a system.

In 1985, a quantitative evaluation and prioritizing system for the installation of audible pedestrian signals was developed by the Committee for the Removal of Architectural Barriers (CRAB) for the City of San Diego's Transportation and Land Use Committee [2]. Their system is divided into the 2 following groups which are listed and explained: Basic Considerations for Installation and Evaluation Factors.

9.5.1.1 BASIC CONSIDERATIONS

1. Intersection must be signalized.
2. The existing hardware must be subject to retrofitting.
3. The audible signal 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.

1. Intersection must be signalized.

The traffic signalization of a standard 4-leg intersection costs about \$60,000 to \$80,000 (1988\$). Most areas having a significant volume of pedestrian and vehicle traffic would already be signalized and would have pedestrian phases. In general, an intersection should not be signalized just so that an audible device can be installed.

2. The existing hardware must be susceptible to retrofitting.

The existing hardware should require little or no wiring to be compatible with the signal device.

3. The audible signal should be equipped with pedestrian signal actuations.

The objection most often given by the general public concerns the noise of the signals even though they are favorable to the idea. The signals need only be used when a visually impaired person is present, though older persons and the handicapped could benefit as well [7]. Use by the impaired will amount to only a small fraction of time per day. The signals will only sound late at night or early in the morning when an occasional traveler uses that particular crossing. Pedestrian-actuated signals should alleviate the noise complaint during the off-peak hours of the day, but the visually impaired must be able to find the button.

4. Location must be suitable to installation of audible signals, in terms of land use, noise level, and neighborhood acceptance.

The devices should only be installed in areas frequented by the visually impaired. The noise levels of the signals should be such that little if any criticism is forthcoming from the nearby residents and/or businesses. No audible signals should be installed in areas where the visually impaired do not want them.

5. There must be a demonstrated need for the audible signal device.

There must be at least one visually impaired person using a dangerous or confusing intersection before any action should be considered. Those persons affected must make their complaint of the site and subsequent request of an audible signal known to the traffic engineers or public works department in his or her city.

9.5.1.2 EVALUATION FACTORS

The evaluation factors for installation are divided into four groups: Intersection Safety, Pedestrian Usage, Traffic Conditions, and Mobility Evaluation. The four groups are further divided making a total of twelve evaluation factors. Each can obtain a score of from 0

(corresponding to situations in which the signals are of lowest priority) to 5 (indicating that the signals are of highest priority). [Five of the factors have a minimum score of one.] Locations having the optimum conditions for an audible signal would receive a maximum of 60 points; other locations are arranged in descending order with the highest point total indicating the highest priority. A team consisting of an orientation and mobility instructor (a person who teaches the visually impaired how to maneuver himself while walking), a traffic engineer, and a visually impaired/blind traveler both chooses the sites and does the scoring. While reviewing the tables concerning the evaluation factors, the reader should note that the bracketed values within the tables are the author's revisions to the CRAB findings. The 12 factors which were developed by CRAB are listed below. A discussion of each follows:

1. Pedestrian Accident Records
2. Intersection Configuration
3. Width of Crossing
4. Vehicle Speed
5. Proximity to Facilities for the Blind or Visually Impaired
6. Proximity to Key Facilities Utilized by All Pedestrians
7. Number of Public Transit Routes and Stops
8. Number of Passengers Boarding and Debarking Each Day
9. Heavy Traffic Flow
10. Light Traffic Flow
11. Uneven Traffic Flow
12. Mobility and Other Miscellaneous Factors

1. Pedestrian Accident Records. Table 1.

Four-year pedestrian accident records for the intersection in question should be obtained from the police department [2].

Table 1. Pedestrian Accident Records

<u>Pedestrian Accidents in 4 Years</u>	<u>Points</u>
[0]	[0]
1	1
2	2
3	3
4	4
5 or more	5

2. Intersection Configuration. Table 2.

The number of approaches at an intersection as well as the geometry (widths, angles) have much to do with the crossing difficulties the visually impaired encounter. According to the CRAB study, 3-leg intersections are difficult to cross because they do not provide adequate audible cues concerning the traffic phases [2]. Traffic circles and intersections involving more than 2 streets are among the worst conditions for the visually impaired pedestrian.

Table 2. Intersection Configuration

<u>Configuration</u>	<u>Points</u>
4-leg right angle intersection	1
3-leg tee intersection	2
3 or 4-leg skewed (non-orthogonal) intersection	3
4-leg intersection with uneven corners	4
Other complex or multiple leg intersections	5

3. Width of Crossing. Table 3.

Wide streets are dangerous to cross since the pedestrian is exposed to the intersection for a longer time. Pedestrian phasing should permit the visually impaired to cross in one continuous movement whether or not there are pedestrian islands or medians, according to the CRAB report. The width of the intersection is measured along the widest pedestrian crossing and includes the medians [2].

Table 3. Width of Crossing

<u>Width of Crossing</u>	<u>Points</u>
40 feet or less	1
41 to 52 feet	2
53 to 68 feet	3
69 to 78 feet	4
79 feet or more	5

4. Vehicle Speed. Table 4.

The higher the vehicle speed, the more danger to the visually impaired for at least two reasons. First, high speeds mean short vehicle closing times, longer braking distances, and less time for the visually impaired to get out of the way of an approaching vehicle. Second, the higher the speed, the greater the severity of the accident should it occur. Intersection speeds for this purpose will be the 85th percentile speed measured along the fastest approach leg [2].

Table 4. Vehicle Speed

<u>Speed Range</u>	<u>Points</u>
0-25 miles per hour	1
26-30 miles per hour	2
31-35 miles per hour	3
36-40 miles per hour	4
41 or over	5

5. Proximity to Facilities for Blind or Visually Impaired.
Table 5.

Departments of Rehabilitation, Social Security offices, organizations of and for the visually impaired, public housing facilities and senior citizen complexes with one or more visually impaired persons are included in this category. Points are assigned on the basis of the proximity (1 block equals 400 feet) of the intersection to these facilities. The closer the facility is to the intersection, the more points are allotted [2].

Table 5. Proximity to Facilities for the Blind

<u>Proximity</u>	<u>Points</u>
4 to 6 blocks	1
3 blocks	2
2 blocks	3
1 block	4
at subject facility	5

6. Proximity to key facilities utilized by all pedestrians (blind and sighted). Table 6.

Medical, educational, social, recreational, shopping, commercial, business, public, and governmental trips come under this heading. Points are assigned using the distance between the intersection and the facility as above. Should there be more than one such facility nearby, the points will be awarded based on the proximity of the closest one [2].

Table 6. Proximity to Facilities Used by All Pedestrians

<u>Proximity</u>	<u>Points</u>
4 to 6 blocks	1
3 blocks	2
2 blocks	3
1 block	4
at subject facility	5

7. Number of transit stops and/or transit routes within one block of proposed audible signal site. Table 7.

Since the visually impaired cannot drive, they depend heavily on public transportation such as buses and subways. Special consideration should be given to crossings that have heavy general use, are located near any of the facilities listed in evaluation factors 5 or 6 above, serve as a transfer point between modes of travel, or serve 2 or more transit routes within a one-block walk [2].

Table 7. Transit Routes and Stops within one Block

<u>Number of Routes and Stops</u>	<u>Points</u>
[0 routes and 0 stops]	[0]
1-2 routes and 1 stop	1
3 or more routes and 1 stop	2
1-2 routes and 2 stops	3
3 or more routes and 2 stops	4
3 or more routes and more than 2 stops	5

8. Passenger Usage. Table 8.

The passenger usage factor is assigned points based on the total number of passengers, both sighted and visually impaired, boarding and debarking each day at a transit stop or transfer point within a one-block walking distance [2].

Table 8. Passenger Usage

<u>Passengers Boarding and Debarking Each Day</u>	<u>Points</u>
[0]	[0]
[1-249]	1
250-499	2
500-999	3
1000-1499	4
1500 and over	5

Vehicle volumes, traffic distribution, traffic congestion and flow characteristics play important roles in a visually impaired person's ability to cross the road. For example, a visually limited person can best utilize his or her orientation and mobility skills at signalized intersections that are at right angles with a moderate but steady flow of traffic through the intersection on each leg with a minimum of left and right turns. Traffic conditions in which the flows are either heavy, light or erratic make it difficult to pick up audible clues as to whether the light is red or green. Audible signals located at the above trouble spots should remove much of the difficulty. Candidate sites can score up to 5 points for each of the next 3 evaluation factors depending on the overall traffic conditions [2].

9. Heavy traffic flow. Table 9.

The sum of approach traffic on all legs is greater than 2000 vehicles per hour during any peak hour [2].

Table 9. Heavy Traffic Flow

<u>Vehicles per hour</u>	<u>Points</u>
[0-1999]	[0]
2000-2999	1
3000-3999	2
4000-4999	3
5000-5999	4
6000 and over	5

10. Light traffic flow. Table 10.

The sum of the approach traffic on all legs is less than 900 vehicles per hour during any one-hour period between 6 AM and 6 PM [2].

Table 10. Light Traffic Flow

<u>Vehicles per hour</u>	<u>Points</u>
[900 and over]	[0]
800-899	1
700-799	2
600-699	3
500-599	4
Under 500	5

11. Uneven traffic flow. Table 11.

Platoons or approaching traffic flow may not coincide with the signal phasing on any leg, thus making it difficult for visually impaired travelers to detect and determine the appropriate signal phase [2]. It is much easier for the visually impaired to determine gaps in traffic when there are platooning vehicles than when the traffic is erratic. Though Table 11 only gives the 2 extreme point values, it is left to the evaluation team to choose intermediate values as deemed necessary.

Table 11. Uneven Traffic Flow

<u>Traffic Flow Condition</u>	<u>Points</u>
Platooning Vehicles	0
Erratic Traffic Flow	5

12. Mobility evaluation. Table 12.

Based on the judgment of the three member evaluation team (traffic engineer, orientation and mobility instructor, and a visually impaired traveler), additional points may be assigned based on observed or special conditions not covered by the previous 11 factors [2]. The points range from zero to 5 for this subjective evaluation factor.

Table 12. Mobility Evaluation

No special circumstances	0
Many special circumstances	5

9.5.2 OPERATION

Once the installation criteria have been evaluated and the intersection is determined to be in need of an audible signal, the operation criteria are applied. Since non-uniform procedures and devices cause confusion among pedestrians and vehicle operators, prompt wrong decisions, and contribute to accidents, comparable traffic situations must be treated in the same manner [59]. This section contains recommendations for the operation of audible signals in order to eliminate confusion and the possibility of accidents caused by non-uniform audible pedestrian devices.

Huntington Beach, California is one of the pioneer cities in the United States concerning the installation and operation of audible pedestrian signals. It is therefore not surprising that the Huntington Beach traffic engineers developed the first known criteria for the operation of the signals in the United States. Many cities such as Salt Lake City, Utah subsequently adopted these criteria. The first 11 criteria are those developed by Huntington Beach; the additional criterion was included by the author. The twelve operating criteria are listed and discussed on the pages that follow:

Signal Operation Criteria

1. Must not be annoying to the average pedestrian or resident.
2. Must have noise levels measured at an intersection from 10 to 120 dB.
3. Must be low cost.
4. Must have upper and lower volume limits.
5. Simple, low-cost installation is required.
6. Must require minimal or no maintenance in a harsh environment.
7. Must be mechanically adjustable as to direction.
8. Should not require any extra wiring to the cabinet.
9. Should in no way interfere with the normal signal operation.
10. Must operate only when the **Walk** indication is displayed.
11. Must have a different, easily distinguished sound for each direction [57].
12. The audible device should operate either by pedestrian actuation [7], time clock, or both.

1. Must not be annoying to the average pedestrian or resident.

An annoying signal would tend to elicit the resentment of both the impaired and sighted community. The visually impaired do not want to be singled out and labeled by an annoying signal. They probably will tend to avoid such intersections if alternate routes are available. Nearby residents and businesses will complain and may succeed in having the signals removed.

2. Must have noise levels measured at an intersection from 10 dB to 120 dB.

Signal noise levels lower than 10 dB may not be loud enough to command attention while levels in the 120 dB range become annoying. The sound must be easily located and detected above traffic noise. Visually impaired pedestrians should not have to strain to hear the signal.

3. Must be low cost.

When more than 10 percent of the cost of an intersection is attributed to an intersection improvement, it becomes a major expenditure. All cities which might

benefit from the system may not be able to afford the devices if this criteria is not satisfied. Typical installation costs are given for the Mallory and Traconex devices in sections 9.1.1.2 and 9.1.1.3, respectively.

4. Must have adjustable upper and lower volume limits.

Traffic noise levels show great variation between peak and non-peak hours, and a successful signal must take these large variances into account. Higher volumes would be effective during peak hours but, in all probability, would be bothersome to nearby residents at night. Lower volumes, while desirable at night, would not be effective during the peak hours. Many devices on the market today have mechanisms which automatically adjust their volume output based on the ambient noise.

5. Simple, low-cost installation is required.

A system which may be effective and inexpensive but is extremely difficult to install will not be attractive to the cities because of exorbitant expenses associated with installation.

6. Must require minimal or no maintenance in a harsh environment.

An effective system should perform well even in the harshest of environments. Systems requiring constant maintenance are unattractive because of their lack of reliability and their increased costs due to maintenance. The device must be reliable so as to gain the pedestrians' confidence. A person who frequents a complex intersection that is known to have a defective signal will tend to ignore the audible cue.

7. Must be mechanically adjustable as to direction.

A unit which is directionally adjustable has 2 advantages:

1. Positioning the signal in the downward direction will both restrict the sound to the pedestrian crossing and allow the volume to be lowered.
2. When the unit is positioned outward, pedestrians can not only hear the sound from his initial corner but also home in on the sound coming from the destination corner [63].

8. Should not require any extra wiring to the cabinet.

Extra wiring means extra cost. While some extra wiring may be required (to provide for the pedestrian clearance interval in the manner in which the City of Cincinnati operates its devices) it should not be excessive.

9. Should in no way interfere with the normal vehicle signal operation.

In the event of a malfunction of the device, the entire intersection (all approaches) may be rendered inoperable if it interfered with the normal operation of the traffic signal.

10. Must only operate when the **Walk** indication is displayed.

There is some dissension concerning this criterion. The Huntington Beach traffic engineers obviously thought that the signals need only operate during the **Walk** indication, but the pedestrian clearance interval must also be considered. Amber lights warn drivers that their right-of-way is ending and to complete their crossing if they are in the intersection but to stop at the light if they are not

in the intersection. Sighted pedestrians are similarly warned during the flashing **Don't Walk** phase. Visually impaired pedestrians should be given the same information to help them cross safely. [See the Operation Criterion Number Eleven discussion which follows for more information in providing for the clearance interval.]

11. Must have a different, easily distinguished sound for each direction.

Identical tones for both crossing directions will cause confusion as to which direction is clear when that tone is heard. A standardized sound for the east-west direction as well as a standardized tone for the north-south direction will eliminate confusion and improve the confidence of the pedestrian. The recommended sound scheme for municipalities using the Mallory devices is to use the SC 110E (constant tone) for the east-west direction and the SC 110Q (buzzer sound) for the north-south crossings. This scheme is currently employed by the city of Cincinnati. Another concept used in Cincinnati that should be used in other municipalities using the Mallory devices is to connect the devices to the controller so that they flash in cadence with

the pedestrian clearance interval. For cities using the Traconex product, the company suggests using the Peep-Peep sound for the east-west direction and the Cuckoo sound for the north-south crossings. The device should also be rigged so as to provide for the pedestrian clearance interval. There is currently no factory installed provision for the pedestrian clearance interval in either the Traconex or Mallory product.

Tones preferably should be of the intermittent pulse type, as this is the easiest sound for the human ear to localize [29]. The intermittent tones can be discerned by pedestrians at lower volumes and/or frequencies than other tones [7].

The optimal frequency for audible signals is 750 Hz according to Adrienne Karp, an audiologist at the Lighthouse (New York City). She states that the intermittent frequency should remain in this area so as to avoid being confused with the sound made by emergency sirens [29].

12. The device should operate either by pedestrian actuation (push button), time clock (the time clock is wired to the device so that it only works during certain hours of the day. e.g. 7a.m. to 7p.m.), or both.

In this way, the device would not be heard continuously throughout the day and would not disturb nearby residents during times of low traffic noise. Nearby residents attempting to sleep would only occasionally be disturbed by pedestrians using the device. The determination as whether to use time clocks or pedestrian push buttons is based on the number and frequency of sight impaired pedestrians using the intersection. For locations having high volumes of sight impaired pedestrians who cross frequently, a time clock system may be of the most benefit. It should be noted, however, that in systems utilizing time clocks, the sound will be emitted during every **Walk** phase of the operating interval set on the time clock unless the time clock is attached to the push button. Oakland, California is one such city which has the time clock and the push button attached. Intersections having low volumes of visually impaired pedestrians who cross rather infrequently would benefit most from installing tones actuated by push

button. It is recommended that systems use tones actuated by push buttons in conjunction with time clocks as opposed to tones controlled solely by time clocks. The use of such a system ensures that the sound will be emitted only upon pedestrian demand. The visually impaired, however, must be informed of the presence of the push button.

10. CONCLUSIONS AND FUTURE STUDIES

Audible pedestrian signals are feasible but only at certain complex or confusing intersections which are used by visually impaired persons. Neither do the visually impaired want them nor are they justified at every intersection. Areas frequented by the visually impaired and the general community such as transit stops, shopping centers, medical and educational facilities, and associations of and for the visually impaired should be evaluated using the installation criteria which begin on page 60 to determine their priority for having audible signals installed.

At present, audible signals indicate only that the Walk indication is displayed and do not indicate if there are vehicles still clearing the intersection. Current technological advances may soon be applied to relieve this situation. The devices are not meant to be a substitute for a visually impaired person's orientation and mobility skills but rather a supplement to them.

The audible signals should operate either by pedestrian actuation, time clock, or both. Any of these methods insures utilization of the devices only when necessary, and unnecessary noise is avoided. Signals which sound at all

hours, regardless of the pedestrian demand, are highly undesirable. It is suggested that the devices operate with both a push button and a time clock.

For the Mallory Sonalert and Traconex Audio signal products, the following tone schemes are recommended. The Mallory SC 110 Q, which has a buzzer sound, should be used for the north-south crossings and the SC 110 E, which has a constant tone, should be used for the east-west pedestrian movements. This scheme was developed and implemented by the City of Cincinnati. A pedestrian clearance interval should be provided in the manner that it is provided for in Cincinnati. This necessitates wiring the device to the controller so that the sound pulses in cadence with the flashing **Don't Walk** indication. For the Traconex devices, the manufacturer suggests using the Peep-Peep sound for the east-west crossings and the Cuckoo tone for the north-south pedestrian movements. The Traconex Audio Signal should also provide a pedestrian clearance interval. The pedestrian clearance indication is necessary to indicate to the visually impaired that the signal is about to change.

The use of bells as sounds for audible pedestrian signals should be avoided because of their poor localization qualities.

Intersections should not be equipped with one, centrally located audible device which is used in conjunction with a Scramble Crossing for the following reasons:

1. These devices have severe limitations at non-orthogonal intersections in that there is neither a sound to allow the pedestrian to orient himself at the corner nor a sound to allow the visually impaired to "home in on" the adjacent corner.
2. No directional information is given to inform the pedestrian whether he/she is crossing in the east-west direction or the north-south direction.
3. One device will have to be adjusted to a higher sound level than would multiple devices located around the intersection.
4. Scramble Crossings always increase pedestrian delay and may increase vehicular delay depending on the vehicle arrival patterns [60].

There has not been sufficient research on the voice applications of audible pedestrian signals in the United States in order to draw conclusions about their use. In 1959, the initial voice application of audible signals in the United States was in New York City, but it was unsuccessful. In San Francisco, an intersection is scheduled to be equipped with a voice cue in the near future. Potential problems with voice signals may arise due to language barriers in that all persons at the intersection may not understand the particular language. A tone such as a beeping sound has universal recognition.

Intermittent pulses in the frequency range of 300-1000 Hz [4], with 750 Hz being optimal [29], are the most effective sounds for the human ear to localize and they do not require a high volume level to be effective [7]. Frequencies in the alpha-rhythm range (8-14 Hz) should be avoided because they may incite epileptic seizures [4].

Driver education concerning the problems of visually impaired pedestrians should be promoted. An initial step is to publicize White Cane Safety Day (Presidential Proclamation 4062) which is the fifteenth of October each year. The proclamation was intended to make citizens more

fully aware of the white cane, and of the need for motorists to exercise caution and courtesy when approaching persons carrying a white cane [9]. The Safety Day is an extension of white cane laws which require motorists to stop when sight impaired persons with extended white canes are crossing the street.

It must also be determined how the Americans with Disabilities Act [S-2345/H.R. 4498] affects the installation and use of audible pedestrian signals. The Act is intended to provide a clear and comprehensive national mandate for discrimination against persons with disabilities. No insight on the relationship between the devices and the Act was available at the time of writing, but the Act will be voted on by Congress in 1989. If the Act passes, developments in this area should be pursued.

Audio-tactile crossing aids should be tested at intersections in the United States; the devices have been quite successful in Australia and in the Scandinavian countries. Units providing both auditory and tactile information are of most help to the deaf-blind.

The development of intermittent pulse signals in the optimal frequency range (approximately 750 Hz) for human localization should be encouraged.

The Appendix section on page 131 entitled Intersection Problems Encountered by the Visually Impaired should be reviewed and solutions devised. Problem areas mentioned in that section which require special attention include right-turn-on-red situations, location of pedestrian push buttons, and the blockage of sidewalks around construction sites.

Further study on the development of uniform standards for audible pedestrian signals is needed. Many companies are currently producing these devices, and non-uniformity will lead only to confusion and possibly hazardous circumstances for the handicapped. An inclusion of standards in the Manual on Uniform Traffic Control Devices would help to alleviate this problem.

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12. APPENDIX

12.1.1.1 SURVEY FOR CITIES

Federal Highway Administration
Safety Design Division, HSR-20
6300 Georgetown Pike
McLean, Va 22101
(703)-285-2414

Dear

I am a Graduate Student doing research with the Federal Highway Administration as part of their Graduate Research Fellowship Program. My project focuses on the feasibility of audible pedestrian signals for the visually impaired. In order to fulfill the requirements of the project, past research and studies must be reviewed. Since your city is listed as having at least one such signal, please answer the following questions and forward your response to me at the above address by August 1, 1988 for inclusion in this report.

1. What warrants or criteria were used in deciding to install the signal? (Please list)
2. What is the cost per signal (product, installation, maintenance)?

3. What is the community response to the signals (complaints, compliments)?
4. What is the reaction of the organizations for the visually impaired to the signals?
5. What is the accident rate before and after installation? (3 years before and 3 years after installation, if possible)?
6. What tone are you using and why did you choose that tone?
7. At what decibel level do the signals operate during the day/night? If your device has a mechanism to regulate the tone noise level based on ambient noise, how many decibels above the ambient noise does it run?
8. What are some of the benefits from using audible signals? (Please list)
9. What are some of the drawbacks from using audible signals? (Please list)
10. What are some of the alternatives to audio signals? (Please list)

I thank you in advance for your cooperation.

Sincerely

Morris Oliver

12.1.2 SURVEY FOR VISUALLY IMPAIRED ORGANIZATIONS

Federal Highway Administration
Safety Design Division, HSR-20
6300 Georgetown Pike
McLean, Va. 22101
(703)-285-2414

Dear

I am a Graduate Student doing research with the Federal Highway Administration as part of their Graduate Research Fellowship program. My project focuses on the feasibility of audible pedestrian signals for the visually impaired. Determining the feasibility of an audible signal without first contacting the organizations for the visually impaired would be impossible. With this view in mind, please answer the following questions and forward your response to me at the address above by August 1, 1988 for inclusion in this report.

1. What is your reaction to audible signals?
2. Do you feel that the signals are or would be helpful? (Why or Why not?)

3. (If applicable) what sounds are or would be most effective for you? (i.e. bells, gongs, voices, buzzers, bird calls, or other)
4. What alternative or additional crossing aids (if any) would you like to have installed?
(Please list)

I thank you for your cooperation with this project.

Sincerely

Morris Oliver

12.1.3 SURVEY FOR AUDIBLE SIGNAL MANUFACTURERS

Federal Highway Administration
Safety Design Division, HSR-20
6300 Georgetown Pike
McLean, Va 22101
(703)-285-2414

Dear

I am a Graduate Student doing research with the Federal Highway Administration as part of their Graduate Research Fellowship Program. My project focuses on the feasibility of audible pedestrian signals for the visually impaired. In order to fulfill the requirements of the project, past research and studies must be reviewed. Since your company is listed as a manufacturer of the audible signals, please answer the following questions and forward your response to me at the above address by August 1, 1988 for inclusion in this report.

1. What is the cost per signal (product, installation, maintenance)?

2. What tones are available and which are most effective? (Please list)
3. If your device does not have a mechanism to regulate the tone noise level based on the ambient noise level, at what decibel level do the signals operate during the day/night?
4. What conditions do you feel warrant the installation of an audible signal? (Please list)
5. What are some of the benefits in using audible signals? (Please list)
6. What are some of the drawbacks from using audible signals? (Please list)
7. What are some of the alternatives to audible signals? (Please list)
8. To further my research, I need to contact cities which have already installed the device. If possible, will you send me a list of contact persons and their addresses from cities which have used your system?

I thank you in advance for your cooperation in helping with this project.

Sincerely

Morris Oliver

**12.2.1 PARTIAL LISTING OF U.S. CITIES WITH AUDIBLE
PEDESTRIAN SIGNALS**

Tuscon, AZ	Little Rock, AR
Berkely, CA	Beverly Hills, CA
Claremont, CA	Concord, CA
Covina, CA	Cupertino, CA
El Monte, CA	Escondido, CA
Fremont, CA	Fresno, CA
Huntington Beach, CA	Los Angeles, CA
Modesto, CA	Norwalk, CA
Oakland, CA	Palm Springs, CA
Riverside, CA	Sacramento, CA
Santa Clara, CA	San Diego, CA
San Francisco, CA	San Jose, CA
San Pablo, CA	Santa Monica, CA
West Covina, CA	Colorado Springs, CO
Littleton, CO	Danbury, CT
East Hartford, CT	Hartford, CT
Mansfield, CT	New Britain, CT
Newington, CT	West Hartford, CT
Wethersfield, CT	Washington, DC

Longwood, FL
Pinellas County, FL
Tallahassee, FL
Honolulu, HI
Peoria, IL
Iowa City, IA
Louisville, KY
Baltimore, MD
Oakland County, MI
Helena, MT
Las Cruces, NM
Chapel Hill, NC
Raleigh, NC
Cincinnati, OH
Columbus, OH
Portland OR
Camp Hill, PA
Philadelphia, PA
York, PA
Ogden, UT
Salt Lake City, UT
Bennington, VT

Orlando, FL
St. Augustine, FL
West Palm Beach, FL
Carbondale, IL
Bloomington, IN
Topeka, KS
Shreveport, LA
Watertown, MA
Jackson, MS
Las Vegas, NV
Kingston, NY
Charlotte, NC
Canton, OH
Cleveland, OH
Youngstown, OH
Salem, OR
Harrisburg, PA
Reading, PA
Houston, TX
Provo, UT
Barre, VT
Burlington, VT

Colchester, VT
Essex Junction, VT
St. Albans, VT
Town of Rutland, VT
Alexandria, VA
Charlottesville, VA
Pullman, WA
Tacoma, WA
Green Bay, WI
Madison, WI
Racine, WI

City of Rutland, VT
Montpelier, VT
South Burlington, VT
Winooski, VT
Arlington, VA
Everett, WA
Seattle, WA
Charleston, WV
Janesville, WI
Milwaukee, WI

**12.2.2 PARTIAL LISTING OF FOREIGN CITIES WITH AUDIBLE
PEDESTRIAN SIGNALS**

New South Wales, Australia

Sidney, Australia

Edmonton, Alberta, Canada

Nelson, British Columbia, Canada

Vancouver, British Columbia, Canada

Brantford, Ontario, Canada

Hamilton, Ontario, Canada

Ottawa, Ontario, Canada

Toronto, Ontario, Canada

Windsor, Ontario, Canada

London, England

Copenhagen, Denmark

Gedera, Israel

Fukuoka, Japan

Hiroshima, Japan

Kobe, Japan

Nagoya, Japan

Osaka, Japan

Tokyo, Japan

Utsonomiya, Japan
Yokohama, Japan
Apeldoorn, Netherlands
Arnhem, Netherlands
The Hague, Netherlands
Auckland, New Zealand
Edinburgh, Scotland
Alicante, Spain
Gothenburg, Sweden
Stockholm, Sweden
Bern, Switzerland
Zollikofen, Switzerland
Frankfurt, West Germany
Marburg/Lahn, West Germany
West Berlin, West Germany

12.3 PARTIAL LISTING OF AUDIBLE SIGNAL MANUFACTURERS

Aldridge Traffic Systems
 6 Queen St.
 P.O. Box 174
 Mitcham
 Melbourne, Australia 3132

Coeval Products
 99 Constitution St.
 Leith
 Edinburgh, Scotland
 EH6 7AE

Dansk Signal Industri a/s
 P.O. Box 510
 Dk-2650
 Hvidovre, Denmark

Edwards Company
 P.O. Box 1188
 195 Farmington Ave.
 Farmington, Conn. 06034

Emhart/Mallory Company
 P.O. Box 1284
 Indianapolis, Indiana 46206

Mr. William Loughborough
 400 N. Columbus
 ## 42
 Goldendale, WA. 98620

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 Holland

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336 Martin Ave.

Santa Clara, Ca. 95050

Traconex Ltd.

P.O. Box 6230

Alexandria, Va. 22306

Wilcox Sales Co.

1738 Finecroft Dr.

Claremont, Ca. 91711

12.4.1 INTERSECTION PROBLEMS ENCOUNTERED BY THE VISUALLY IMPAIRED

The sight impaired population has been very vocal in expressing their intersection difficulties. The following responses were obtained not only from private correspondences to the author and others but also from personal interviews with various visually impaired groups:

- o People drive over the pedestrian crosswalks while waiting for the light to change. Orientation and mobility specialists teach us not to take chances by walking in front of those vehicles.
- o Four-way stops are difficult to because it is hard to determine which car will move next.
- o Some corners only have one curb cut and that leads into the middle of the intersection (under the light). It is easy to follow the sidewalk and the curb cut directly into the center of the intersection.
- o Intersections with more than four legs are difficult to cross.
- o Traffic circles are difficult to negotiate.
- o Overhangs from street signs are dangerous.

- o It is very easy to bump into telephone booths and newspaper stands.
- o Intersections which permit right-turn-on-red are sometimes difficult to cross.
- o It is hard to find the pedestrian push buttons because there are inconsistencies (e.g. height and location on the pole) in the way they are installed.
- o Construction sites pose a problem because sidewalks are often closed and the pedestrians are expected to walk in the street.
- o Short pedestrian phases are a problem during peak traffic hours.
- o Under low volume and erratic volume conditions, it is hard to "read the traffic" because of the lack of audible cues.
- o Wide streets and acute-angle intersections pose problems.
- o Pedestrian islands without curb cuts can be hazardous.
- o It is difficult to prepare for drivers who are making U-turns.
- o Impatient drivers often blow their horns at visually impaired persons who may be crossing slowly and often carelessly run over our white canes.

12.4.2 INTERSECTION IMPROVEMENTS SUGGESTED BY THE VISUALLY IMPAIRED

The mail survey responses as well as the personal interviews with the visually impaired brought out some additional intersection improvements which do not include audible signals. The most important being the stricter enforcement of pedestrian laws by police officers. According to the responses, the visually impaired pedestrians do not feel that many motorists are aware of the meaning of the White Cane laws which require motorists to stop when they see a pedestrian holding an extended white cane while trying to cross at an intersection. Further intersection improvement responses suggested by the visually impaired are mentioned below:

- o Do not allow vehicles to park in crosswalks, or turn into crosswalks where pedestrians are walking. This may be achieved in part by keeping stop lines brightly painted and well maintained.
- o Prevent unnecessary hornblowing at slow moving pedestrians.

- o In urban areas there is a need to implement wider sidewalks and crosswalks, while in rural areas, there is a need for more side- and crosswalks.
- o Additional over and underpasses will increase pedestrian safety.
- o Textured crosswalk pavements made of brick or stone and angular corners rather than rounded ones will help us to orient ourselves while preparing to cross.
- o Braille maps may be of help in understanding the surrounding environment.
- o Raised studs on the edge of the crosswalk boundaries will help us stay within the pedestrian lanes.[48]
- o Blind Resident signs inform the motorists to be more alert.
- o Longer pedestrian **Walk** phases allow the slower and handicapped pedestrians adequate crossing time.
- o Place stop signs at signals which allow RTOR. [This does not conform with the Manual on Uniform Traffic Control Devices (MUTCD) and cannot be implemented.]
- o Encourage the city Public Works Departments to be more strict in the uniform placement of traffic signals curb cuts, and pedestrian push buttons.

- o Encourage the visually impaired to listen more closely to traffic flow conditions.
- o Use an All Red Phase which concurrently prohibits all vehicle movements and allows all pedestrian movements. This is commonly referred to as Barnes' Dance or Scramble timing.
- o Eliminate Right-Turn-On-Red. [There already exist certain standards which dictate when RTOR can be eliminated]

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