DESIGN AND CONFIGURATION OF AUDIBLE PEDESTRIAN SIGNALS IN THE CITY OF WINNIPEG

by

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A Thesis submitted to the Faculty of Graduate Studies of

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In partial fulfillment of the requirements of the degree of

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ABSTRACT

The city of Winnipeg is making a continuous effort to improve city accessibility. One of the projects the city has implemented to achieve this goal was installing audible traffic signals (ATS) at some intersections to help visually impaired people (VIP) to cross the streets safely. These ATSs were installed at about 200 intersections so far. However the performance of these systems was not satisfactory due to inconsistent audibility resulting from various aspects such as; traffic noise, wind interference, existence of high rise buildings around intersections, etc. This research outlines the specific issues surrounding the current system and suggests the potential solutions to counteract them.

Design of experiments was used to analyze the effectiveness of the ATS system in different levels of speaker height, seasons, number of lanes, and existence of high-rise buildings nearby. Data was collected from a questionnaire through a set of tests conducted at intersections with the help of 16 VIPs. Conclusions were drawn based on the Analysis of Variance (ANOVA) using the MINITAB® software. Finally, the results were reported along with the recommendations related to the system design and maintenance. One of the main recommendations was to lower the speaker height to 4 feet (1.22 meters) instead of the current 10 feet (3.05 meters) height.

In view of the results that manifested from the experiments and to counter all other known issues such as echoing effects, annoyance in the neighbourhood, vandalism, etc., a new design of the ATS speaker also has been developed in this thesis and its prototypes submitted to the Public Works Department City for their consideration to implement in the city of Winnipeg.

ACKNOWLEDGEMENT

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CHAPTER 1

INTRODUCTION

1.1 Background

In the past years, various techniques have been tried by the visually impaired community to cross the streets at the intersections even before the introduction of the audible pedestrian signals. These techniques and cues used in crossing streets are diverse and vary by location and individual. In the absence of ATSs the most commonly used techniques for crossing the intersection is by judging the traffic by the vehicular sounds and crossing the street that is perpendicular to the street with moving traffic. However, there are always some new barriers at some intersections due to the intersection geometries, acoustic conditions, and traffic control systems. These barriers make it difficult for persons who are visually impaired to get the indication necessary to cross streets independently and safely. In these circumstances, audible traffic signal technologies can be helpful to pedestrians.

Many countries such as US, Australia, Hong Kong, Sweden, Germany, Denmark, Belgium and Austria use these pedestrian signals much more widely than that has been done in Canada. The Canadian National Institute for the Blind (CNIB) reports that as of 2002 there are over 100,000 registered visually impaired citizens across Canada. Of these, atleast 5,000 are Manitobans from a total Manitoba population of 1.16 million i.e. 0.43 % approx [CNIB statistics 2002, Manitoba Health Population Report 2002]. Moreover, the Canadian human rights commission also

insists on promoting human rights for persons with disabilities. The above reasons signify our effort and investment for improving the performance of ATS systems. In Winnipeg these pedestrian signals were introduced as early as 1970's deploying bells and buzzers. But as it is well known that changes to traffic signal systems cannot be made overnight and those municipalities or transportation departments have many projects competing for their budgets. Hence the city of Winnipeg has been striving to gradually make these systems more viable and accessible.

1.2 Introduction

The term "Audible Traffic Signal" means a traffic signal which can be heard by the pedestrians while crossing the street. It was used when the first Audible Pedestrian Signal Standard was introduced in Canada. This Audible Pedestrian Signal standard, served as a basic and necessary accessibility feature at street crossings, particularly for persons who were visually impaired or blind.

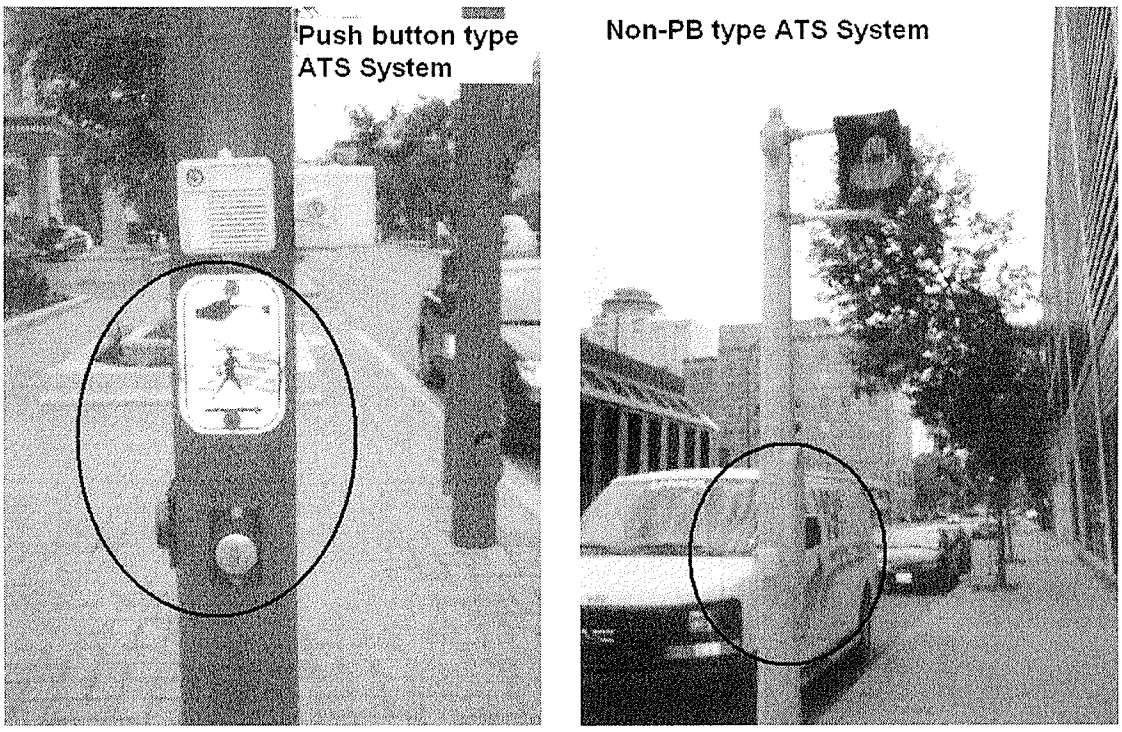
The audible pedestrian traffic signals are used because a number of visually impaired pedestrians want to be mobile and walk in different directions to reach their destinations in different places. Therefore, they may quite often need to cross streets which have a flowing vehicular traffic. The audible signals help them to communicate with the flowing traffic to know when it is safe to cross the street and facilitate crossing the street. The audible traffic signals normally require the use of a locator tone to identify the crossing point at any traffic intersection and the use of a crossing tone to identify the other end of the crosswalk.

The locating tone is an intermittent ticking sound that assists pedestrians to locate the crossing point by providing them with a sense of the poles location. It is emitted from the speakers placed on the poles and is active at all times except for when a crossing tone is in operation.

The crossing tones are those which begin to sound once the traffic light changes to convey to the pedestrians that it is safe to cross the street and are emitted from the same speakers as the locating tones. To ensure the pedestrians will not be confused as to which direction is safe to cross, the crossing tones for the North-South and East-West directions emit different sounds. For example, "Cuckoo" sound for north-south direction such as walking along Fort Street crossing Broadway and "Chirp" sound for east-west direction such as walking along Broadway crossing Fort Street. Both speakers at each ends of the crosswalk emit same tone at the same frequency and intensity. The crossing tone stops when the flashing hand begins, which means do not begin crossing the street because there is not enough time to cross the street and to alert those who are already in the crosswalk so that they have enough time to cross. The flashing hand begins just a few seconds before the end of the total pre-programmed crossing time. The crossing tone not only conveys the message to the blind pedestrians to cross the street but also guides them about the direction of their travel.

A pedestrian who wants to cross the street first locates the intersection's crossing point with the help of the locating tone. If the kind of system used there is a push button type, then the pedestrian activates the push button by keeping the

button pushed for about 5 seconds until the crossing tone is heard (figure 1.1. a). While on the other hand a non-push button type system doesn't need to be activated; they run at all times acting as both crossing and locating tones (figure 1.1. b). The non-push button type system is very helpful to the pedestrians who carry guide dogs or those who are physically handicapped or for the pedestrians whose both hands occupied and it is difficult to use the typical activation button on a push button type system. This kind of the system is installed at the intersection of Donald Street & York Avenue and the intersection of Smith Street & York Avenue on an experimental basis. This kind of the system is installed at the intersection of Donald Street & York Avenue and the intersection of Smith Street & York Avenue in Winnipeg for investigational purposes.



(a) (b)

Figure 1.1: City of Winnipeg's existing ATS systems.

The current ATS systems in the city of Winnipeg in either of these two types of systems, the tone emitting speakers are normally placed at a height of 10 feet (12 feet at some places) above the ground level. Moreover they are set to the same standard volume setting of 5 dB to 9 dB above the ambient noise level to last for about 7 seconds. The volume is automatically controlled by an auto-volume sensors ensuring that the tone is audible at all times over the ambient traffic noise. Thus, it also reduces the annoyance to the neighborhood by reducing the tone volume in the absence of the traffic.

1.3 Other Systems

Other than the above mentioned types of systems, there is a variety of various other kinds of systems used in different cities in the world. A few of these systems are discussed below.

Push button – integrated: This type of system has been commonly used in Europe and Australia for years. It has a speaker and a vibrating surface or arrow at the pedestrian button. The sound comes from the push button pedestrian housing, rather than the Pedhead and it can be used at both actuated and fixed-time signal timing locations. A locator tone that repeats every second constantly provides information to the blind person about the presence of a pedestrian push button and its location and it is intended to be audible only 2-4 meters from the pole.

Vibrotactile: This type of ATS has an arrow or button that vibrates rapidly during the walk interval but there is no audible indication. Devices of this type are useful to

blind pedestrians only when they know the pushbuttons exist and know where to find them.

Receiver-based: With this kind of system, users scan with receivers for pedestrian signal information as they approach the street. When receivers are oriented in the direction of pedestrian signals, a prerecorded message corresponding to the status of the signal is received. Receiver-based systems can provide clear, unambiguous information and directional guidance at typical intersections where there are more than four crosswalks and when tones may overlap and therefore be misleading. Information is available only to individuals who have the receivers and not audible to others.

All these systems discussed above have their own advantages and they have proved to be quite efficient and versatile. But these systems are not adaptable for the kind of the weather existing in Winnipeg. This sounds quite obvious as it has been noted that these systems utilize either a vibrating surface or the use of a pedestrian signal receiver which may not be possible or convenient while wearing the winter wear in extreme cold conditions in the city.

1.4 Problem Statement

Inspite of the City of Winnipeg - Public Works Department's concerted effort for the past few years to improve the effectiveness of the audible pedestrian signal systems, the current system in Winnipeg is causing a variety of barriers for the persons with visual impairments. To list a few, these issues include –

- Some speaker sound boxes are too high off the ground to provide adequate sound for persons using the audible signals. This makes it difficult for the pedestrians to locate a push button and determine the crossing point. Moreover the pedestrians may lose their sense of direction and may not cross the street on time.
- At a few intersections, it has been noticed that the ATS speaker sound boxes generated sound that is annoying to people living in immediate proximity. This was reflected by many complaints received by the City of Winnipeg.
- The ATS Speaker sound boxes mounted at lower heights have been vandalized in the past.
- In addition to the above, there were also complaints that it was sometimes confusing to determine if there is a push button or not.

1.5 Research Objective

To assist the City of Winnipeg's Public Works Department in identifying the root causes of all the issues addressed in the previous section. Eliminate the barriers that are preventing the existing system from realizing its potential benefits through an intensive research and a thorough analysis. To achieve this objective and identify the best viable solution two goals have been set.

1. Investigate and evaluate the performance of the ATS system at varying levels of speaker height, activation system, seasons, street width and complexity and make specific recommendations regarding its future configuration.

2. Custom design a speaker that can be mounted more streamlined on the pole or inside the pole whose sound level is pre-set to a level which can be clearly heard by a person with visual impairment, meet community usability needs without disturbing the people living close by in the community, reliable enough to withstand the extreme weather conditions and durable enough to endure the vandalism.

1.6 Research Approach

To achieve the given objectives, the research has been designed as follows.

1. Selected about 16 subjects (volunteers) from the visually handicapped community whose vision is between 0% to 10 %, to assess the performance of the system and identify the potential barriers in using these systems. In order to have the volunteers participate in the testing, all volunteers had to sign a consent form (refer to Appendix 1) assuring their anonymity throughout the project and informing them about the purpose of the experiments.
2. Selected four different intersections in the city and designed a set of experiments to do an actual real-time testing on the current signal systems with the help of the appointed volunteers. Each selected intersection possessed a unique property set allowing for direct comparison of each variable as detailed in Chapter 3 (Table 3.1) of this thesis.
3. Collected data by repeating the experiment with each subject individually at all intersections in both directions North/South and East/West considering various factors and at peak traffic conditions.

4. Evaluated the data by doing an analysis of variance (ANOVA) to compare performance at each intersection, at different speaker heights, at streets with different widths – with or without median and in both seasons.
5. Custom designed a special speaker using the concept of an exponential horn to generate more dynamic and efficient tones which are easily audible to the pedestrians using the ATS system without disturbing the people living close by in the community.
6. Concluded with specific recommendations for the overall enhancement of the systems and discussions relating to the directions for future work.

1.7 Thesis Organization

The complete thesis has been divided into 7 chapters. The next chapter gives an overview of all the research work done in the past on pedestrian crossing and the ATS system technology. The detailed description of the approach; an overview & basics of experimental design and the method the experiments are covered in the third chapter. The forth chapter is devoted to the analysis of the experiments. Apart from the analysis and its conclusions, there are a few other issues that are identified during the experiments which are discussed in the fifth chapter. A new design of the ATS speaker is proposed in chapter six. The thesis concludes with chapter seven summarizing the final results of the analysis and recommendation of directions for future research.