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Bus Stop Assessment: Bringing Worcester to Code

An Interactive Qualifying Project Report
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Abstract

The Central Massachusetts Regional Planning Commission (CMRPC), in conjunction with the Worcester Regional Transit Authority (WRTA), sponsored this project to create a more accurate and detailed inventory of Worcester bus stops. The main goal of the project was to create a master database that could be shared by our sponsors and the Worcester Department of Public Works (DPW). We also created an assessment tool that gave explicit details of each stop regarding overall safety and handicap accessibility and that can be used in later data collection. Based on data collected, recommendations were made to improve safety and accessibility on evaluated stops.

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Authorship Page

Our project team, consisting of Chase Johnson, Stephen King, Rachael Petty, and Liza Tuttle combined our individual strengths throughout this project. Every aspect was fruit of our brain-storming, as we were as open-minded as possible. Therefore, we assert that all tasks were distributed evenly in the completion of C'07 Interactive Qualifying Project, "Bus Stop Assessment: Bringing Worcester to Code".

Executive Summary

Public transportation is a vital component of society and essential to a properly functioning city. Without a safe and efficient public transportation system people who are unable to drive would not be able to easily maintain a normal lifestyle. Public transportation in the City of Worcester includes not only the busses but all of the bus stop signage and the waiting area around each stop. Maintenance of each stop can be a difficult task because of the large volume of stops (over 1000) and because of a lack of information available about those stops.

The Central Massachusetts Regional Planning Commission (CMRPC) came to WPI when they found they did not have an efficient way to evaluate the location, safety and accessibility of each bus stop. The CMRPC shares the list it has with the Worcester Regional Transit Authority (WRTA) and the Department of Public Works (DPW); however each of the three organizations has a different copy of the "official" list originally kept by the DPW. This becomes a consistency problem when one organization changes something related to a bus line and/or stop and the list is not updated for the other two organizations. The CMRPC wanted a single database created so the inventory information as well as the safety and accessibility data could be accessed by all three organizations. The CMRPC agreed that they would create the database but they needed an assessment tool encompassing the inventory as well as safety and accessibility aspects that were deemed to be important.

The layout of the assessment tool needed to be something that was logical as well as easy to use. We had to determine what would go into each of the sections and what part of the safety assessment it was most important to.

The inventory part of our assessment tool has attributes that identify the bus stop to a DPW administrator or rider such as the sign, street name and route identification numbers. We also wanted to include whether or not there are shelters or benches.

The safety aspects include condition of sidewalk, location of stop (is it in traffic or its own pull-off?), posted speed limit around stop, traffic conditions, the existence of any crosswalks in the area and whether or not the vegetation around the stop is a potential danger to anyone.

Finally accessibility needed to be addressed and this would include: does the stop have a crossing signal, are there curb cuts, do curb cuts meet ADA standards and are there tactile strips on the curb cuts? Since our assessment tool included all aspects of inventory, safety and accessibility we were able to fully determine whether or not a stop was in proper condition.

A GIS map of the City of Worcester was put into a Personal Digital Assistant (PDA) that was provided by the CMRPC so that each stop and its location could be recorded on the map and associated with the assessment tool data. Once the data had been collected it was stored on a CMRPC computer in the database that they had created. Approximately 70 stops in the City of Worcester were evaluated using the assessment tool. Once we became familiar with the PDA the average time at a stop went from approximately 15 minutes down to 9 minutes. Assessing the stop still took longer with

the PDA than with the paper version (which took under 5) but it took less time to load the data into the computer later.

When we analyzed our data, we discovered that overall the city is doing fairly well with maintaining the stops in the city. Based on our data analysis, the following recommendations were made: (1) All bus stop signs should be adjusted to include the route numbers. The lack of route numbers on the signs makes it impossible to know which routes run through that specific stop. (2) The Database should be completed by getting the information for the stops that we were unable to finish due to our time constraints. This would be extremely helpful to all the organizations involved because that would create one master database to be used by all. A complete and accurate database is a valuable asset to the bus services in the City of Worcester. It is sure to make it easier for the city to maintain its bus stops and when the system is more efficient it is sure to increase ridership.

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Chapter 1 Introduction

A safe and efficient public transportation system is a critical component in maintaining a functional urban society. Without some form of public transportation, important facets of daily commerce can never be achieved. Public transportation provides every citizen the ability to get where they need to go in a cost efficient and timely manner. Public transportation also leads to fewer vehicles being on busy streets which results in less traffic related accidents and reduced air pollution. Since there is no underground transit (subway) system in the City of Worcester, and taxicab services are privately owned, the fixed-route bus system is Worcester's only means of public transportation. Due to heavy reliance on the fixed-route bus system, consistently maintaining passenger and pedestrian safety in all aspects is a crucial task for the City of Worcester. As such, it is essential that the fixed-route bus system provide a convenient and a safe means of public transportation in order to increase its appeal to the city's citizens and residents. This will ultimately increase ridership and prevent more traffic related accidents.

Nearly 45,000 Americans are killed in traffic related accidents each year and three million more are injured. Approximately 14 percent or 6,300 of those killed in traffic accidents are pedestrians and bicyclists (Decoding Transportation Policy & Practice # 10, 2003). In order to help lower the risk of injury or death for the 30 percent of Americans who use walking as their primary means of transportation, a safer walking environment is essential (National Cooperative Highway Research Program, 2004). Therefore, there is no doubt that pedestrian and rider safety is the vital component in assessing bus stop safety.

Since many different organizations comprise the public transportation system, actual maintenance of safety at stops can be an arduous process. The Central Massachusetts Regional Planning Commission (CMRPC), Worcester Regional Transit Authority (WRTA) and Worcester Department of Public Works (DPW) are the primary organizations that compose Worcester public transportation.

The CMRPC is the agency charged with constructing ideas to better the bus system in general. The CMRPC is also the primary sponsor of this project. The WRTA is a group of organizations in charge of facilitating all of the operations associated with the busses themselves. Their responsibilities include; hiring and maintaining personnel as well as maintaining the busses. The DPW, who has the "official" list of bus stops, is the agency charged with manufacturing, deploying and maintaining the signs to identify bus stops.

At the start of this project the three organizations had three different lists of bus stop locations (See Appendix A). This lack of a current, all encompassing and accurate inventory of bus stops did not allow the CMRPC, WRTA and Worcester DPW to effectively coordinate with each other. That became a major issue in terms of maintaining consistency with the stops and lines as well as accuracy and continuity with the signs themselves (See Appendix A). As such, accurate and efficient communication between the organizations was essential when trying to maintain safety standards and keeping the stops up to code. With the current state of affairs specifically with no consistent inventory, actions such as replacing signs or correcting sign errors took much longer than necessary. Likewise, if a stop were to become unsafe, inconsistent information between the organizations could prevent a speedy resolution and cause discrepancies. These

discrepancies would ultimately lead to substandard and inaccurate labeling of signs as well as having no current safety evaluations.

The assessments that were conducted in this project sought to improve the three main components of the bus stops: inventory, safety and accessibility. Creating an up to date inventory by utilizing the Geographic Information System (GIS) allowed for an accurate means of data collection that was easily populated into an online database. This laid the groundwork for a master inventory to be shared by all the organizations.

Secondly, creating an assessment tool which we used to evaluate bus stop safety, provided details about each stop and what needed to be improved or further evaluated at each stop.

Lastly, accessibility was an issue because none of the Worcester bus stops had been evaluated to ensure that they met the American's with Disabilities Act (ADA) standards. The City of Worcester's answer for complying with these standards is a program called Para-transit Brokerage Services Incorporated (PBSI) which provides a means of transportation for handicapped individuals when a bus is not within in a reasonable distance. Because disabled persons are located all over the city, there were no consistent lines that the PSBI vans followed. As such, the service often times becomes more of a livery service than a bus service. This is very inefficient in terms of time and money. A current accessibility evaluation of preexisting bus stops on the fixed-route system revealed that many stops could potentially be deemed as handicap accessible.

Ultimately, the outcome of the project was the cohesion of these three components: an updated and accurate inventory of selected bus stops, a safety evaluation guideline, and an accessibility evaluation guideline. All the inventory data collected and

the evaluation guidelines that were developed can now be used as a tool for transit workers to re-inventory and evaluate safety and accessibility at the remaining stops throughout the city in the future.

To begin solving a problem like this, it is always important to consider what others have done. As such, looking at other cities and how they have addressed their public transportation systems in terms of safety and accessibility was a very useful step. However, it is also important to consider what makes the area you are working on unique. This is one of the most important factors we considered: What makes Worcester different? What are the factors specific to Worcester make our assessment tool different from that of another city?

In conceiving an assessment tool that would be Worcester specific, the individual components should be as Worcester specific as necessary. More specifically, this includes what aspects and components of a safe bus stop will our assessment tool address. In order to create the most specific list, it was paramount that we considered what we had researched about other cities, our sponsors' ideas, as well as our own ideas. Taking all these into account and synthesizing them into one composite list provided the most accurate and effective tool for conducting the safety evaluations.

To gain a better sense of scope for our project, we had to decide which lines and stops we were going to inventory and evaluate. This was a meticulous and concentrated evaluation process. Ridership data allowed us to see which lines were used the most. Also, route maps allowed us to see which lines are the most centralized and which particular stops are intersections between heavily ridden lines. We also relied heavily on our sponsors' recommendations as well as what we were able to find in the field. Specifically,

which routes we found to be the most diverse in terms of shelters, sidewalks and environment.

With the new assessment tool, it will be much easier to effectively evaluate safety. Moreover, our inventory provided the ground work for a master list that all three organizations can use. This is expected to result in more efficient maintenance and the ultimate goal, increasing ridership and profit. However, in order to achieve these results, we need to take many significant steps beforehand. Through our preliminary research, we aimed to learn how to find the most effective way to not only collect data, but to also determine what our data should consist of. Researching previous public transportation related safety, accessibility, and inventorying projects aided us in presenting similar situations, procedures and methods by which others have solved these problems. Specifically, what aspects have projects in other cities used in evaluating bus stop safety? Also, what did we need to consider specifically for our inventory? Utilizing resources available to us combined with our own intuition towards the project ultimately yielded the best possible results.

The remainder of this report is organized in the following manner. Chapter two will address all the background research conducted for the project. The third chapter will explain in detail our research methodology to be followed by a chapter of our data analysis and results. Lastly, the final chapter will discuss our recommendations and overall conclusions about the project.

Chapter 2 Background

This chapter will give an overview of the topics included in this project. It will first aid the reader to gain an understanding of the importance of this venture to the City of Worcester and why the problem exists. Solutions to the main problem will then be discussed followed by the three main components it entails: inventory, safety and accessibility. Finally, research areas are analyzed concluding with a brief summary.

2.1 Project Preface

Public transportation is a very important part of sustainable society. Within a community, the residents need to travel for a variety of reasons whether the destination is work, the store, a doctor's appointment, or a family visit. In the initial project meeting, the CMRPC indicated their concern about the current status of the bus stop database. They felt that a lack of current database could be detrimental to the entire Worcester community (See Appendix A).

2.1.1 Why this issue occurred

The main issue was identified as poor communication between the main Worcester organizations and an overall lack of a master bus stop database. The WRTA knows which streets the busses travel down but has no data about where the stops actually are located. The DPW has the "official" list of stop locations but it is not completely up to date. As such they are unable to efficiently maintain correct signage (See Appendix A).

The WRTA did an inventory of the bus stops approximately nine years ago which became the DPW's official list and the master list for all involved organizations. The main problem arose when the same information was kept in different databases. After

years of small yet significant changes to the inventory and routes (e.g. if a bus stop needed to be added to a route, WRTA would have had to go through city council before they are able to request that the DPW move the stop or put up a new sign.), the lists became different. Also, many times the DPW would put up a sign on an existing post or light pole and not inform the other two organizations of the change and over time, the lists became considerably distorted and inconsistent (See Appendix A).

2.1.2 Solving the main issue

Once the main problem was identified, the next step was to figure out how to go about solving it. The city needs an accurate inventory of the bus stops to ensure that each stop is being properly maintained. In order to create a database that can be utilized by all three organizations, a new inventory had to be initiated.

Since Worcester has over 1,000 bus stops, going out into the field and individually inventorying each stop was unfeasible given the resources and time constraints of this project. As such, the scope of how many stops could be inventoried would rely heavily on a prioritized list of bus stops. Ridership data and other information about the habits of the disabled and elderly in Worcester was something vital to our project. By studying these resources, we were able to focus our efforts on the stops that could benefit the most from our assessments.

Another goal was to make use of available technology. Specifically we needed to figure out how Global Information System (GIS) will deliver Global Positioning System (GPS) coordinates so that could be used in online GIS databases such as *Google Maps*, *MapQuest*, or *Yahoo! Maps* to create trip planners for the city. Another benefit of having precise coordinates of the stops is that it will now allow much more efficient

communication between the CMRPC, WRTA and the Worcester DPW to effectively create a much more accurate and available map of the Worcester bus lines and stops. For instance, if something needs to be fixed at a stop, the coordinates can be the identifying number, rather than trying to describe what part of the street the stop is on. Effectively, utilizing GPS technology by assigning new accurate coordinates to each stop will significantly limit the margin of error incurred by communication issues.

Since this project requires significant field work, research needed to be performed in selecting the appropriate unit that would meet the project's GPS needs as well as its cataloging and database needs. Also, having a system that would be Windows compatible was essential since establishing an online database is one of the projects main goals. After much online research, a comparison matrix was generated (See Appendix B) and based on this information, the following model of GPS unit was considered by us, to be the best.

The Trimble Recon handheld provides us with the impact proof, weatherproof handheld that we needed for this project. It also has Microsoft® Windows Mobile® version 5.0 software, as well as built-in Bluetooth wireless technology which make it a valuable asset because of the compatibility it has with our PC's. (Trimble Navigation Limited, 2006)

Figure 1 - Trimble Recon

2.2 Safety

In a large city or a small town, safety plays a large role in the sustainability of a society. "While safety is an important consideration in many human activities, it has a

particularly prominent role in transportation." (Evans, 2003) Worcester is no different. Many people use public transportation in their everyday lives and as such it is one of the City's primary responsibilities to ensure that the bus stops are safe. This section will deal with the different aspects that influence pedestrian safety at bus stops including traffic, weather, and the environment around each stop followed by an overview of the assessment of safety.

2.2.1 Pedestrian Safety

"On average, nearly 45,000 Americans are killed in traffic accidents each year and three million more are injured. Pedestrians and bicyclists make up about 14 percent or approximately 6300 of those who are killed in traffic accidents" (*Decoding transportation policy & practice # 10.*2003). Since pedestrians are the main component of bus stops they are ultimately the most important factor in bus stop safety. More clearly, "Specific groups that do not or cannot drive primarily depend on walking for transportation, including children, the elderly and low-income populations. These individuals comprise up to 30 percent of the population in many communities and are particularly in need of a safe walking environment to help lower their risk of injury and death" (National Cooperative Highway Research Program, 2004).

With an increased number of drivers on the road traffic becomes heavier which increases the need for pedestrian safety at bus stops. "Traffic congestion in small urban and rural areas is increasing 11 percent per year-twice the rate in urban areas" (American Public Transportation Association, 2006). This means that in the City of Worcester the traffic rate is increasing on average five percent a year, which invariably increases the likelihood of a traffic accident. Public transportation reduces the number of cars on the

road as well as energy consumption. However, traffic related accidents will still occur at a fairly consistent rate, especially in an urban setting. Likewise, designing areas with pedestrian safety in mind has proven to be a difficult task for engineers and urban planners. To be blunt, “Safety can influence a person’s decision to use public transportation” (National Cooperative Highway Research Program, 2004). If a pedestrian does not feel safe waiting at a bus stop they are not going to use the bus system.

When pedestrian safety is ignored or not given a high priority it becomes difficult for pedestrians and vehicles to share the roadways (Retting, Ferguson, & McCartt, 2002). The National Cooperative Highway Research Program has stated that to improve pedestrian safety, the distance between the pedestrian and the automobiles must be increased (National Cooperative Highway Research Program, 2004).

Traffic is not the only safety issue that faces pedestrians waiting at and leaving bus stops. Another factor that affects the safety of a bus stop is the weather conditions of the area the stop is located in. Specifically with our project, “Worcester hosts some of harshest winters in New England because of its hills. With average annual snowfall of around 60 inches” (Dellinger, 2004). The City of Worcester in the winter can have some very dangerous conditions at bus stops if they are not taken care of properly. If the sidewalk around a stop is not in good condition in the first place, adding snow and ice is going to make conditions much worse. Also, if sidewalks are not plowed and salted frequently they can become slippery and are a hazard to everyone when stepping off of the bus, especially those who are disabled or the elderly.

A third factor that affects pedestrian safety is the area surrounding the stop. Lighting and barriers (fences, walls, and buildings) are important safety factors

specifically in terms of person-on-person safety. What constitutes the safety of the stop will indubitably vary from person to person; and it also depends on the city the stop is located in. Elements of the safety checklist which ensures the bus stop is safe for all pedestrians will be discussed in the next section

2.2.2 Assessing Safety

Statistics indicate that "riding a transit bus is 79 times safer than car travel" (American Public Transportation Association, 2006). Despite this, the general perception of urban pubic transportation is still viewed as unsafe (Worcester Regional Research Bureau, 2002). By analyzing safety at bus stops we were able to create a prioritized list of stops that need the most attention. A safety checklist was used in helping us to prioritize these stops.

There are several factors that were considered when it came to bus stop safety. Several checklist styles had to be considered to create the one that fit the City of Worcester best. All of the factors listed above also had to be considered when creating our assessment tool. According to *Easter Seals Project Action* an important factor in bus stop design was safety and warning (Easter Seals Project ACTION). That project provided a sample assessment tool in “Toolkit for the assessment of Bus Stop Accessibility and Safety” which encouraged users to modify in order to best fit their individual needs.

The Easter Seals checklist was very helpful when we assessed what needed to be included in our assessment tool and also in trying to begin to define “what is safe.” Specific safety issues that the City was not able to address were sidewalk conditions, the surrounding area of the stop and the condition of the stop in times of poor weather. When

the inventory was taken of each stop in Worcester the safety, accessibility and condition of each stop were recorded. At that point recommendations were made to the CMRPC on what needs to be changed at each bus stop to make it "safer."

2.3 Accessibility

Another issue that is easily overlooked because of the lack of one database is accessibility pertaining to the disabled persons, elderly, and families with small children. Therefore, evaluating accessibility became the third component of our project. Specifically, it was important that we looked into what the ADA requires of bus stops so that those aspects would be included in the assessment tool. This section will give background into the laws for the disabled, what Worcester had to do to abide by those laws, and an understanding of this project's steps toward a better solution.

2.3.1 Disability Laws

In 1990 the Americans with Disabilities Act (ADA) was passed. ADA states: "This broad civil rights act bans discrimination on the basis of disability … [in] transportation [and] public services…" (American Foundation for the Blind, 2006). Essentially all people must be able to access public transportation whether they have a disability or not. Disabilities ranging from loss of limb to blindness and deafness to mental disabilities all fall under the constraints of this act. This project addresses mostly disabilities that would allow the disabled to live alone, but would hinder them in their daily business. Specifically, wheelchair restricted, deaf, and blind citizens.

To address the service to the vision impaired, one has only to look at a bus stop. There is little to nothing in place that would allow a blind person in the City of Worcester

to safely and confidently use the fixed-route bus system without a guide. There is no Braille or raised lettering in the stops that were observed. It would be very difficult for a blind person to know where it is safe to stand to wait for a bus to arrive.

> Public transportation is a major key to independence, productivity, and community participation for people who are blind or severely visually impaired - most of whom are not able to drive a motor vehicle because of their visual impairment (American Foundation for the Blind, 2006).

Providing service to the completely blind proved to be a difficult task and we had to look into it further. Visually impaired persons who are not completely blind, but still cannot get a drivers license, are able to use fixed-route transportation systems in Europe specifically in Denmark, where a previous IQP group did a project to help the public transportation system service the visually impaired. Some of the things that were implemented there could easily and cost efficiently be applied to Worcester's bus stops such as large-print, high-contrast and non-glare informational signs. These signs would allow visually impaired persons to be able to determine self-sufficiently where they are and how to get to their destination. By placing Braille and tactile information (raised print) around the stop, the visually impaired will be able to easily read signs. Also, in order to let the visually impaired know where the bus is going, instead of having the destination written on the front of the bus, have a recorded voice read off the stop announcements inside and outside of the transit vehicles (American Foundation for the Blind, 2006).

2.3.2 Para-transit Brokerage Service Incorporated (PBSI)

To address the wheelchair and hearing impaired concerns with the project, we had a meeting with the employee in charge of accessibility at the CMRPC on Monday the 27th of November 2006, to find out what is already being done to service these disabled persons. It was important to get different perspectives about the issues that we are dealing

with, and also to learn about any legal requirements which we will need to be familiar with. Since the fixed-route system alone did not comply with the regulations, a new service had to be created to bring Worcester up to code. (See Appendix A) This service is called the Para-transit Brokerage Service Incorporated (PBSI). The PBSI is a service offered by the WRTA which adheres to those who are unable to use the fixed-route system. People with disabilities such as blindness or restrictions to wheelchairs apply for use of this service. If a person is accepted by the PBSI they are able to use the system at their leisure and the PBSI vans will meet all their transportation needs. Even though this proves to be an expensive solution for Worcester, it was the most efficient solution to comply with ADA standards.

2.3.3 Cutting down on PBSI

Upon realizing the high cost of the PBSI service, accessibility gained additional perspective in this project. By evaluating accessibility at bus stops in areas where PBSI is most frequently used, the need for PBSI services would be significantly reduced. This is because if more stops on the fixed-route system are deemed handicap accessible, then disabled individuals could be using the fixed-route system rather than relying on PBSI. Reducing the need for PBSI would dramatically reduce the costs associated with.

2.4 Research

Once the components of the project were agreed upon, further research was needed. The safety and accessibility components were researchable, as they have been implemented in many other cities. This research pointed us towards our goals of making a full assessment of a bus stop that can be logged during the time that the GPS

coordinates are taken at the stop. This section will discuss the many different areas that we looked into as well as different problems that were encountered.

2.4.1 Research Areas

One of our principal research questions was: What constitutes safety? This is something that had to be determined using other safety assessment tools and adapting them to be appropriate for use in Worcester. “Passenger security is a major issue in bus stop design and location and can positively or negatively influence a bus patron’s perception of the bus stop” (Easter Seals Project ACTION). In our research we found a previous IQP entitled, “Assessing Playground Safety; Design of Audit and Maintenance System for the Playgrounds of Worcester, Mass.” This IQP was helpful to us because they created a playground safety audit. The main goal of this playground safety IQP was “…to define the components of a safe playground and investigate what needs to occur to ensure and maintain safety in Worcester’s playgrounds” (Wolfe, Whitaker & Sama 2002). Even though playground safety is significantly different from bus stop safety, the goals of the playground IQP were very similar to our goals for bus stop safety; we wanted to be able to define what is safe for a bus stop and then create an audit system to assess the safety of bus stops in the City of Worcester. Using the playground safety audit as well as the Easter Seals safety checklist, we were able to create a proper assessment tool for the City of Worcester.

Another IQP we looked at was called, “A Road Maintenance and Accounting System for GASB-34 Compliance in Spencer, MA.” The research found here helped in creating a rubric for identifying the overall rate of each stop. This IQP used a picture

representation of the criteria followed by a sentence to describe each rate. We decided to adapt the idea since it was best formatted for this IQP.

Other research pointed to the fact that the ADA requires those with disabilities to be able to take advantage of public transportation. Also many of the deaths in auto accidents involve pedestrians. Since bus riders waiting at bus stops are actually pedestrians, their safety is of the utmost concern of this project.

Another point that was addressed was where the PBSI has the most stops and pickups. In Denmark there were special pickup services for the disabled. Another component of the Denmark IQP was whether or not tactile pathways could be implemented to give visually impaired a raised pathway so they could know when the stop was approaching. It had to be investigated whether or not the pathways could be implemented there (Osberg, Leduc, Casavantes, & Smith, 2006).

2.4.2 Research Problems

When looking through the different areas of research, we always kept in mind the question of what specifically constitutes bus stop safety. As a result we concluded that there were many different views. At first glance the answer seems almost trivial however aside from basic safety mandates and needs pertaining to stop location, and the general habitat of the bus stop, there is really no limit to safety protocol. As such, one of the chief components of our project was to not only assess the safety of the Worcester bus stops, but to also be responsible for the conception of a universally appropriate safety evaluation for the Worcester bus system. However, despite the great sources we were able to find relating to bus safety, there was still seemingly inherent differences between what specifically constituted bus stop safety. This is not all that surprising given that

every country, state, city and town will have different ideas and needs that together comprise and maintain “safety.” With our project being in an urban setting such as Worcester, safety precautions for public transportation should be as meticulous and specific to Worcester as possible. Using only the safety checklists generated for other cities and purposes would be very inappropriate and generate an assessment tool that is not specific to Worcester. If we had only used the resources in the literature, important items could have been omitted from our safety checklist.

Given all the individual components, (inventory, safety and accessibility), this project was an arduous process. However, upon completion, our finished product was a significant contribution to the City of Worcester and its residents. Bringing the bus lines and stops up to code in terms of safety and accessibility, as well as creating a new accurate inventory, was a very significant step for the entire city. With that in mind, it was in our best interest to utilize all that is available to us in order to do the best job possible while executing our IQP.

2.5 Summary

To summarize, the three main components of our project, (inventory, safety and accessibility) all required extensive research. The on safety and accessibility lead us to conceive an accurate and appropriate Worcester bus stop assessment tool. Also, our research on GPS equipment and inventorying processes lead us to be able to make an informed proposal to our sponsor on the unit to be purchased for the project. Upon inspection, the extent of this project significantly expanded in comparison to the original

proposed scope of work set out by the CMRPC. Given that the three main components of our project are all equally important; our methodology had to reflect that.

Chapter 3 Methodology

This chapter will give an overview of the methods we used to collect, analyze and interpret our data as well as the processes we used for our project. There are two parts to our methodology that will be discussed: the data collection and the assessment tool creation. We have utilized many techniques in acquiring the data including focus groups, literature review, interviews, content analysis, and observations.

3.1 Complete a Master Assessment Tool

This section will discuss the methods used to determine how to prioritize the stops to be assessed during our project. It will also, discuss the equipment we used for assessment.

3.1.1. GPS Equipment

To select the right GPS system to use, a matrix was created comparing different aspects of GPS systems such as price and compatibility (See Appendix B). Once everything was analyzed, we selected the GPS unit(s) for our project to propose to our sponsor for purchase. Since GPS is the critical component of our data collection, we needed to find methods that work best for collecting the data we need. Collecting global addresses, storing and recording the data, and making sure that there is an easy transition for data input between the unit itself and the computer we used to store the data were all critical for our project. Likewise, finding a way to incorporate the data we collected on safety and accessibility with the inventory information was critical to our inventorying process. Although the unit was chosen specifically for our project, testing its accuracy and developing an efficient consistent method of data collection was a vital preliminary

step of our project. However, simply choosing an appropriate unit to purchase for the project was not sufficient.

Aside from the factors outlined above, there were two significant additional factors that warranted consideration: Firstly, as suggested by our sponsor, given we have a group of four, splitting up into teams of two, each with their own unit, would yield a greater quantity of inventoried stops. Secondly, given that two units are to be purchased, our sponsor's GPS budget was essentially halved. As such, a different, less expensive unit had to be chosen

3.1.2 Choosing the Stops

We set up a timeline of when all of the parts of this project should be done. A big part of the timeline was how many stops we would like to assess/inventory. Before we could estimate a number of stops we could evaluate, we had to start looking at which stops we were going to pick. Elderly citizens are most likely to have trouble accessing the bus. Also, a much higher percentage of elderly people are disabled than younger people. By looking at the habits of elderly people, and asking the PBSI where they pick up and drop off the most disabled people, we were able to figure out which stops should have the greatest priority. If our group could make recommendations to the City of Worcester about which stops they should make accessible, they can use those recommendations to bring the stops up to the standard that a handicapped person would need. Then, the handicapped would be able to use the bus system instead of having to rely on the PBSI. Our thoughts after meeting with our sponsors suggested that this would save the City of Worcester a great deal of money, considering the PBSI essentially provides a taxi cab service which is much more expensive than the fixed-route system. By reducing the PBSI

range of service, we would be saving the City of Worcester money while still expanding accessibility throughout the City.

There are over 1,200 bus stops in the City of Worcester. As such, to inventory and evaluate safety and accessibility at each one during the seven weeks allotted to this project would be far too optimistic. Therefore, one of our main tasks was to decide which stops, or particularly which bus routes, were the most critical for our project. For the greatest effect on our project, it made the most sense to sample the routes with the highest ridership and/or the most centralized routes and stops. Ridership and centrality are figures we considered when selecting which routes to inventory and evaluate; however, they were not necessarily limited to those specific statistics. We also considered other factors such as location of schools, elderly housing, and major businesses. We acquired this information from the info sessions with PBSI. Once we had a final list of stops to evaluate and inventory we had a much more specific scope to our project.

3.2 Assessment Tool to Represent Best Practices

This section discusses the steps taken toward the assessment tool we created. It also documents results from all different focus groups and meetings regarding the assessment tool as well as the respective changes made to the assessment tool.

3.2.1 Meeting with PBSI

Meeting with PBSI allowed us to conceive the idea of utilizing focus groups. Our PBSI contact suggested that we create a focus group with the Transportation Planning Advisory Group (TPAG). While we were meeting with PBSI we set up a meeting with TPAG in January. PBSI also gave important feedback on specific things they were

looking for at stops such as locations and barriers around the stops. These things and more were taken into consideration but were also addressed at the focus groups (discussed in 3.2.3).

3.2.2 Forming the initial assessment tool

To form our initial assessment tool, we took ideas from the sources we researched and meetings we attended. We had the initial idea to research different checklists and analyze the data to fit components of Worcester, but when we began to analyze the data our methods changed. We found one very helpful piece of research called the "Toolkit for the Assessment of Bus Stop Accessibility and Safety." We used this as our main source of background information and combined that with feedback from our sponsor, assisting organizations and the two focus groups. Following the research done on the key elements we put together our initial assessment tool (See Appendix C). The assessment tool consisted of the three main components which were inventory, safety and accessibility. Each component has sub-categories that were important aspects of assessing safety and accessibility. After completing the initial assessment tool we brought it to the focus groups that will be discussed in the next section.

3.2.3 Focus Groups

Two focus groups were conducted so that we could broaden our scope in terms of input for our assessment tool. The first focus group was held at the monthly TPAG meeting in January. TPAG members consist of "riders, human service organizations representing elder and disabled clients, WRTA service providers, the WRTA Administrator and representatives from CMRPC who act as staff to TPAG." (Transportation Planning Advisory Group (TPAG). 2007) The second focus group was

designed to get the input of those who maintain and run the bus system. In attendance at this focus group were representatives from CMRPC, WRTA, DPW and the City of Worcester. This focus group gave us input for the assessment tool from an administrative point of view. It was critical to utilize the ideas gathered in these focus groups in order to create a thorough assessment tool.

3.2.4 Assessment Rubric

Once the components to be included in the assessment tool were identified, a rating system for each component needed to be created. Our advisors helped us to realize the importance of a standard assessment method. It was critical that the assessment method could be understood by anyone who may have to use it so that the database can be maintained and updated in the future. Our rating system needed to have explanations of the conditions that each rating corresponded to so it could not be the subjective opinion of the user. We used the Spencer IQP as an example of such rubric and decided to follow those guidelines (Ferguson & Shea, 2005). The rating system uses a value between 1.0 and 5.0. The higher the rating the better condition each component is in. Each value is based upon various forms of upkeep or damage. To see the full and complete rubric for this project see Appendix D.

3.2.5 Pilot run for the assessment tool

After combining all of our research and observations and forming the assessment tool (See Appendix E), we pilot tested our assessment tool and data collection procedures. The process of choosing stops for our pilot test run was relatively random. This allowed us to get a better idea of things that had been left out or mistakes we had made with the assessment tool. Since the stops for the pilot test were selected at random, we were then

able to throw out the data, revise the assessment tool and data collection process, and start evaluating the more frequently used centralized stops around Worcester. It was in our best interest to first conduct pilot test runs on bus stops that were not as important to the overall database. The stops we attended during the pilot test run were not on any of the routes we went out to during our actual data collection. It was not difficult or time consuming to go out to stops that were not a part of our actual data collection process. Carrying out pilot test runs allowed us to practice the system we would use at each stop. Also, we were able to conceive a time efficient method of data collection even though our pilot test run had to be conducted on paper.

3.2.6 Revision of the assessment tool

Despite how thorough our assessment tool was, after the pilot test run it still needed revisions. After the pilot runs, any problems identified regarding the assessment tool needed be fixed. One issue that kept reoccurring was the idea of having an overall rating system, devised by adding up the numbers of each sub-category grade. Initially the assessment tool was going to include an overall scale that would represent what stops needed the most attention. After much discussion and research we decided that it would be best not to include the overall grade in the assessment tool. The reason that we decided not to grade stops based on an overall scale was because we felt that the numbers wouldn't appropriately represent what stops to be renovated over others. The grading system would become a problem when some of the things we were grading were not pertinent to a particular stop. A stop that was weak in the basic needs of a bus stop but scored highly in other areas would still score fairly decent. This stop would more than likely not be considered for renovation even though it would benefit. Therefore, we

graded bus stops by each aspect rather than overall. This way, when the City of Worcester decides that they would like to install more shelters at bus stops, they can look at ridership data and then cross reference it with the database, to see the most populated stops that do not already have shelters and install them at those stops first.

Another reason that the overall grade for stops was eliminated was because if City of Worcester decides to improve the bus stops they are not going to go to each stop and fix everything at once. Doing so would be extremely inefficient and would make the stops far too different throughout the city. They more than likely are going to look at some of the bigger overall problems and fix them one part at a time. As was the case with the shelters, they would take a problem like sidewalk cutouts, go to the database and see which sidewalk cutouts were graded worst, and then send a sidewalk construction team out to fix the problem. After we had identified why something did not work with the assessment tool we needed to propose a way to have it fixed, if there was no real conceivable way to do so, it had to be removed. The final task that had to be done to edit our assessment tool was to add any new elements that we had discovered during our test runs.

3.3 Training for Equipment

Before using the equipment we were given for this project we had to go through different training sessions. Below is what we needed to do to acquire and properly use our technology and vehicle.

3.3.1 PDA and GPS System

Once the CMRPC received the PDA and GIS system they bought for use in this project. They brought us in to do a small half hour training session. We worked with Matthew Franz, who is the CMRPC GIS Analyst, and he assisted us in learning how the PDA operated. The software provided with the PDA is called *Arc Pad Mobile GIS* software. This software was used to give an aerial view of Worcester and most of the bus stops in the city. You can see from Figure 2 we were able to view streets and buildings clearly, and each bus stop was identified with a red or green dot.

Figure 2 - Aerial view of Worcester, MA seen from PDA

After learning how to operate *Arc Pad Mobile GIS* we were also trained on how to sync the GPS with the PDA. This way we wouldn't have to scan the PDA to find where we were, the GPS was able to assist in positioning us on the GIS software.

3.3.2 WRTA automobile

In coming to the realization that it would be easier and a lot more efficient to drive from stop to stop instead of using the bus, the CMRPC talked to the WRTA and acquired a vehicle for us to use. Two members of our team, Stephen King and Chase Johnson, participated in a three hour training session to be able to use the vehicle. They sat through videos, took tests, and completed a driving evaluation before receiving access to the vehicle. Once they passed the training they were the only two team members allowed to drive from stop to stop.

3.4 Collecting the data

After acquiring the PDA and GPS unit and being trained in how to operate them properly, we were able to establish and execute our data collection procedure. When we used the vehicle from the WRTA, we attached the GPS unit to the roof and kept the PDA inside with us. The PDA not only had markers for each approved stop, but was linked to the GPS unit. As such, the aerial photography on the PDA followed us as we drove. Following predetermined bus routes, we not only looked for the markers on the PDA, but also the signs outside. This way allowed us to look for errors between what was currently in the database and the actual stops themselves.

3.5 Conclusion

Seven weeks is not a lot of time to complete a project of this magnitude. However once all of the steps of our methodology were completed the project came together in no time. Each step of this process was important to completing this project in timely manner

and also helped us complete a quality project that greatly benefited, and will continue to benefit, the City of Worcester. Our full project schedule can be found in Appendix F.

Chapter 4 Results

This section will first discuss the results from our two focus groups and changes and resulting issues with the technology. This chapter also presents the final inventorying procedure and an explicit analysis of both our qualitative and quantitative data from the previous chapter. The data was separated into the three main categories we have been dealing with: inventory, safety and accessibility. These three aspects were analyzed cumulatively and then separately by location.

4.1 Focus Group Results

At the first focus group, TPAG was presented with the initial assessment tool we had created. The group made several helpful suggestions and comments about the assessment tool in terms of what should be added or removed. After collecting the comments and suggestions from TPAG, the assessment tool was edited to reflect all applicable suggestions so that it was ready for the second focus group.

At the administrative focus group, the items in the assessment tool that did not pertain to accessibility or safety issues were the main focus. The representatives from all associated organizations gave several helpful suggestions to make the assessment tool more thorough and Worcester specific. In addition to discussing the assessment tool itself, the focus group gave important bus stop locations to be looked at and added to the list of stops we would be assessing. After meeting with the second focus groups the assessment tool was revised one more time and then put into a form that could be used as an actual assessment tool.

4.2 Changes in Technology

In a meeting between representatives from the CMRPC, WRTA, and the DPW, it was agreed upon that a Tablet PC, that the City already had from a previous project, with GPS/GIS capabilities would be an optimal choice for our project. To be cost effective, it was agreed upon that in addition to the Tablet PC, a Personal Digital Assistant (PDA) (See figure 3) with GPS/GIS capabilities (See Figure 4) would also be purchased (See Appendix B for product matrix).

Figure 3 - PDA with GIS Software

Figure 4 - GPS

4.2.1 Resulting Problems

Because the technology's arrival was later than expected, it took much longer than originally anticipated to assess each individual stop. When we printed out the form in its paper form and inventoried the pilot stops, it ended up taking approximately four

minutes for each stop. As such we were not able to test out the inventory with the correct equipment. There were significant inefficiencies and some of the bus stops took up to 15 minutes to inventory. This, in addition to the time it took to keep the information we had already collected consistent with the new assessment tools was a very significant setback. Once the technology arrived and we were trained in operating it, the inventory process was significantly quicker, (under four minutes), and we were able to execute our inventory procedure.

4.3 Inventory Procedure

The inventory portion of the project consisted of two simple aspects in the overall design: The actual GPS coordinates and the pictures of the signs and bus stops. Upon arrival at each stop, the GPS coordinates went directly into the PDA and then were transferred to the database. We were then able to use the PDA to access and execute our assessment tool. We returned to the stops at night to complete the lighting component. For the components that needed images, (the signs, sidewalk, curb cuts, bench, and shelter) we took pictures which we gave to the CMRPC to be included with the database. At the end of the day we returned the vehicle to the WRTA offices and the equipment to the CMRPC. Once at the CMRPC we input the data from the PDA into the database.

4.4 Applying the Rubric

The rubric was formed through combining information found in the Easter Seals Checklist (Part B Row 11 of Easter Seals Project ACTION) with the Spencer IQP (Ferguson, B., Shea, J. (2005). After the pilot test, we were able to take real pictures from

Worcester and set different standards based on those pictures. That combined with the descriptions from the Easter Seals and the Spencer IQP gave us our final product which can be seen in full in Appendix D. These ratings varied from 1-5, each number had a corresponding picture and a concise description next to it.

- Rating 1 was designated as a "hazardous" element. This meant that the part of the stop we were assessing was dangerous to the public and needed to be looked at and corrected immediately.
- Rating 2 was the next level and was identified as being in "poor" condition. If it was rated "poor" the element was still in need of repair, although not a high threat to the public.
- Rating 3 was designated as "fair" condition. This rating was for those elements that were not a danger but not desirable to use. An element that would receive a "fair" rating would be a bench that was old and heavily worn, but only had a few cracks in it.
- Rating 4 was considered to be "good." A "good" rating is given to an element that has no defects. A "good" shelter or a bench would be desirable to sit on but be old and slightly worn.
- Rating 5 was considered to be "excellent." An "excellent" element is a new and unworn sidewalk, bench or shelter, vegetation that will never impede on the stop and curb cuts that meet ADA standards with zero cracks or damage.

An example of how our rubric works would be if a curb cut was identified as having no cracks and with tactile strips it would be given an "excellent" rating (5). On the other hand, if a curb cut had many cracks and was built too high for a wheelchair to

access it, it would be given a “hazardous” rating (1). With this rubric in place it was easy to identify and evaluate each element of the stop.

4.5 CMRPC Database

Now that the data collection was complete, it was input into the database created by the CMRPC. This database consisted of a matrix that contained all the information we collected. (See disc 1) We were able to clearly identify all the elements of the assessment tool and sort the information that we thought was important. All the information was looked at and placed under the three key factors: inventory, safety, and accessibility.

4.6 Descriptive Statistics

The next parts of this section will present the results of our inventory which are grouped by street name. These statistics, as previously mentioned, will fall under the three areas: inventory, safety and accessibility.

4.6.1 Inventory Analysis

The first set of statistics deals with the inventory elements of the assessment tool. Major areas that we felt were important to look at included: whether or not the stop had a sign indicating it was a bus stop, if that sign had a no parking sign, and whether or not there were route numbers on the sign. In looking at the shelters and benches, we assessed whether there actually was a shelter or bench. Additionally, if there was a stop or bench, its condition was also assessed and recorded. Listed below is the data collected from the signs, the shelters and the benches:

Table 1 - Overall Signs

Overall Signs (71 stops)			
Category	**Yes**	**No**	**Total N**
Has bus stop sign	68 (96%)	3 (4%)	71
No Parking sign	65 (92%)	6 (8%)	71
Route numbers	52 (76%)	16 (23%)	68

Table 2 - Overall Shelters and Benches

Overall Shelters and Benches (71 stops)			
Category	**Yes**	**No**	**Total N**
Have shelter	9 (13%)	62 (87%)	71
Have bench	11 (15%)	60 (85%)	11

You can see from the data that an impressive 96% of the stops had some kind of sign saying there was a bus stop in the area. On the other hand, 27% of those signs did not have route numbers on them. Relating to shelters and benches, 67% of the shelters were in “good” or better condition and 73% of the benches were as well.

4.6.2 Safety Analysis

The second set of statistics deals with the safety assessment. Areas that were included in this analysis included: whether there was a crosswalk within 100 feet of the stop, if there was vegetation encroaching on any part of the bus stop, and whether or not there was a sidewalk and its condition. Listed below is the overall data collected for the safety of the stop:

Table 3 - Overall Crosswalks

Overall Crosswalks (71 stops)			
Category	**Yes**	**No**	**Total N**
Has crosswalk within 100 feet	45 (63%)	26 (37%)	71

Table 4 - Overall Vegetation

Overall Vegetation (71 stops)			
Category	**Yes**	**No**	**Total N**
Sign	13 (18%)	58 (81%)	71
Sidewalk	3 (4%)	68 (96%)	71
Bus	10 (14%)	61 (86%)	71
Pedestrian	9 (12%)	62 (88%)	71
Blind	11 (15%)	60 (85%)	71

Table 5 - Overall Sidewalks

Overall Sidewalks (71 stops)			
Category	**Yes**	**No**	**Total N**
Has sidewalk	65 (92%)	6 (8%)	71

A very interesting result from this data set is that only 92% of the stops have adjacent sidewalks. This is remarkable because the absence of a sidewalk at a stop greatly decreases pedestrian safety from traffic. There is more of a risk for the pedestrian to be injured because there is no safe place to wait for the bus.

4.6.3 Accessibility Analysis

The third set of statistics deals with the accessibility assessment. The elements we included in this part were: whether or not there was a walking signal within 100 feet of the stop, whether or not there was a chirper on that walking signal, and whether or not there was a curb cut. Listed below is the overall data collected for the accessibility of the stop:

Table 6 - Overall Walking Signals

Overall Walking Signals (71 stops)			
Category	**Yes**	**No**	**Total N**
Has walking signals	18 (25%)	53 (75%)	71
Has chirpers	9 (50%)	9 (50%)	18

Table 7 - Overall Curb Cuts

Overall Curb Cuts (71 stops)			
Category	**Yes**	**No**	**Total N**
Has curb cut within 100 feet	39 (55%)	32 (45%)	71

The data indicates that only 25% of the stops had walking signals in the surrounding area, and only 50% of those signals had chirpers. The absence of a walking signal is very unsafe for anyone with disabilities. A chirper is essential to those who are seeing impaired and cannot see when the signal changes.

In looking at the curb cuts it was very disconcerting to see that only 55% of the stops had one nearby. It is nearly impossible for a person with a wheelchair to access a sidewalk without a curb cut of some degree. This is one of the many reasons the City needed to install PBSI into the Worcester transportation system. In a few of the curb cuts we also noticed the height was too high for a wheelchair to even access. This is where the rubric was most useful. The ratings of “hazardous” and “poor” now meant the curb cut either did not exist or was too high. As such, these designations now indicated that the sidewalk did not meet ADA standards.

4.6.4 Other findings

After the preliminary data analysis, we categorized the data into the different streets. (To see the complete statistics See Appendix G) Ironically, some of the unexpected data came from streets with the most ridden bus routes. On Main Street, specifically routes 19, 27, and 33 (all with very high ridership), and 100% of designated bus stops had signs, but 17% had no route numbers. There were significant issues with sidewalk and curb cut conditions, and 14% of the stops had encroaching vegetation. Highland Street, primarily route 21, had major issues with vegetation with 42% of the stops having encroaching vegetation. Also, there is a significant lack of curb cuts and crosswalks. Pleasant Street, the outbound branch of route 21, did show 100% of the stops having crosswalks but only 20% had walking signals.

During the pilot test runs we discovered that there were different types of shelters and benches. In City Hall Plaza there are two different kinds of shelters. The nicest shelter overall, was the one that we identified as having the medieval roof. It was a large shelter, with Plexiglas walls and a metal roof with a very detailed edge. Another shelter in the plaza had a bubble roof made of Plexiglas with the same walls as the first shelter. One more near Clark University had walls made of Plexiglas with steel holy mesh like wall inside the Plexiglas.

We have not found any other kind of shelter within our data collection. The names that we used for the shelter types in the assessment tool and database are: metal roof w/ detail; bubble roof clear walls; steel mesh. We also left a space for “other” in the event that another type of shelter is located in the future.

The benches were much the same situation as the shelters. Three different types of benches were identified. There is the park bench type which we named “Park bench

(BAAG)" because it has a "back arch and groove" which means groove in the seat. This is the best type of bench because it is the most comfortable. The other two types were both flat benches. A flat bench that had no arm rests was considered "flat bench" and the flat bench which had the bars separating the seats out was what we called the "single seat".

We used the above names in the drop down menus on the PDA in the form which we had for each stop (See Appendix H). This made the act of taking the inventory take less time as we did not have to individually input the type of bench or shelter that the stop had.

Chapter 5 Implications

This chapter will present final conclusions and recommendations developed from this project. It will give recommendations on each of the three main components of this project and ideas for the future.

5.1 Inventory Recommendations

Prior to starting the project, our sponsors were very clear in communicating to us that many approved stops were missing signs. After collecting all the data it was shown that 4% of the stops inventoried were in fact unlabeled. As such, our first recommendation to the City of Worcester is to locate those stops without signs and replace them. This is inarguably one of the first things the City should concentrate on. After labeling all the stops the next step would be to put route numbers on the signs. This will make for a much more efficient transportation system if the riders know what routes go to which stop. The final recommendation for the inventory portion would be to add multiple “No Parking” signs to each stop. One sign does not seem to suffice in creating a wide enough lane for a bus to pull over. In numerous streets in Worcester there is no designated place for the bus to pull off if cars are parked in the way.

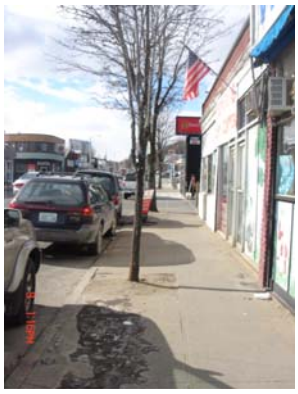

Figure 5 - Parking on street

Figure 5 is a prime example of what happens when there is only one or no signs indicating “No Parking.” This picture was taken directly under a bus stop sign and there was no room for a bus to pull over. Therefore when picking up passengers, the bus would block traffic and create an unsafe environment.

With a new inventory, it should be much easier for the DPW to correct all issues pertaining to signage.

5.2 Safety Recommendations

In looking at all the elements of safety, one important recommendation would be to take improvement of sidewalk conditions at the stops into serious consideration. First, looking at stops that do not have an adjacent sidewalk and make sure there is a safe waiting area for riders and then sidewalks with a “hazardous” (1) or “poor” (2) designation. Next on the list is the maintenance of the vegetation around each stop. Looking at the stops that need substantial renovation would help greatly in improving the safety. As for those stops that are located on privately owned property, a letter can be drafted informing them of the safety and visibility hazard their vegetation is creating. Crosswalks also play a major role in creating a safer stop, letting a car know there is a potential for pedestrians to be crossing would be a vast improvement. As such, more crosswalks should be created so that each stop has convenient and above all else safe access within short walking distance.

5.3 Accessibility Recommendations

The last set of recommendations deal with improving stop accessibility. Each stop near an intersection should have a walking signal equipped with a chirper. Aiding the seeing impaired in accessing the bus stops would increase riders for the buses and decrease PBSI usage. The final aspect of bus stop accessibility is the curb cut. Many of these stops did have curb cuts, but a lot of them were found to be too steep and in too poor condition to access. These curb cuts need to be assessed with high priority for ADA compliance in the goal of making each stop wheelchair and ultimately handicap accessible.

5.4 Future Thoughts

It is imperative to continue collecting this data and complete the inventory for all the bus stops in Worcester. If this data is not continued and kept current, it will continually cause communication problems between the three organizations. With further data and analysis, this project will serve to provide significant amounts or information giving Worcester a broader scope towards a safer and more efficient transportation system.

5.5 Final Conclusions

Overall, the current state of the Worcester public transportation system, in terms of safety and accessibility, is above average but still in need of renovation. Though it does leave a lot of room for improvement, the data that was collected showed promise. Provided the database is shared by all involved organizations, this will become a valuable asset to the bus services in the City of Worcester. Once the database is finished it is sure

to make it easier for the City to maintain bus stops in the ultimate goal to provide a safer means of public transportation for all of its citizens. This will then result in increasing ridership.

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Appendix A: CMRPC Meeting Minutes

November 6, 2006

After completing another project it was found that there was a lack of consistency between CMRPC's list and the DPW
Major issues if the lists are not consistent
DPW maintains the "official" list
Petition city council to adjust any bus stop items (i.e. signs, benches, etc.)

Inventory using GPS
Road Safety Audit – Proactive

Safety Checklist – Scoring system
-No safety checklist in the US that they know of, maybe in Europe or overseas elsewhere

Rich – Official lists, how city interacts
Suzanne – Safety
Jonathon – Safety checklist, Google maps (inner City of Worcester)

Starting over with GPS units
Prioritize routes with GPS units (Main roadways with more than one route)

Safety:
Well lit?
Neighborhood
Sidewalk condition
Crosswalk nearby?
How far from the road?
Driveway or business access
Handicap accessible?

Only spend 10-15 minutes at each stop
-Traffic level - we won't need to find

Priority:
GPS Location
Photo's of Sign
Safety Checklist – What can be collected in 10-15 minutes?

317 Main Street – Pick up Bus Pass
-Bring Rich Glavin's business card with us

To Do:

Research Safety and GPS Units

What GPS unit is best?
Main Technical Source
Trimble.com
-cost
-benefits

1st – GPS Unit – Add attribute info
2nd – Palm – first GPS second

HP ipack -> How to make into a GPS unit

CTPS in Boston (talk to if needed)
-Clinton Bench, Manager, Transit Planning CTPS, Bus Stop Questions
-Mark Demaris- GPS Unit Questions
-Telephone Number - 617-973-7100

Passenger Complaints very low
2.5 million trips a year
~20 complaints a month

City cooperation poor sometimes

Next meeting: 9am November 13, 2006 same location

November 13, 2006

Routes (Sponsor gave us a route map and pointed out the following routes)
The 4 biggest routes for the bus system are 19, 23, 26 and, 27
The second largest routes are 8 and 24
The last important routes are 1, 2, 6, 7, 21, 30 and 31

Buses run on different time schedules most are 6-8:30

- Each bus has a different waiting time
- Some wait for 30 min while others could be 45 min to an hour

When we get our ID cards we can pick up schedules for the routes above

Our sponsor will get us a ridership count

One major part of our inventory is: What type of sign is at the stop?

- There are 3 types of signs out in the field

Safety is a proactive thing for WRTA?/CMRPC

- Tie in safety as best we can with the inventory
- Inventory is the most important part of our project for the CMRPC

Remember to send a draft of our paper to our sponsor

GPS Units:
Matt Fairnsworth(?) went to Woburn to look at GPS units pointed out by our group

Create a GPS matrix to compare cost, features and pros and cons of each unit
They are hoping to get 2 units for use

Our sponsor is going to create a CD-Rom with the driver count for the new routes (Accurate as of 10/27/06)

What our sponsor is looking for in a checklist:

- Sidewalk (Yes or No?)
  - Width, condition
- On street parking
  - If so where and is there enough room for the buses to move in and out?
- Distance to nearest crosswalk
- Pedestrian visibility
  - Are there objects in the way that do not allow the bus driver to see them?
  - Are there objects that block other driver's view of bus passengers leaving the bus?
  - Can pedestrians see traffic as they are entering/exiting the bus?
- Lighting
- Nearest telephone
- Shelter (Yes or No)
- Bench (Yes or No)
- Barrier to note location of stop? (Yes or No)

Sponsor told us about a website that they are going to send us that talks about what a user thinks makes a good bus stop

Are the colors on the bus stop signs visible by those who are color blind?

Sponsor informed us that we may find stops that are not on our list and we also my not be able to find stops that are on our list due to inconsistent record taking between the DPW, WRTA and CMRPC

Sponsor is going to provide us with:
A list of stops used by the WRTA
A CD-Rom with images and data of current ridership counts

We have to:

Get our passes
Come up with stop priority that we are going to use (If possible)
Draft safety checklist

Next meeting: 9am November 27, 2006 same location

November 27, 2006

Wendy Steinhilber – Transportation Planner, Elderly and Disabled Transportation,
Present at this meeting and we spoke to her about PBSI and what they would like
Trip by trip eligibility – using our database, digital photo of stop to be pulled up

"Inventory is the bare minimum. We cannot do the other things with out the inventory" – Suzanne LePage

Want to be able to identify the stops that are ADA eligible so people can access them on an individual basis – If there trip is not able to be accommodated by the PBSI

Meet 317 Main Street for a meeting with the PBSI

To Do:
Begin Checklist if possible
Send out paper

Next Meeting: 9am Monday, December 4, 2006

December 4, 2006

CMRPC is going to order a GPS unit soon; they will send us an email with the information in it about the brand, and all of that

Focus group- idea: DPW maintains signs
DPW needs to have access to inventory
WRTA also needs access
Someone from both organizations would be good to include in focus group

Going to give us contacts so we can set up the focus groups before we leave for break

Timeline: Weeks 1-3 - Setting up everything
Week 4 - Pilot test
Week 5-6 - Inventory
Week 7 - Finalize everything

GPS: Include things so we can enter everything into it

To Do:
Send out draft of paper

No meeting next week

Send out info about final presentation

Meeting 9am 317 Main Street – PBSI

Things the PBSI is looking for at a stop:
Sounds for vision impaired (crosswalk)
Curb Cuts
Sidewalk condition
Overhanging branches
Anything that could be a barrier
Shelter
Somewhere to sit
Identification (sign)

Elders, older disabled – typically go to doctor's appointments
Young disabled – Work, Shopping, Movies, etc.
Young people – schools

3rd Wednesday of the month at 1pm there is a meeting with Transportation Planning Advisory Group (TPAG)
-We are invited to attend this meeting on January 17th

Speakers inside and outside of the bus
Signs on the bus to show the route

WRTA is in charge of updating that database

Appendix B: GPS Cost Analysis Matrix

Brand	Model	Est. Cost (MSRP)	Operating System	Size (Vol in^3)	GPS Accuracy	Durable
Trimble	Recon/GeoExplorer	$600-$2400	Microsoft Windows Mobile	39.81	2-5m	Yes
TomTom	Smartphone	$300-$500	TomTom Navigator 6	22.5	n/a	Yes
Garmin	iQue 3000	$400	Palm OS 5.2.1 Garnet	9.21	<15m	No
Pharos	Traveller 525	$550	Microsoft Windows Mobile 5.0	45.15	n/a	Yes

Appendix C: Checklist Version 1

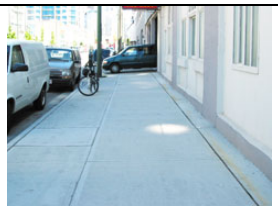
Sample Checklist

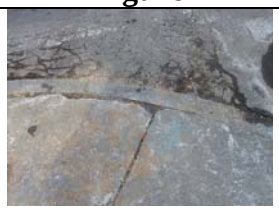
1. Shelter/ Bench
    a. Location / orientation
    b. Description of area
    c. Type
    d. Dimensions (could a person using a wheelchair maneuver in and out easily
    e. Condition
    f. Rank
2. Sidewalk (Y or N)
    a. Width
    b. Condition
    c. Rank (1-5) and justify
3. Traffic Issues
    a. Bus stop location
    b. Is bus stop designated as no parking
    c. Posted speed (MPH)
    d. Traffic controls
    e. On street parking
    f. Total lanes
    g. Traffic Hazards
        i. Stop is over crest of hill
        ii. Stop is just after curve
        iii. Near railroad crossing
        iv. Passengers are hidden from view of drivers
4. Environment around stop
    a. Trees/Bushes encroaching on the landing area
    b. On sidewalk
    c. Does it hit the bus
    d. In the way of pedestrians
5. Signage
    a. Bus stop sign
    b. Routes
6. Crosswalk (Y or N)
    a. Distance
7. Pedestrian Visibility
8. Lighting
    a. Type
    b. Distribution of light
9. Phone
    a. Distance from stop
    b. Wheelchair accessible
    c. Police call box

10. Adjacent Area Description
    a. What properties surround stop
11. Pedestrian Amenities
    a. Curb Cuts
    b. Crossing Signals
    c. Traffic Lights
    d. Visible Crosswalks
    e. Crossing Guards
    f. Tactile strips on curb cuts
12. Connections to other Means of Transportation
13. Trash Receptacles
14. Trip Generators

Overall Rating

Appendix D: Rubric

Sidewalk Condition	Figure
1) **Hazardous** - Large cracks, breaks, roots or vegetation coming through the sidewalk.	 **Figure 6 - Hazardous Sidewalk**
2) **Poor** – Very rough there are cracks and breaks as well as some roots and vegetation coming through.	 **Figure 7 - Poor Sidewalk**
3) **Fair** – There are some small cracks or roots that maybe coming though the sidewalk but they do not affect normal use because they are very small.	 **Figure 8 - Fair Sidewalk**
4) **Good** – Small if not any cracks, not perfect but no immediate repair.	 **Figure 9 - Good Sidewalk**
5) **Excellent** – No cracks, very smooth surface	 **Figure 10 - Excellent Sidewalk**

Curb Cut Condition	Figure
1) **Hazardous** – Large cracks, too steep for wheelchair to access, does not meet ADA standards	 **Figure 11 - Hazardous Curb Cut**
2) **Poor** - Slope of the cut is slightly too steep, small cracks or breaks. Does not meet ADA standards	 **Figure 12 - Poor Curb Cut**
3) **Fair** – Small cracks, no immediate repair. Meets ADA standards	 **Figure 13 - Fair Curb Cut**
4) **Good** - No breaks or cracks, meets ADA standards	 **Figure 14 - Good Curb Cut**
5) **Excellent** – Tactile Strips on curb cuts, no breaks or cracks. Meets ADA standards.	 **Figure 15 - Excellent Curb Cut**

Shelter Condition	Figure
1) **Hazardous** – Broken glass or material, many cracks in structure, vandalized	
2) **Poor** – Cracks in structure, broken material	
3) **Fair** – Slight cracks, overall structure is good	 **Figure 16 - Fair Shelter**
4) **Good** – Not new but in almost new condition, no cracks or broken parts	 **Figure 17 - Good Shelter**
5) **Excellent** – New, perfect condition	 **Figure 18 - Excellent Shelter**

Bench Condition	Figure
1) **Hazardous** – Many breaks and cracks in material, vandalized	
2) **Poor** – Cracks in structure, broken material	 **Figure 19 - Poor Bench**
3) **Fair** – Slight cracks, overall structure is good	 **Figure 20 - Fair Bench**
4) **Good** – No cracks, good structure	 **Figure 21 - Good Bench**
5) **Excellent** – Clean, upkeep is good, no cracks	 **Figure 22 - Excellent Bench**

Degree of Vegetation	Figure
1) **Hazardous** - Completely over grown, can not see the sign for the stop, covering the sidewalk, low hanging branches, branches in danger of hitting pedestrian or bus.	 **Figure 22 - Hazardous Vegetation**
2) **Poor** - Slightly over grown, growth is starting to cover the pedestrian waiting area, some low hanging branches on trees, potential of obstruction to stop if not trimmed.	 **Figure 23 - Poor Vegetation**
3) **Fair** – Light vegetation, is not covering or blocking anything, but without maintenance in the future could be hazardous.	 **Figure 24 - Fair Vegetation**
4) **Good** - The vegetation is not covering or over hanging at all on the sidewalk, sign is clearly visible. It will not affect pedestrians, the bus stop sign or the bus.	 **Figure 25 - Good Vegetation**

Degree of Vegetation	Figure
5) **Excellent** - There is no risk that if/when the vegetation is not maintained that it will cause a potential problem for the stop.	 **Figure 26 - Excellent Vegetation**

Appendix E: Checklist Version 2

Stop Identification			
Route Number:	**Street Name:**	**Weather:**	**Photo ID # :**
Is Stop Approved:			
Is Still Serviced:			
Sign Identification			
Type:			
Route Numbers?:			
No Parking Sign?:			
Shelter:			
Location:			
Type:			
Condition:			
Overall Rating:			
Bench:			
Location:			
Type:			
Condition:			
Overall Rating:			
Sidewalk			
Width:			
Condition:			
Overall Rating:			

Crosswalk:
Distance:
Crossing Signal:
Chirper?:
Pedestrian Amenities
Curb Cuts:
Meet ADA Standards?:
Condition:
Tactile Strips on curb cuts:
Overall Rating:
Traffic Issues
Bus Stop Location:
Posted Speed:
Traffic Light:
Total Lanes of Traffic?:
Is stop over crest of hill?:
Is stop just after curve?:
Near railroad crossing?:
Overall Rating:
Vegetation
Public/Private Property?:
Impact on sidewalk:
Impact on sign:
Impact on pedestrian:

Impact on bus:
Overall Rating:
Phone
Type:
Distance:
Wheelchair Accessible:
Does it work?:
Adjacent Area Description
Doctor's Office:
Grocery Store:
Bank
Pharmacy:
Church:
Lighting
Type:
Overall Rating:

Appendix F: Project Timeline

Tasks	*Week Of...*							
	7-Jan	*14-Jan*	*21-Jan*	*28-Jan*	*4-Feb*	*11-Feb*	*18-Feb*	*25-Feb*
Meeting with PQP advisors								
Compile checklist criteria								
TPAG Focus Group								
Organizations Focus Group								
Compile new checklist								
Send checklist back to Focus Group								
Assess Ridership Data and Major Routes								
Locate Hot Spots								
Determine Pilot Test Locations								
Identify which Stops to Inventory								
Determine How Many Stops are Feasible								
Make Map of Stops we are Inventorying								
Perform Pilot test								
Show Organizations our Results								
Make Corrections to Pilot Test								
Perform Real Inventory								
Import into Database								
Analyze Data								
Final proposal / recommendation								

Appendix G: Complete Statistical Information

All Stops (71 Stops):

Overall Sidewalks (71 stops)			
Category	**Yes**	**No**	**Total Yes**
Has sidewalk	92%	8%	65

Overall Sidewalk Rating (71 stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total**
Sidewalk	0 (0%)	2 (3%)	20 (32%)	32 (51%)	9 (14%)	63

Overall Curb Cuts (71 stops)			
Category	**Yes**	**No**	**Total Yes**
Has curb cut	55%	45%	39

Overall Curb Cut Rating (71 stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total**
Curb Cut	0 (0%)	4 (10%)	11 (28%)	18 (46%)	6 (15%)	39

Overall Crosswalks (71 stops)			
Category	**Yes**	**No**	**Total N**
Has crosswalk within 100 feet	45 (63%)	26 (37%)	71

Overall Walking Signals (71 stops)			
Category	**Yes**	**No**	**Total N**
Has walking signals	18 (25%)	53 (75%)	71
Has chirpers (out of 18)	9 (50%)	9 (50%)	18

Overall Vegetation (71 stops)			
Category	**Yes**	**No**	**Total N**
Sign	13 (18%)	58 (81%)	71
Sidewalk	3 (4%)	68 (96%)	71
Bus	10 (14%)	61 (86%)	71
Pedestrian	9 (12%)	62 (88%)	71
Blind	11 (15%)	60 (85%)	71

Overall Signs (71 stops)			
Category	**Yes**	**No**	**Total N**
Has bus stop sign	68 (96%)	3 (4%)	71
No Parking sign	65 (92%)	6 (8%)	71
Route numbers	50 (73%)	18 (27%)	68

Overall Shelters and Benches (71 stops)			
Category	**Yes**	**No**	**Total N**
Have shelter	9 (13%)	62 (87%)	71
Have bench	11 (15%)	60 (85%)	71

Overall Shelter and Bench Rating (71 stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total**
Shelter	0 (0%)	0 (0%)	3 (33%)	2 (22%)	4 (44%)	9
Bench	0 (0%)	0 (0%)	3 (27%)	5 (45%)	3 (27%)	11

Main Street (35 Stops):

Main Street Sidewalks (35 Stops)			
Category	**Yes**	**No**	**Total N**
Has sidewalk	34 (97%)	1 (3%)	35

Main Street Sidewalk Rating (35 Stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total**
Sidewalk	0 (0%)	1 (3%)	13 (38%)	17 (50%)	3 (9%)	34

Main Street Curb Cut (35 Stops)			
Category	**Yes**	**No**	**Total N**
Has curb cut within 100 feet	27 (77%)	8 (23%)	35

Main Street Curb Cut Rating (35 Stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total**
Curb Cut	0 (0%)	2 (7%)	12 (44%)	10 (37%)	3 (11%)	27

Main Street Crosswalks (35 Stops)			
Category	**Yes**	**No**	**Total N**
Has crosswalk within 100 feet	11 (15%)	24 (85%)	35

Main Street Walking Signals (35 Stops)			
Category	**Yes**	**No**	**Total N**
Has walking signals	8 (23%)	27 (77%)	35
Has chirpers	4 (50%)	4 (50%)	8

Main Street Vegetation (35 Stops)			
Category	**Yes**	**No**	**Total N**
Sign	4 (11%)	31 (86%)	35
Sidewalk	2 (6%)	33 (94%)	35
Bus	2 (6%)	33 (94%)	35
Pedestrian	3 (9%)	32 (91%)	35
Blind	5 (14%)	30 (86%)	35

Main Street Signs (35 Stops)			
Category	**Yes**	**No**	**Total N**
Has bus stop sign	35 (100%)	0 (0%)	35
No Parking sign	33 (94%)	2 (6%)	35
Route numbers	29 (83%)	6 (17%)	35

Main Street Shelters and Benches (35 Stops)			
Category	**Yes**	**No**	**Total N**
Have shelter	6 (17%)	29 (83%)	35
Have bench	6 (17%)	29 (83%)	35

Main Street Shelter and Bench Rating (35 Stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total**
Shelter	0 (0%)	0 (0%)	2 (33%)	2 (33%)	2 33%)	6
Bench	0 (0%)	0 (0%)	1 (17%)	3 (50%)	2 (33%)	6

Highland Street (12 Stops):

Highland Street Sidewalks (9 Stops)			
Category	**Yes**	**No**	**Total N**
Has sidewalk	9 (100%)	0 (0%)	9

Highland Street Sidewalk Rating (9 Stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total N**
Sidewalk	0 (%)	1 (11%)	6 (67%)	2 (22%)	0 (0%)	9

Highland Street Curb Cuts (9 Stops)			
Category	**Yes**	**No**	**Total N**
Has curb cut within 100 feet	3 (33%)	6 (67%)	9

Highland Street Curb Cut Rating (9 Stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total N**
Curb Cut	0 (0%)	0 (0%)	0 (0%)	2 (67%)	1 (33%)	3

Highland Street Crosswalks (9 Stops)			
Category	**Yes**	**No**	**Total N**
Has crosswalk within 100 feet	4 (44%)	5 (56%)	9

Highland Street Walking Signals (9 Stops)			
Category	**Yes**	**No**	**Total N**
Has walking signals	3 (33%)	6 (67%)	9
Has chirpers	1 (33%)	2 (67%)	3

Highland Street Vegetation (9 Stops)			
Category	**Yes**	**No**	**Total N**
Sign	5 (56%)	4 (44%)	9
Sidewalk	0 (0%)	9 (100%)	9
Bus	4 (44%)	5 (56%)	9
Pedestrian	3 (33%)	6 (67%)	9
Blind	3 (33%)	6 (67%)	9

Highland Street Signs (9 Stops)			
Category	**Yes**	**No**	**Total N**
Has bus stop sign	7 (77%)	2 (23%)	9
No Parking sign	8 (88%)	1 (11%)	9
Route numbers	7 (100%)	0 (0%)	7

Highland Street Shelters and Benches (9 Stops)			
Category	**Yes**	**No**	**Total N**
Have shelter	0 (0%)	0 (0%)	0
Have bench	0 (0%)	0 (0%)	0

Highland Street Shelter and Bench Rating (9 Stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total N**
Shelter	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0
Bench	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0

Pleasant Street (10 Stops):

Pleasant Street Sidewalks (7 Stops)			
Category	**Yes**	**No**	**Total N**
Has sidewalk	7 (100%)	0 (0%)	7

Pleasant Street Sidewalk Rating (7 Stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total N**
Sidewalk			1 (14%)	3 (43%)	3 (43%)	7

Pleasant Street Curb Cuts (7 Stops)			
Category	**Yes**	**No**	**Total N**
Has curb cut within 100 feet	5 (72%)	2 (28%)	7

Pleasant Street Curb Cut Rating (5 Stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total N**
Curb Cut				4 (80%)	1 (20%)	5

Pleasant Street Crosswalks (7 Stops)			
Category	**Yes**	**No**	**Total N**
Has crosswalk within 100 feet	7 (100%)	0 (0%)	7

Pleasant Street Walking Signals (7 Stops)			
Category	**Yes**	**No**	**Total N**
Has walking signals	0 (0%)	7 (100%)	7
Has chirpers	0 (0%)	0 (0%)	0

Pleasant Street Vegetation (7 Stops)			
Category	**Yes**	**No**	**Total N**
Sign	2 (28%)	5 (72%)	7
Sidewalk	1 (14%)	6 (86%)	7
Bus	2 (28%)	5 (72%)	7
Pedestrian	2 (28%)	5 (72%)	7
Blind	1 (14%)	6 (86%)	7

Pleasant Street Signs (7 Stops)			
Category	**Yes**	**No**	**Total N**
Has bus stop sign	6 (86%)	1 (14%)	7
No Parking sign	5 (83%)	1 (17%)	6
Route numbers	5 (83%)	1 (17%)	6

Pleasant Street Shelters and Benches (7 Stops)			
Category	**Yes**	**No**	**Total N**
Have shelter	0 (0%)	0 (0%)	0
Have bench	0 (0%)	0 (0%)	0

Pleasant Street Shelter and Bench Rating (7 Stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total N**
Shelter	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0
Bench	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0

Richmond Street (5 Stops):

Richmond Street Sidewalks (5 Stops)			
Category	**Yes**	**No**	**Total N**
Has sidewalk	5 (100%)	0 (0%)	5

Richmond Street Sidewalk Rating (5 Stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total N**
Sidewalk	0 (0%)	0 (0%)	1 (20%)	4 (80%)	0 (0%)	5

Richmond Street Curb Cuts (5 Stops)			
Category	**Yes**	**No**	**Total N**
Has curb cut within 100 feet	0 (0%)	5 (100%)	5

Richmond Street Curb Cut Rating (5 Stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total N**
Curb Cut	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0

Richmond Street Crosswalks (5 Stops)			
Category	**Yes**	**No**	**Total N**
Has crosswalk within 100 feet	1 (20%)	4 (80%)	5

Richmond Street Walking Signals (5 Stops)			
Category	**Yes**	**No**	**Total N**
Has walking signals	0 (0%)	5 (100%)	5
Has chirpers	0 (0%)	0 (0%)	0

Richmond Street Vegetation (5 Stops)			
Category	**Yes**	**No**	**Total N**
Sign	1 (20%)	4 (80%)	5
Sidewalk	0 (0%)	5 (100%)	5
Bus	1 (20%)	4 (80%)	5
Pedestrian	0 (0%)	5 (100%)	5
Blind	0 (0%)	5 (100%)	5

Richmond Street Stops (5 Stops)			
Category	**Yes**	**No**	**Total N**
Has bus stop sign	5 (100%)	0 (0%)	5
No Parking sign	4 (80%)	1 (20%)	5
Route numbers	0 (0%)	5 (100%)	5

Richmond Street Shelters and Benches (5 Stops)			
Category	**Yes**	**No**	**Total N**
Have shelter	0 (0%)	5 (100%)	5
Have bench	0 (0%)	5 (100%)	5

Richmond Street Shelter and Bench Rating (5 Stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total N**
Shelter	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0
Bench	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0

Salisbury Street (4 Stops):

Salisbury Street Sidewalks (4 Stops)			
Category	**Yes**	**No**	**Total N**
Has sidewalk	0 (0%)	0 (0%)	0

Salisbury Street Sidewalk Rating (4 Stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total N**
Sidewalk	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0

Salisbury Street Curb Cuts (4 Stops)			
Category	**Yes**	**No**	**Total N**
Has curb cut within 100 feet	0 (0%)	0 (0%)	0

Salisbury Street Curb Cut Rating (4 Stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total N**
Curb Cut	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0

Salisbury Street Walking Signals (4 Stops)			
Category	**Yes**	**No**	**Total N**
Has walking signals	0 (0%)	0 (0%)	0
Has chirpers	0 (0%)	0 (0%)	0

Salisbury Street Vegetation (4 Stops)			
Category	**Yes**	**No**	**Total N**
Sign	1 (25%)	3 (75%)	4
Sidewalk	0 (0%)	4 (100%)	4
Bus	1 (25%)	3 (75%)	4
Pedestrian	1 (25%)	3 (75%)	4
Blind	1 (25%)	3 (75%)	4

Salisbury Street Signs (4 Stops)			
Category	**Yes**	**No**	**Total N**
Has bus stop sign	4 (100%)	0 (0%)	4
No Parking sign	4 (100%)	0 (0%)	4
Route numbers	3 (75%)	1 (25%)	4

Salisbury Street Shelters and Benches (4 Stops)			
Category	**Yes**	**No**	**Total N**
Have shelter	0 (0%)	0 (0%)	0
Have bench	1 (25%)	3 (75%)	4

Salisbury Street Shelter and Bench Rating (4 Stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total N**
Shelter	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0
Bench	0 (0%)	0 (0%)	0 (0%)	1 (100%)	0 (0%)	1

Flagg Street (2 Stops):

Flagg Street Sidewalks (2 Stops)			
Category	**Yes**	**No**	**Total N**
Has sidewalk	1 (50%)	1 (50%)	2

Flagg Street Sidewalk Rating (2 Stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total N**
Sidewalk	0 (0%)	0 (0%)	0 (0%)	1 (100%)	0 (0%)	0

Flagg Street Curb Cuts (2 Stops)			
Category	**Yes**	**No**	**Total N**
Has curb cut within 100 feet	0 (0%)	0 (0%)	0

Flagg Street Curb Cut Rating (2 Stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total N**
Curb Cut	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0

Flagg Street Crosswalks (2 Stops)			
Category	**Yes**	**No**	**Total N**
Has crosswalk within 100 feet	0 (0%)	0 (0%)	0

Flagg Street Walking Signals (2 Stops)			
Category	**Yes**	**No**	**Total N**
Has walking signals	0 (0%)	0 (0%)	0
Has chirpers	0 (0%)	0 (0%)	0

Flagg Street Vegetation (2 Stops)			
Category	**Yes**	**No**	**Total N**
Sign	0 (0%)	0 (0%)	0
Sidewalk	0 (0%)	0 (0%)	0
Bus	0 (0%)	0 (0%)	0
Pedestrian	0 (0%)	0 (0%)	0
Blind	0 (0%)	0 (0%)	0

Flagg Street Signs (2 Stops)			
Category	**Yes**	**No**	**Total N**
Has bus stop sign	2 (100%)	0 (0%)	2
No Parking sign	2 (100%)	0 (0%)	2
Route numbers	0 (0%)	2 (100%)	2

Flagg Street Shelters and Benches (2 Stops)			
Category	**Yes**	**No**	**Total N**
Have shelter	0 (0%)	0 (0%)	0
Have bench	0 (0%)	0 (0%)	0

Flagg Street Shelter and Bench Rating (2 Stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total N**
Shelter	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0
Bench	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0

Front Street (2 Stops):

Front Street Sidewalks (2 Stops)			
Category	**Yes**	**No**	**Total N**
Has sidewalk	2 (100%)	0 (0%)	2

Front Street Sidewalk Rating (2 Stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total N**
Sidewalk	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (100%)	2

Front Street Curb Cuts (2 Stops)			
Category	**Yes**	**No**	**Total N**
Has curb cut within 100 feet	1 (50%)	1 (50%)	2

Front Street Curb Cut Rating (2 Stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total N**
Curb Cut	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (100%)	1

Front Street Walking Signals (2 Stops)			
Category	**Yes**	**No**	**Total N**
Has walking signals	2 (100%)	0 (0%)	2
Has chirpers	2 (100%)	0 (0%)	2

Front Street Vegetation (2 Stops)			
Category	**Yes**	**No**	**Total N**
Sign	0 (0%)	0 (0%)	0
Sidewalk	0 (0%)	0 (0%)	0
Bus	0 (0%)	0 (0%)	0
Pedestrian	0 (0%)	0 (0%)	0
Blind	0 (0%)	0 (0%)	0

Front Street Signs (2 Stops)			
Category	**Yes**	**No**	**Total N**
Has bus stop sign	2 (100%)	0 (0%)	2
No Parking sign	2 (100%)	0 (0%)	2
Route numbers	1 (50%)	1 (50%)	2

Front Street Shelters and Benches (2 Stops)			
Category	**Yes**	**No**	**Total N**
Have shelter	2 (100%)	0 (0%)	2
Have bench	2 (100%)	0 (0%)	2

Front Street Shelter and Bench Rating (2 Stops)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total N**
Shelter	0 (0%)	0 (0%)	1 (50%)	0 (0%)	1 (50%)	2
Bench	0 (0%)	0 (0%)	1 (50%)	0 (0%)	1 (50%)	2

Franklin Street (1 Stop):

Franklin Street Sidewalks (1 Stop)			
Category	**Yes**	**No**	**Total N**
Has sidewalk	1 (100%)	0 (0%)	1

Franklin Street Sidewalk Rating (1 Stop)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total N**
Sidewalk	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (100%)	1

Franklin Street Curb Cuts (1 Stop)			
Category	**Yes**	**No**	**Total N**
Has curb cut within 100 feet	0 (0%)	1 (100%)	1

Franklin Street Curb Cut Rating (1 Stop)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total N**
Curb Cut	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0

Franklin Street Crosswalks (1 Stop)			
Category	**Yes**	**No**	**Total N**
Has crosswalk within 100 feet	1 (100%)	0 (0%)	1

Franklin Street Walking Signals (1 Stop)			
Category	**Yes**	**No**	**Total N**
Has walking signals	0 (0%)	5 (100%)	1
Has chirpers	0 (0%)	0 (0%)	0

Frankliln Street Vegetation (1 Stop)			
Category	**Yes**	**No**	**Total N**
Sign	0 (0%)	1 (100%)	1
Sidewalk	0 (0%)	1 (100%)	1
Bus	0 (0%)	1 (100%)	1
Pedestrian	0 (0%)	1 (100%)	1
Blind	0 (0%)	1 (100%)	1

Franklin Street Stops (1 Stop)			
Category	**Yes**	**No**	**Total N**
Has bus stop sign	1 (100%)	0 (0%)	1
No Parking sign	1 (100%)	0 (0%)	1
Route numbers	0 (0%)	1 (100%)	1

Franklin Street Shelters and Benches (1 Stop)			
Category	**Yes**	**No**	**Total N**
Have shelter	1 (100%)	0 (0%)	1
Have bench	1 (100%)	0 (0%)	1

Franklin Street Shelter and Bench Rating (1 Stop)						
Category	**1 (hazardous)**	**2 (poor)**	**3 (fair)**	**4 (good)**	**5 (excellent)**	**Total N**
Shelter	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (100%)	1
Bench	0 (0%)	0 (0%)	1 (100%)	0 (0%)	0 (0%)	1

Appendix H: Database Checklist

Sample Checklist

15. Bench
    a. Location (text)
    b. Type of Bench (Drop down)
    c. Condition (text)
    d. Overall Rank (num 0-5)
16. Shelter
    a. Location (text)
    b. Type of Shelter (Drop Down – contents unknown)
    c. Condition (text)
    d. Overall Rank (nun 0-5)
17. Sidewalk (Y or N)
    a. Width (num 3-10)
    b. Condition (text)
    c. Rank (0-5)
18. Traffic Issues
    a. Bus stop location (text)
    b. Is bus stop designated as no parking (y/n)
    c. Posted speed (MPH) 15-50 5 increment
    d. Traffic light? (y/n)
    e. Walk/do not walk light?(y/n)
    f. Chirper? (y/n)
    g. On street parking (y/n)
    h. Total lanes (num 1-4)
    i. Traffic Hazards
        i. Stop is over crest of hill (y/N)
        ii. Stop is just after curve (y/n)
        iii. Near railroad crossing (y/n)
        iv. Passengers are hidden from view of drivers (Y/N)
    j. Overall (num 0-5)

19. Environment around stop
    a. Whos property? (drop Down [public\private])
    b. Trees/Bushes encroaching on the landing area
    c. On sidewalk (y/n)
    d. Does it hit the bus(y/n)
    e. In the way of pedestrians(y/n)
    f. Potential to harm the blind? (y/n)
    g. Overall (num 0-5)
20. Signage
    a. Route Number (text)
    b. Street name (drop down)

c. Weather (drop down [dry\wet\ice\snow]
d. Photo (4 fields for filenames)
e. Is approved? (Y/N)
f. Is Still Serviced? (Y/N)
g. Bus stop sign type (drop down)
h. No parking sign? (Y/N)
i. Route Numbers? (Y/N)
j. Overall (num 0-5)

21. Stop
    a. Route Number (text)
    b. Street name (drop down)
    c. Weather (drop down [dry\wet\ice\snow]
    d. Photo (4 fields for filenames)
    e. Is approved? (Y/N)
    f. Is Still Serviced? (Y/N)
    g. Is there a sign? (Y/N)
    h. Overall (num 0-5)
22. Crosswalk (Y or N)
    a. Distance (num 0-100)
23. Pedestrian Visibility
24. Lighting
    a. Type (drop down [not lit/moderately lit/heavily lit])
    b. Overall (num 0-5)
25. Phone
    a. Phone (Drop Down [PayPhone/Police Call Box/No Phone])
    b. Distance from stop (num 0-100 ft)
    c. Wheelchair accessible (Y/N)
26. Adjacent Area Description
    a. Doctors Office (Check Box)
    b. Grocery Store (Check Box)
    c. Name of Grocery Store (drop down, price chopper \Shaws \stop & shop \white hen \Big Y \other
    d. Bank(Check Box)
    e. Name of Bank (drop down BofA\ td banknorth \fleet \citizens \sovereign \comm national \bank of boston \flagship \baystate \other)
    f. Pharmacy(Check Box)
    g. Name of Pharmacy (drop down CVS \walgreen \osco \brooks \pharmacare \other)
27. Pedestrian Amenities
    a. Curb Cuts (Y/N)
    b. Meet ADA standards? (Y/N)
    c. Condition of curb cut (drop down [poor/mod/good])
    d. Curb Comments (text)
    e. Crossing Signals (Y/N)
    f. Traffic Lights(Y/N)
    g. Visible Crosswalks(Y/N)

h. Crossing Guards(Y/N)
i. Tactile strips on curb cuts(Y/N)

Overall (num 0-5)

Appendix I: 12/21/06 Meeting Overview

Bus Stop Inventory & Safety Evaluation
Inter-Agency Meeting
December 21, 2006

In Attendance:

Jonathan Church, CMRPC
Suzanne LePage, CMRPC
Jim Parker, RTA Transit Services
James Kempton, City of Worcester DPW Services
Matt Franz, CMRPC
Rich Glavin, WRTA
Nicole Rohan, RTA Transit Services
Shane White, City of Worcester Technical

Discussion Overview:

Global Positioning System (GPS) Purchase

Prior to the meeting, CMRPC and WRTA had prepared to purchase two GPS units for use in this project. Statistics and price comparisons were researched by Matt and distributed to the group. Shane noted that using Tablet PCs (with GIS software installed) for data collection was accurate and efficient in a recent City project and recommended that the group consider using this technology instead of GPS units. After discussion, consensus was reached to do so. Jim (Kempton) offered the use of the City's recently purchased tablet PC for the project. Shane indicated that approval to purchase the software for the tablet PC required, as it was not originally budgeted. Suzanne offered to write to Joe Borbone and make the request to do so.

Agreement/Protocol for Maintaining/Updating Bus Stop Inventory

Rich indicated that Worcester City Ordinances stipulate that the Worcester DPW is the "official keeper" of the bus stop inventory, which, according to Jim (Kempton), is largely updated by hand. Questions regarding which list is most current generated much discussion. Jim (Parker) supplied recent DPW printouts of the existing inventory. This listing indicates stops that are no longer served by bus routes as well as stops that are not currently signed. Jim (Kempton) noted that this seemed to be the most current list. Jim (Parker) has an additional list of stops that are utilized by existing bus routes, but are not shown on the DPW list. While Jim (Parker), Nicole, and Rich believed the stops on the additional list have been approved by the City Council, they offered to check with Jim (Kempton's) files and provide the most current information to the students.

In general, it was agreed that a web-based inventory that can be accessed and updated by CMRPC, DPW, RTA, and WRTA would be the goal for the future. A written agreement stipulating access/permission protocols for editing the inventory should be discussed further in the future. Those present indicated a willingness to enter into such an agreement if needed.

Next Meeting

The WPI student team has requested that a focus group be formed to assist them with the creation of the data dictionary for the bus stop inventory. Those present will likely need to meet again in mid- to late-January for this purpose.