IMPROVING PEDESTRIAN SAFETY AT SIGNALIZED INTERSECTIONS

Final Report

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Richard W. Wall, Denise H. Bauer

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16. Abstract:

Our research investigated methods and technologies to make signalized intersections safer for pedestrians using the capabilities of accessible pedestrian systems. Our research focused on three technologies: acoustic beaconing, passive pedestrian detection, and pedestrian preemption. The effectiveness of proposed enhancements was measured by engineering performance analysis, pedestrian and traffic agency feedback, and an open forum one-day workshop involving constituents of pedestrian advocacy groups. The engineering performance analysis studied both the equipment and user interface from a human factors perspective. The experiments were completed using existing Advanced Accessible Pedestrian Signals (AAPS) hardware. Human factors studies were completed to determine the human response to information presented in both audible and visual format.

The changes for improved safety listed below are subject to the consideration of numerous factors before an intersection is equipped with the capability or technology.

1. Audio beaconing is a low cost but highly effective method to direct pedestrians to the destination curb. AAPS hardware modifications are needed to be most effective.
2. Passive pedestrian detection is simple to interface to the existing AAPS equipment but equipment costs are high relative to the AAPS equipment.
3. Information conveyed during preemption must have a low cognitive load and unambiguous interpretation.

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EXECUTIVE SUMMARY

We have investigated technologies that are intended to reduce personal risk for pedestrians at signalized intersections. Our research assumes that improving safety for one class of pedestrians will result in improved safety for all pedestrians. However, we realize there are inherent risks associated with allowing technology to remove the need for personal responsibility to determine risk. The 2001 report “Embedded, Everywhere” recognizes the risk of indiscriminate application of technology in the statement “There are few, if any, ethically neutral technologies [1].” Therefore, the questions we centered our research around are what to do and how to do it.

We investigated three concerns of traffic agencies who are currently using or who are considering using Accessible Pedestrian Systems (APS). All testing was conducted using the AAPS developed at the University of Idaho and manufactured by Campbell Company. The three major concerns of these agencies are acoustic beaconing, passive detection, and pedestrian signal operations in the event of intersection preemption.

Acoustic beacons are audible tones that are generated at the destination curb. The target beaconing method offers good orientation assistance and less audible distraction for low vision pedestrians who are attempting to focus on other audible cues. Multiple speakers are required to direct the audible message or tones. There is ongoing research to determine the best positioning of the beacon speaker, the timing of the message or signal tones, and the content of the message or tone frequency. Audible countdowns during the pedestrian transition interval have been proposed. Integrating the second speaker into the AAPS will require both hardware and software changes.

Passive pedestrian detection has advantages for physically impaired and low vision pedestrians in that they are not required to make physical contact with the pedestrian button. We successfully integrated the Traficon Safewalk [2] system to detect the presence of pedestrians at the curbside. We also integrated the Traficon TraffiCam [3] system to monitor the presence of a pedestrian in the crosswalk. There is a risk that common use of passive video detection can lull pedestrians into unsafe behavior from lack of proper attentiveness.

Our research concluded that the benefit comes at a high cost for the detection equipment. We are investigating other solutions that provide non-contact activation at a much lower cost.

Preemption is an event that disrupts the normal traffic signal timing. The two most common types of preemption are railroad and emergency vehicle. The MUTCD states that the pedestrian clearance (pedestrian change interval) interval may be "abbreviated." This has a negative safety effect on disabled and low vision pedestrians. The Advance Pedestrian Controller (APC) unit in the AAPS systems has two inputs designated to function as preemption inputs. The two major concerns are what the pedestrian button audible message should be during the preemption interval and the timing of those messages.

Currently, the common display during preemption follows MUTCD Section 4E.07 Paragraph 10:

> *"If the pedestrian change interval is interrupted or shortened as a part of a transition into a preemption sequence (see Section 4E.06), the countdown pedestrian signal display should be discontinued and go dark immediately upon activation of the preemption transition."*

There is no mention of what preemption audible message should be heard in the MUTCD. Therefore, we are investigating possible audible as well as visual messages that will inform pedestrians of a possible dangerous situation if they are to remain in or enter the intersection.

DESCRIPTION OF PROBLEM

The definition of pedestrian must be expanded from the classical meaning to address the population who are served by the pedestrian controls at signalized intersections. Common traffic signals combine vehicle movements with pedestrian movements. Right and left turning vehicles will frequently conflict with a permitted pedestrian movement. For this instance, the vehicle is legally obligated to yield to the pedestrian since he or she is the most vulnerable party. If the law can make us safe, why were there 47,700 pedestrians killed between 2000 and 2009 [4]? North Carolina reports that approximately 2,500 car accidents involving pedestrians happen every year. On average, more than 400 pedestrians are either killed or injured severely in North Carolina pedestrian accidents annually. The internet is replete with anecdotal accounts describing the use of personal electronic devices contributing to pedestrian injuries [4]. The basic question becomes, “How can technology improve pedestrian safety with minimal adverse affects?”

Blindness of varying degrees affects more than three million Americans over 40 and that number will double by 2030 [5]. Accessible pedestrian signals (APS) are intended to provide information concerning traffic conditions and intersection operations using three sensory modes: auditory, tactile, and visual. Vision impaired pedestrians desire the information to be succinct and unambiguous so that they can focus their attention on sensing what is happening in their environment using other auditory and tactile cues.

When dealing with pedestrians, we also cannot always assume that people who have normal visual acuity will see the dangers in crossing at intersections. Although alcohol seems to be a cause in 12 percent of pedestrian-involved accidents, distraction is likely another leading cause of walkers being struck by a vehicle [6]. More recently, researchers now refer to “inattention” as “selective attention” and declare that the ability for humans to “multi-task” is a myth and to attempt to do so in critical situations is dangerous [7]. The study of the psychology of inattentional blindness has shown it is responsible for many errors with serious consequences [8].

Hence, a distraction that causes attention to be diverted can either have a positive or negative impact on safety. Our research attempts to evaluate three specific technologies applied to pedestrian control systems and identify both positive and negative attributes associated with using them: audio beaconing, passive pedestrian detection, and preemption warnings.

Audio Beaconing

Audio beaconing refers to the use of an audible tone generated at the destination curb or sidewalk to help guide the pedestrian in a straight line from his present position [9]. This has nothing to do with beacons as discussed in the Section 4F.01 of the MUTCD or Rectangular Rapid Flashing Beacons (RRFB) [10]. Figure 1 illustrates the recommended placement of APS pushbuttons. It is obvious from Figure 1 that the direction of the speaker used for the locator tone is orthogonal to the intended crosswalk [12]. The purpose of the speaker is to help pedestrians locate the pushbutton, and the best practices guide suggests that the audible range be in order of 10 feet. Clearly, the placement and the volume settings suggest that using this speaker is not suitable for beaconing that provides orientation help for pedestrians.

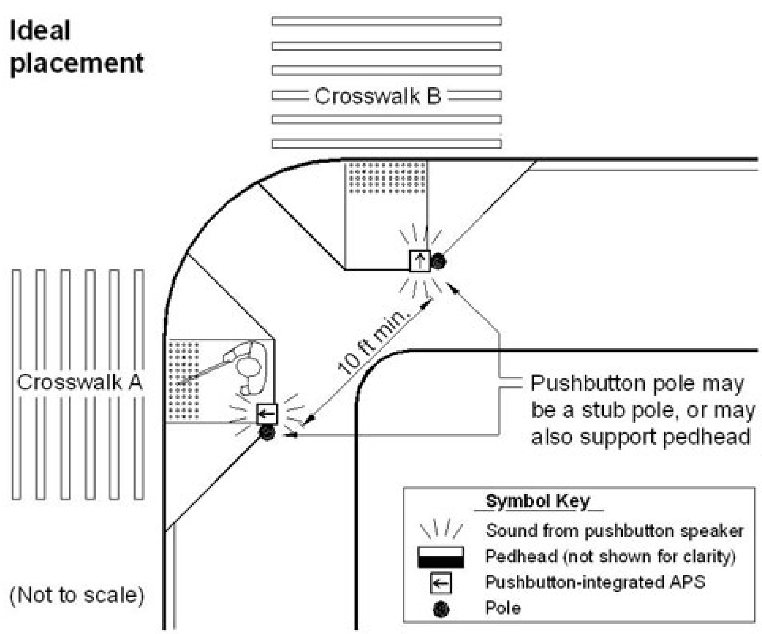

Figure 1. Optimal placement of APS pushbuttons [11].

The MUTCD does not address this feature for APS systems and there is little guidance available as to what audible message or tones should be played to provide this service. As previously discussed, an audible signal must be a useful distraction and limited in duration to allow the listener to return to focusing on conventional audible navigational cues. Clearly text based messages require higher cognitive loading to mentally process the message.

Another factor that must be considered is the effect by and on the environment. If a broad beamed audio signal is emitted, then one must consider the effects of echoes off buildings and vehicles at the intersection. An audible signal at a low volume level may not be detectable across the intersection in the presence of high ambient noise. An audible signal at a high volume level intensifies the acoustic reflection problem as well as raises the potential for objection by homeowners and business operators in the proximity of the crosswalk.

Passive Pedestrian Detection

While the transition interval is timed based upon an assumed walking speed and the length of the crosswalk, typically, the walk interval is limited to five to seven seconds regardless of the time allotted to the green time for the parallel traffic. This practice may be used to platoon pedestrian traffic such that all of the pedestrian crosswalk occupancy is limited to a portion of the total green time. The remaining green time can be used for right turn on red vehicle movements that would not be in conflict with pedestrian movements. The second reason is that the total green time may not be known at the end of the walk interval because green time extensions are based upon the current traffic conditions.

The challenge for blind or mobility-impaired persons is to move from the button location to the curb where they are to initiate their crossing [12]. It is quite common for the traffic controller to begin the walk interval immediately after the button is pressed. Hence, part of the walk interval is consumed by the pedestrian just getting to the crosswalk. The construction of the intersection can be such that a blind or mobility impaired pedestrian cannot reach the crosswalk in the allotted walk interval.

Passive pedestrian detection has advantages for physically impaired and low vision pedestrians in that they are not required to make physical contact with the pedestrian button [13]. A report in 2005 indicated that false detection was a serious concern in the broad deployment of passive detections systems [14]. Our research focused on the interface of the Traficon Safewalk and Traficam systems [3,4] with APB devices to determine the detection capability, effectiveness, and what information is available from an existing commercialized passive pedestrian detection system.

Preemption and Pedestrian Signals

Preemption is the disruption of normal traffic control timing plans and is usually initiated for approaching emergency vehicles and railroad trains. The MUTCD is very clear and concise on the transition from normal traffic control operations and operations that serve preemptive operations. Intersection operation during preemption events is generally part of the traffic controller programming. Although feedback from Campbell Company suggests some traffic agencies are requesting an input to the APC that can be used to monitor preemption type events, there has been no clear direction from these agencies as to what to do for these events.

When considering the response of visual and audible pedestrian signals, it is good to consider what information is available for use. Figure 2 shows the block diagram of the APC unit shown in Figure 3. Visual pedestrian signals are driven from load switches that transform low voltage binary signals to switching 120 VAC outputs on and off. The load switches are also used to control the on-off condition of the green, amber, and red traffic lights as well. In TS2 traffic controller cabinets, the load switches can be set to switch on the 120 VAC output during either the positive half, negative half, or both halves of the voltage waveform to control the signal power consumption and/or luminescence. The traffic controller is programmed to use selected load switches for the WALK and DON’T WALK signals. The load switch alternates between the on and off condition at approximately a one hertz rate during flash conditions. The only information that the APC has access to is the voltages that are applied to the WALK and DON’T WALK signals.

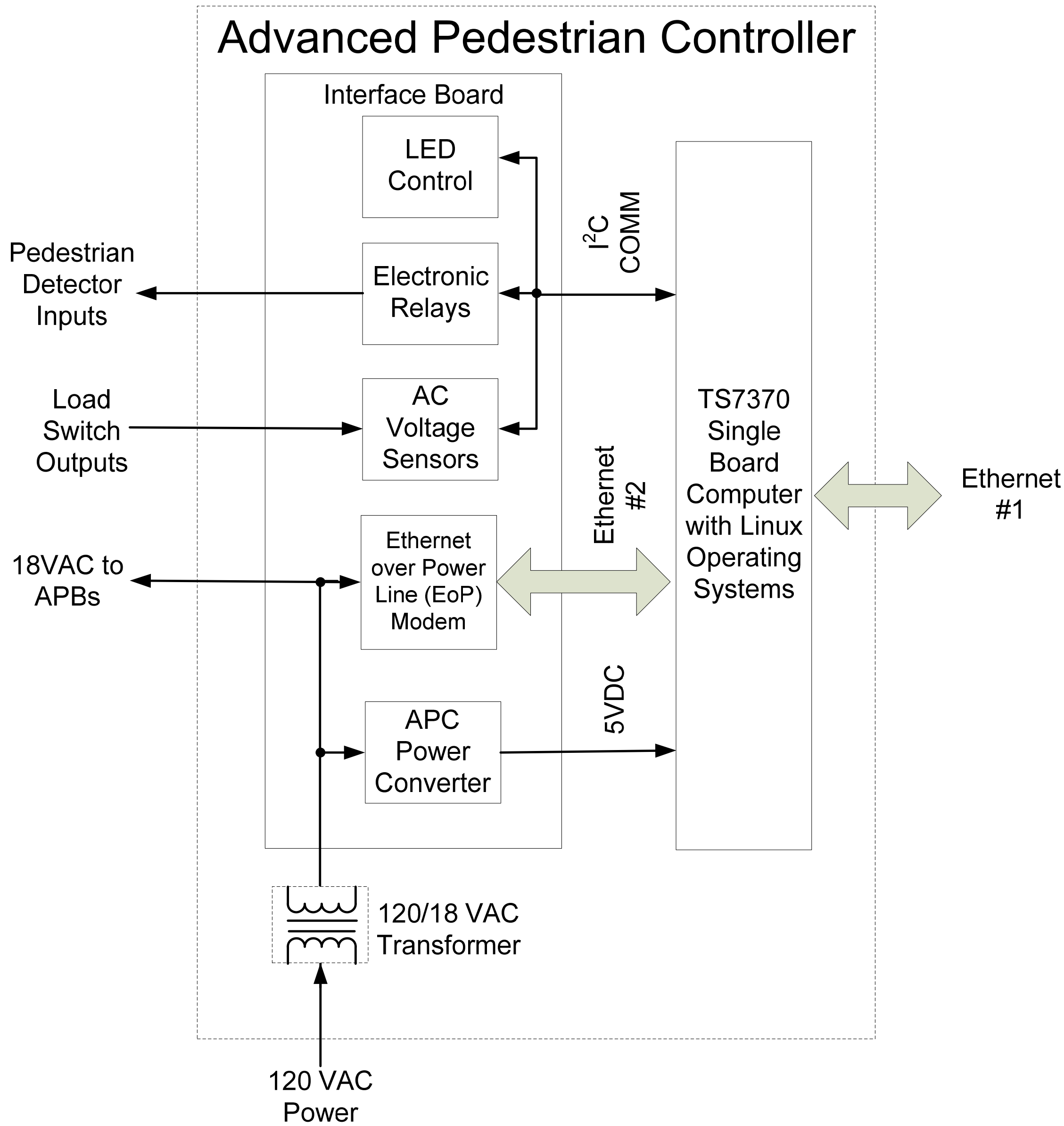

Figure 2. Advanced Pedestrian Controller block diagram.

Figure 3. APC unit.

The MUTCD specifies the pedestrian signal timing for transitioning into, during, and out of preemption operations.[1] The effects of these operations are only observable at the load switch outputs; there is no useful audio information available for a blind pedestrian who is unable to comprehend visually the reason for the change in operations. In addition, the MUTCD does not specifically address a preemption audible message. The lowest risk pedestrian operation is to indicate audibly the status of the pedestrian signal. Hence, the audible response to a pedestrian button pressed when the walk signal is not on is the message "WAIT" or the extended APS wait message that includes additional location information.

[1] MUTCD Section 4D.27, Paragraph 08, Standard: B. "The shortening or omission of any pedestrian walk interval and/or pedestrian change interval shall be permitted." This statement appears to be in conflict with Paragraph 10, "During priority control and during the transition into or out of priority control: B. The shortening of any pedestrian walk interval below that time described in Section 4E.06 shall not be permitted. C. The omission of a pedestrian walk interval and its associated change interval shall not be permitted unless the associated vehicular phase is also omitted or the pedestrian phase is exclusive. D. The shortening or omission of any pedestrian change interval shall not be permitted. Section 4E:06 Paragraph 7: "Except as provided in Paragraph 08, the pedestrian clearance times should be sufficient to allow a pedestrian crossing in the sidewalk who left the curb or shoulder at the end of the WALKING PERSON … signal condition to travel at a walking speed of 3.5 feet per second to at least the far side of the traveled way…" Section 4E.06, Paragraph 08: "A walking speed of up to 4 feet per second may be used to evaluate the sufficiency of the pedestrian clearance time at locations where an extended pushbutton press has been installed …."

It is helpful to consider the pedestrian signal operations from a blind or low vision person's perspective. In some localities, emergency vehicles do not operate their sirens unless they are in the immediate vicinity of an intersection or otherwise impeded. The emergency vehicles will activate the preempted signal operations several hundred yards from the intersection. Consequently, the emergency vehicles are operating in a stealth mode for the visually impaired pedestrian. This can lead to a dangerous situation where a visually impaired pedestrian may step off the curb into the oncoming emergency vehicle's path. This appears to have a higher probability of occurrence than with a pedestrian with normal acuity. Another possible dangerous situation occurs even when the emergency vehicle sounds its siren and a deaf pedestrian may have his or her vision blocked from seeing the approaching emergency vehicle. Therefore, the question is how to deal with these potential dangerous and deadly situations.

The MUTCD reference cited in the footnote does offer some confusion as to whether the pedestrian change interval can or cannot be altered for preemption. The pedestrian signals are under the control of the traffic controller and not AAPS. However, we asked ourselves, "If we could display something to the pedestrian on the walk signal or provide an audible message using the beaconing speaker, what would be the most helpful information to provide?"

APPROACH AND METHODOLOGY

All hardware and software experiments were performed in the University of Idaho Digital Research Laboratory. The traffic control equipment shown in Figure 4 consisted of a TS2 Type I controller cabinet, an In ASC TS2 traffic controller (Econolite Controls Inc., Anaheim, CA), a MMU-16LEIp malfunction management unit, (Eberle Design Inc., Phoenix, AZ), and Model 262 loop detector (Diablo Controls, Inc., Crystal Lake, IL). The pedestrian controls also shown in Figure 4 are the Advanced Accessible Pedestrian Systems designed at the University of Idaho [15] and are being produced and distributed by Campbell Company, Boise, Idaho.

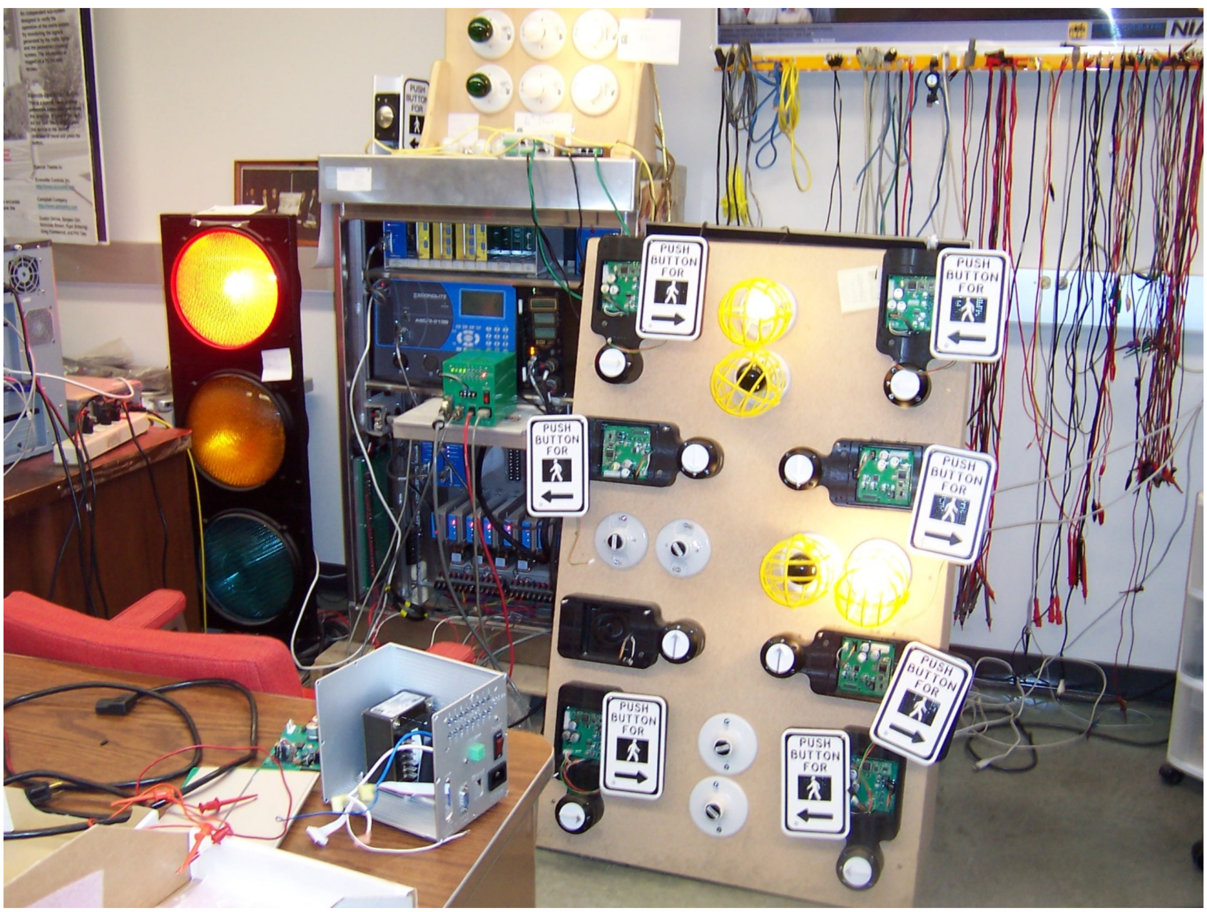

Figure 4. University of Idaho laboratory equipment used for pedestrian control research.

Audio Beaconing

The Campbell Company pushbutton shown in Figure 5 of the appendix was used for our research and is typical of APS pedestrian stations. It consists of a pressure activated mechanical or piezo-electric button that is designed to have a raised arrow that indicates the direction to the crosswalk for the intended crossing. The button is constructed on a surface that vibrates when the walk signal is active. The light emitting diode (LED) immediately above the button provides visual feedback to the pedestrian that a signal has been sent to the traffic controller indicating that a pedestrian requested a walk signal.

Figure 5. Typical APS pedestrian station (courtesy of Campbell Company, Boise, ID).

To add a second speaker, the electronics required modification as illustrated by the shaded parts of the APB block diagram shown in Figure 6. The audio codec is a common audio electric component and for our experimentation, we tested multiple codec devices that have differing degrees of complexity and capability. The MAX5556 provided the simplest interface and costs $1.84 [16]. The NXP UDA1342TS audio codec permits the software control of the output volume though an independent I2C serial interface and costs $3.16 [17]. The NXP UDA1380 stereo audio coder-decoder integrated circuit provides the capability to provide both digital to analog conversion and analog to digital conversion in a single silicon package for only $1.23 [18].

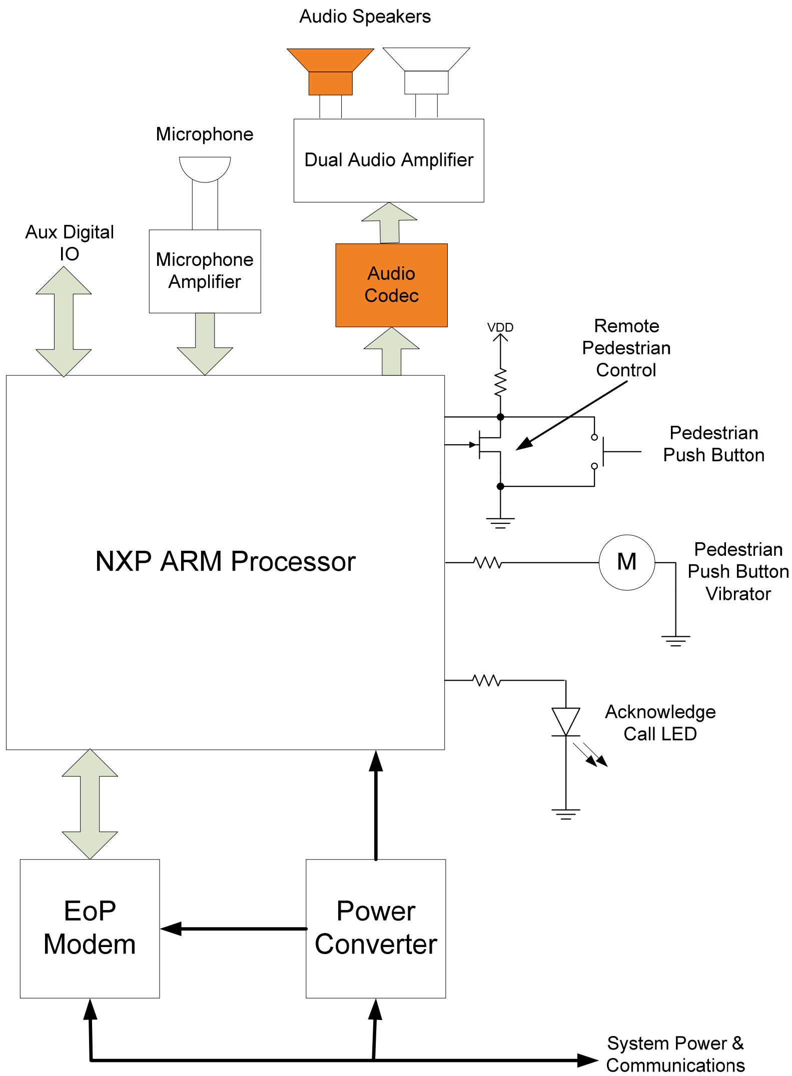

Figure 6. Block diagram of Advanced Pedestrian Button with added capability for second speaker.

The audio output amplifier currently used in the APB is the LM4755 integrated circuit originally produced by National Semiconductor but currently marketed by Texas Instruments [19]. Since the audio codec uses a serial binary interface, the original APB circuit was not modified during testing. Instead, two of the auxiliary digital outputs were used to interface with each of the codec units described above.

Passive Pedestrian Detection

The use of passive detection in conjunction with AAPS was tested. Our research focused of the interface of the Safewalk and Traficam systems marketed by Traficon USA [3,4]. The two units were set up in the UI pedestrian research laboratory by affixing the units to the ceiling support I-beam located approximately 10 feet above the floor. Conductors containing a twisted pair of #18 stranded wire were used to connect the Safewalk and Traficam detection outputs to one of the auxiliary digital IO pins of the NXP processor illustrated in Figure 6. Figure 7 shows the circuit used for this interface. Depending upon which IO pins are used, the NXP processor can be programmed to detect the contact closure in the passive detection devices using either processor interrupts or by polling the IO pin and determining the logic level.

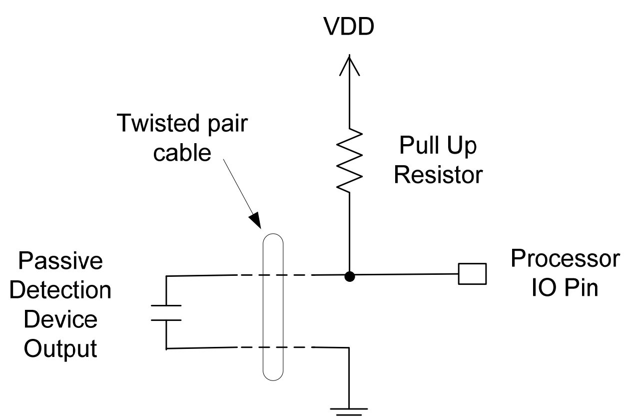

Figure 7. Passive detection interface circuit.

The network packet that is sent from the APS to the APC when a pedestrian pushbutton press is detected was modified. Additional bits in the packet byte that contained the pedestrian button call type are programmed to identify the passive detection input status. The modified detection software now generates an unsolicited User Data Protocol (UDP) message whenever a pedestrian button press is detected or the relay contact closes on either passive detection device.

Preemption and Pedestrian Signals

The APC shown in Figure 2 is capable of sensing 16 load switch outputs to monitor the WALK and DON'T WALK signal status using MID400 optically isolated AC voltage detector integrated circuits. Two additional inputs that also use the MID400 IC are allocated for AC or DC voltage detection, and the logic outputs can be read by the APC processor as shown in Figure 8. AC or DC voltage input to the MID400 is set by selecting the value of R1 as described in the product datasheet [20]. The ACS3 can be programmed to output a signal that indicates that a preemption sequence has been initiated.

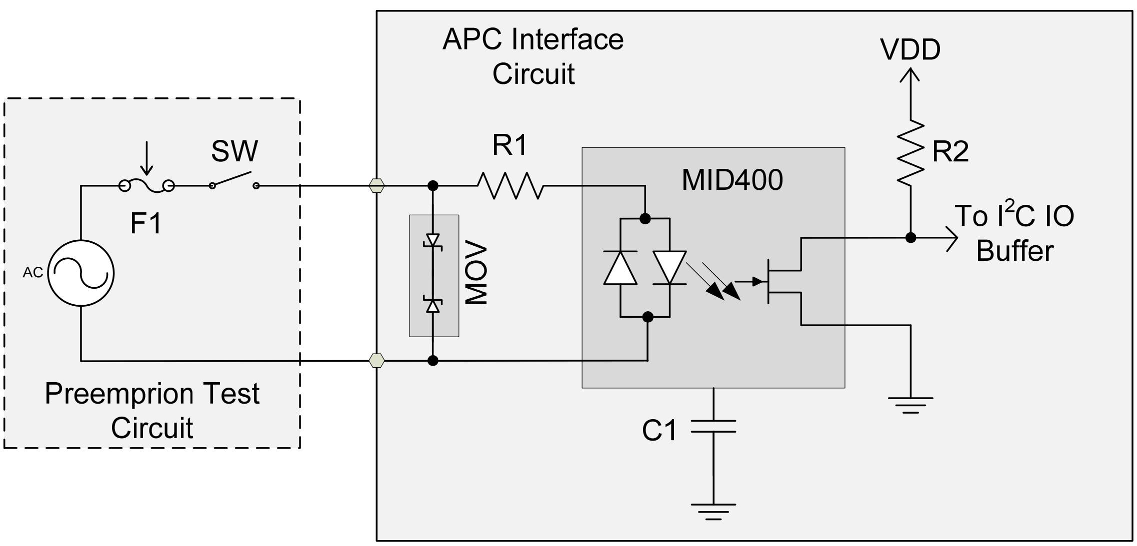

Figure 8. Preemption test circuit and APC AC sense circuit.

To determine the best visual and audible message to display to pedestrians, surveys were conducted to collect data from actual users. Undergraduate students completed an initial survey to determine the symbol that best portrays that an emergency vehicle is approaching the intersection. From this survey, the eight symbols for each emergency vehicle (police car, fire engine, ambulance) were reduced to five. The researchers then made an educational visit to a local school where we talked about the safety of crossing streets, distracted drivers and pedestrians, and had the 6th grade students complete the revised survey on emergency vehicle symbols. We felt it was important to include children since they can be pedestrians as well and would need to interpret the symbols just as older pedestrians would. From the results of the 6th graders, it was obvious there were some issues with a few of the symbols. We then revised the survey once again and included more detailed ambulance symbols. This survey was taken by additional undergraduate students to help narrow the possibilities to three.

In addition, a preliminary survey on audible preemption messages was given to engineering students. The messages varied from a simple “Clear intersection” to a more complex message “Emergency vehicle approaching, clear intersection” with a siren included.

FINDINGS; CONCLUSIONS; RECOMMENDATIONS

The following results were determined by analysis of experimental data, weekly phone conference meetings involving UI researchers and Campbell Company engineers, and by verbal feedback given at the PED ACCESS 2012 WORKSHOP, Boise ID, May 5, 2012. The meeting agenda and notes of the workshop are provided in the appendix.

Audio Beaconing

Audio beacons are intended to supplement crosswalk signs and markings. For the low-vision public, determining the destination curb is a daunting task and made even more daunting if the intersection has unusual geometries. The pedestrian route can be difficult if markings are obscured by snow, worn off the street by traffic, or unobservable by lack of light or loss of sight. Pedestrian signals can be difficult to read when the signals are placed at a considerable distance or obscured by background visual noise created by street lighting, business advertisements, and ornamental lighting.

The use of audio tones and/or messaging is effective for helping pedestrians who have a wide range of abilities. This group includes children, young adults, adults, and elderly pedestrians whenever they have difficulty in determining the point of destination. It was reported in the 2011 TRB Pedestrian Workshop in Washington DC that audio beaconing is as effective of a navigational aid as raised markings on the street surface. One suggestion under consideration is the use of the audible countdown as the audible beacon. This idea combines both navigational information and information concerning task completion time in the same audible message.

The current version of APS has implemented beaconing using a single speaker positioned as suggested by the MUTCD. Feedback from the PED ACCESS Workshop suggests that a second speaker is required to direct the audible beacon to be most effective. Laboratory experiments have shown that the second speaker can be added to the current APB design using low-cost electronic hardware components and minor modifications to the current ABP computer code. Additional power consumption is required to power the second speaker.

Implementation challenges with audio beaconing include managing multiple audible messages from the same source point in a manner that will not confuse or distract pedestrians. Selective activation restricting the use of audio beacons to only select intersections and for APS (extended press) calls will minimize complaints from any unintended audience.

The placement of the beacon speaker was not investigated during this research. Placing the beacon speaker at head level will give higher directionality, provided the speaker is mounted where the crosswalk meets the curb. The potential problems with the low-level placement center on distortion due to acoustic echoes. The elevated speaker location can be accomplished by providing an audio jack or fixed wiring. Either method has cost and reliability implications.

In conclusion, audio beaconing has a high benefit to cost ratio and this capability will be integrated into the design of the second generation AAPS.

Passive Pedestrian Detection

The Traficon passive pedestrian detection devices have the potential to provide improved access for low vision and mobility handicapped pedestrians. The system may provide safety advantages when used for school crossings or near homes for the elderly. We defer to other research to define the proper deployment of pedestrian detection systems [14, 21, 22, 23]. The use of passive pedestrian detection may address the need for the “extra press” option needed to mitigate loss of the walk cycle due to excessive orientation time or late-in-cycle pedestrian calls for low-vision pedestrians.

The equipment provides a contact closure whenever a person is detected in the programmed detection area, whether that is on the curb or in the crosswalk. The low technology binary output renders a simple interface, with AAPS and APB units requiring minimal circuit modification. No equipment failures were observed during laboratory experiments using the SafeWalk and Traficam devices.

We conclude from our investigation that integration of a passive detection system is feasible should the specific situation arise that justifies the expense of the additional equipment.

Preemption and Pedestrian Signals

The capability of the APC to detect a preemption input was tested in the UI Digital Laboratory by simulating a switched 120V AC signal as shown in Figure 8. Software modifications in the APC and APB units were necessary to allow the status of the preemption inputs to be communicated with the pedestrian stations around the intersection. The APBs can be programmed to respond to these signals. Even though various traffic agencies have requested this capability, to date, no agency has specified the exact content of the preemption message or what the response of the AAPS should be. Clearly, there is an expectation by the traffic industry that something should be done, but the correct thing to do has not been determined.

The final surveys indicated that three symbols were significantly preferred for the fire engine and ambulance (Figure 9 and Figure 10, respectively). However, there was only one symbol was significantly preferred for the police car as is seen in Figure 11. The surveys will once again be revised to include only three symbols for each vehicle and administered to pedestrians of all ages. The idea is that these symbols should be recognizable to all pedestrians. Symbols relating to rail trains will be examined in the future.

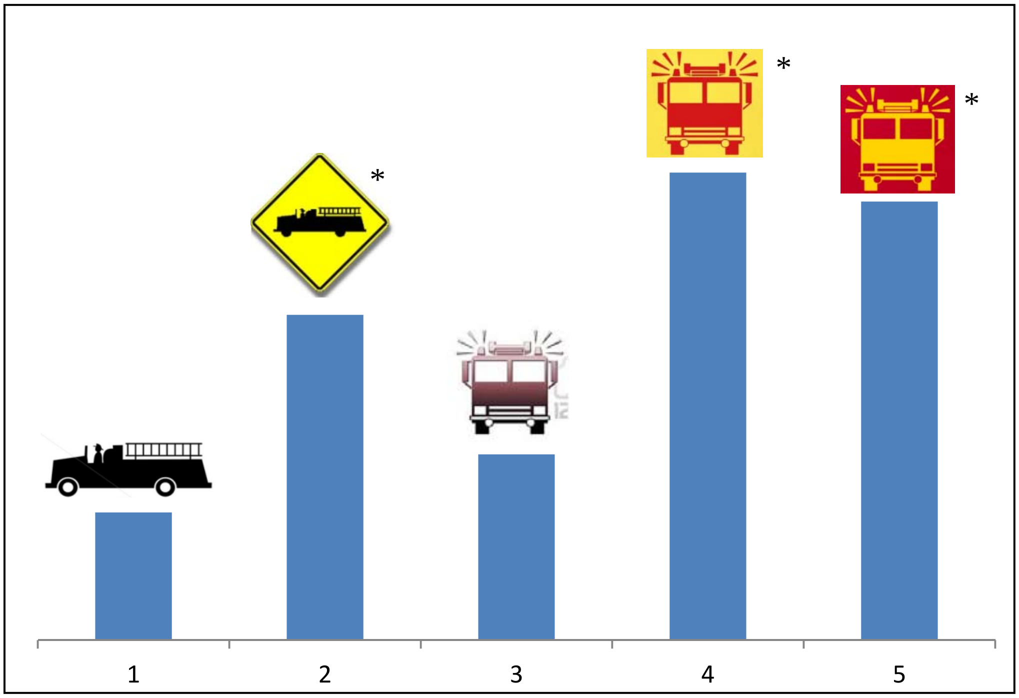

Figure 9. Results for the fire engine preemption symbol (* indicates significantly different at 95%).

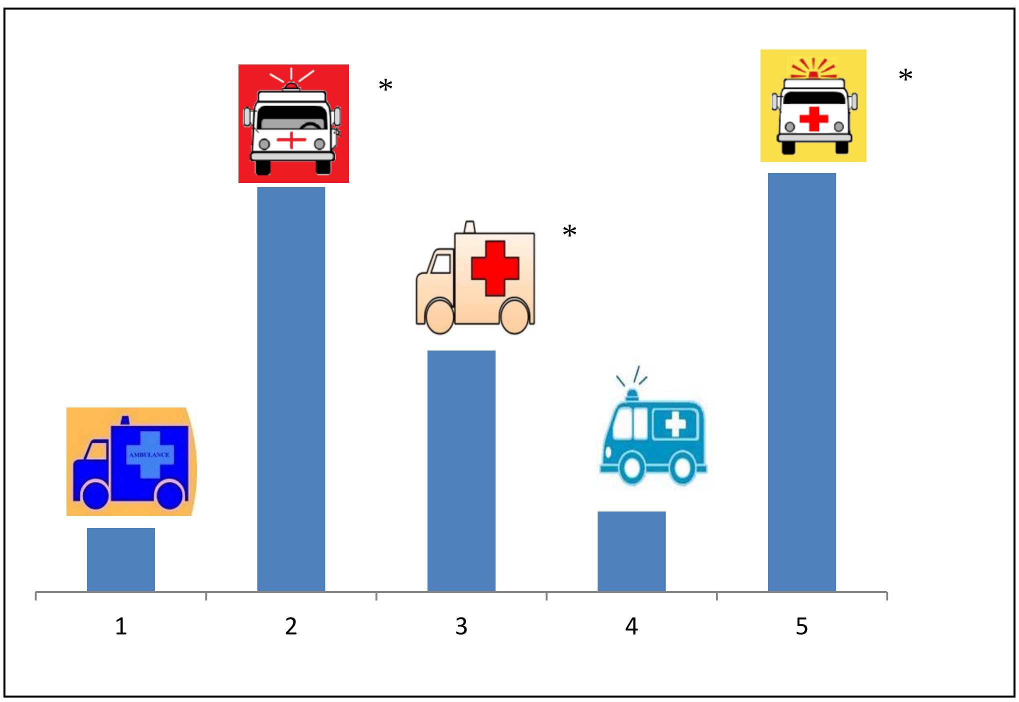

Figure 10. Results for the ambulance preemption symbol (* indicates significantly different at 95%).

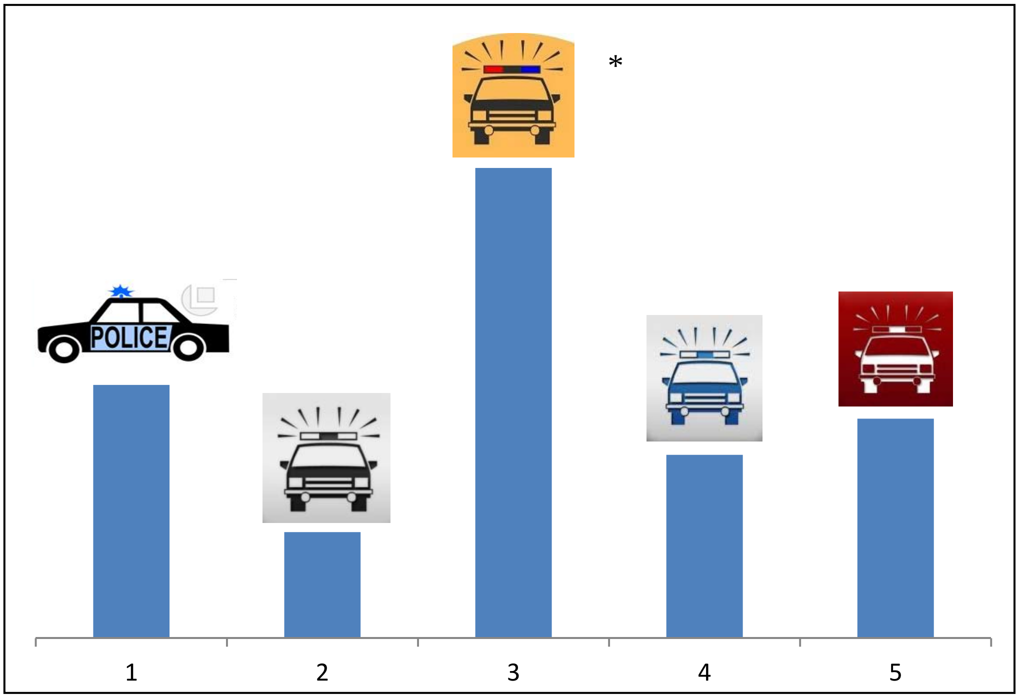

Figure 11. Results for the police car preemption symbol (* indicates significantly different at 95%).

Since a big part of designing the pedestrian signals for all users includes the blind and low vision users, the use of an audible preemption message must also be examined. Results from the preliminary survey shown in Table 1 indicate that finding a "correct" message may be difficult without more guidance from traffic engineers or the blind pedestrian community. Further studies on audible messages should be conducted to find the best message as well as include various age groups to examine understanding. Additional experiments would include location of the speakers (related to beaconing), loudness of the message, and conjunction of a visual and audible message.

Table 1. Results from the Preemption Audible Message Survey

Message	Number of Respondents	Percent of Respondents
Clear intersection	2	5.7
Emergency vehicle approaching, clear intersection	15	42.9
Emergency vehicle approaching	10	28.6
Emergency vehicle, clear intersection	8	22.9

The preliminary results and feedback from the blind community as well as those in the transportation field indicate that some form of a preemption warning is needed. The cost is low with a high benefit, making it worthwhile to pursue.

APPENDIX

PED Access Workshop Agenda

May 4, 2012

8:30 – 9:00 a.m. Coffee and donuts
9:00 – 10:15 a.m. Welcome, introductions and workshop notes (Richard and Phil)
10:15 – 11:00 a.m. AAPS

1. Review of Smart Signals (Richard)
2. Web site for Research Activity (Karen)
3. Recent Research Activity
   a. Pedestrian Fault Monitor (Ben)
   b. SDLC Interface (Jacob)

11:00 – 11:10 Break
11:10 – 12:00

4. Changes in MUTCD and APS (Phil)
   a. Advisor independent APS

12:00 – 12:30: Lunch and visits
12:30 – 1:30

5. AAPS Features and Controls (Cody)

1:30 – 2:00

6. Preemption notification (Denise)
7. Pedestrian community Input

2:00 – 2:15 Break
2:15 – 3:00

8. Pedestrian safety – accessibility for people with barriers and vision limitations
   a. Traffic – pedestrian interface and coordination
   b. Operations and maintenance (traffic agencies)
   c. Users – what helps – what doesn't
   d. Wish list

3:00 – 3:15 Future work (Richard)
3:15 – 3:45 Where to go – action items
   a. Identify key issues
   b. Cost benefit discussion
   c. Prioritize effort

3:45- 4:00 Wrap up (Richard and Phil)
4:00-5:00 Plant Tour

REFERENCES

[1] "Embedded, Everywhere: A Research Agenda for a Network of Embedded Computers", Committee on Networked Systems of Embedded Computers, National Research Council, ISBN 0-309-51127-5, 2001, pg 34, available at http://www.nap.edu/catalog.php?record_id=10193.

[2] "SafeWalk - The First Stereovision Video Sensor", manufactured by Traficon Video Detection, available at http://www.traficon.com/pagenode.jsp?id=13&type=ProductCategory.

[3] "TrafiCam – The First Integrated Video Sensor", manufactured by Traficon Video Detection, available at http://www.traficon.com/pagenode.jsp?id=6&type=ProductCategory.

[4] D. Stavrinos, Byington, K.W., and Schwebel, D.C., "Effect of Cell Phone Distraction on Pediatric Pedestrian Injury Risk", PEDIATRICS, Vol. 123, No. 2, February 1, 2009, available at http://pediatrics.aappublications.org/content/123/2/e179.full.

[5] "The Aging Eye", The Eye Digest, University of Illinois Eye & Ear Infirmary, 2002, available at http://agingeye.net/mainnews/usaging.php.

[6] "Pedestrian Distraction Can Lead to High Risk of Accidents Involving Cars in Asheville", Lee Law Offices, North Carolina Personal Injury (Lee Law Offices), September 17, 2011, available at http://www.northcarolinapersonalinjurylawyersblog.com/2011/09/pedestrian-distraction-can-lea.html.

[7] Christine Rosen, "The Myth of Multitasking", *The New Atlantis*, Number 20, Spring 2008, pp. 105-110.

[8] "Inattentional Blindness: What Captures Your Attention", Institute for Safe Medical Practices, February 26, 2009, available at http://www.ismp.org/Newsletters/acutecare/articles/20090226.asp.

[9] D.A. Noyce, and Barlow, J.M., "Interfacing Accessible Pedestrian Signals (APS) with Traffic Signal Control Equipment" Access Board Research, April 2003, available at http://www.access-board.gov/research/APS/report.htm.

[10] "Rectangular Rapid Flash Beacon (RRFB)"**,** Federal Highway Administration, FWHA-SA-09-009, May 2009.

[11] "APS Design in New Construction", Accessible Pedestrian Signals | Guide to Best Practices, National Cooperative Highway Research Program Project 3-62, Chapter 6, available at http://www.apsguide.org/chapter6_new.cfm.

[12] "Dangerous by Design 2011", Transportation for America, available at http://t4america.org/docs/dbd2011/Dangerous-by-Design-2011.pdf. Last accessed on May 25, 2012.

[13] "Passive Pedestrian Detection", Accessible Pedestrian Signals | Guide to Best Practices, National Cooperative Highway Research Program Project 3-62, Chapter 4, available at http://www.apsguide.org/chapter4_detection.cfm.

[14] "Selecting the Most Effective ITS Application for Pedestrian Safety", Report prepared for the Florida Department of Transportation by the University of South Florida, September 2005, available at http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_TE/FDOT_BC353_50_rpt.pdf.

[15] DeVoe, D., S. Giri, and R.W. Wall, "A Distributed Ethernet Network of Advanced Pedestrian Signals", Transportation Research Board Record, Washington, DC, 2009, Access # 01125542, Report # 09-3256.

[16] MAX556 Low-Cost Stereo Audio DAC Datasheet, datasheet available at http://datasheets.maxim-ic.com/en/ds/MAX5556.pdf.

[17] UDA1342TS Audio Codec, NXP Semiconductor, datasheet available at http://www.nxp.com/documents/data_sheet/UDA1342TS.pdf.

[18] UDA1380 Stereo Audio Coder-Decoder for MD, CD, and MP3, NXP Semiconductor, datasheet available at http://www.nxp.com/documents/data_sheet/UDA1380.pdf.

[19] LM4755 Stereo 11W Audio Power Amplifier with Mute Data Sheet, Texas Instruments Semiconductor, datasheet available at http://www.ti.com/lit/ds/symlink/lm4755.pdf.

[20] MID400 AC Line Monitor Logic-Out Device data sheet, Fairchild Semiconductor, datasheet available at http://www.fairchildsemi.com/ds/MI%2FMID400.pdf.

[21] "Passive Pedestrian Detection", Accessible Pedestrian Signals – a Guide to best Practices, Chapter 4, available at http://www.apsguide.org/chapter4_detection.cfm.

[22] "ITS Technologies Ped Smart Pedestrian Detection", walkinginfo.org Design & Engineering, US Department of Transportation, Turner-Fairbank Highway Research Center, available at http://www.walkinginfo.org/pedsmart/p.htm.

[23] "Pedestrian Safety - Report to Congress", US Department of Transportation Federal Highway Administration, August 2008, available at http://safety.fhwa.dot.gov/ped_bike/legis_guide/rpts_cngs/pedrpt_0808/chap_3.cfm.