Devising a Method to Employ and Evaluate Traffic Control Methods in An Effort to Discourage Commuter Traffic Along Putnam Avenue.

An Interdisciplinary Qualifying Project
Submitted to the faculty of
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Degree of Bachelor of Science

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1. Introduction

With the development of easily affordable personalized transportation, the 20th century helped establish the socioeconomic force that is the modern city, and people began to inhabit them in record numbers. The city is a complex web of roads that acts as a lifeline for its infrastructure. Currently in the United States, the number of vehicles is increasing twice as fast as the population (EPA Impact of Commuters). While cities continue to improve upon their infrastructure of roads in hopes of accommodating more vehicles, many major city traffic arteries remain congested, and increasing population can make matters even worse. The strained roadways result in economic damage to businesses, increased pollution, and in general a lowered quality of life for residents and commuters alike. In addition, city spending has increased for maintaining, upgrading, and controlling roadways, parking facilities, etc. Due to the continuing problem of overcrowded major roadways, spillover of motorized traffic onto secondary arteries is becoming a significant problem for cities.

With the available space for roads and parking dwindling, cities are running out of ways to cope with their traffic. Cambridge, Massachusetts is employing innovative practices to reduce traffic, including measures to restrict parking and to promote public transportation and bicycling. Despite these measures, Cambridge still experiences a heavy traffic load. Motorists are exploiting the secondary roads in order to bypass congested main roadways, which has an adverse effect on the residential and commercial areas through which these roads run. Putnam Avenue is one such secondary roadway that is experiencing a congestion problem. The congestion from commuter traffic coming from the several main roadways in the area, such as Western Ave. and River St., is not compatible with the current traffic control measures in place.

Putnam Avenue is not equipped to handle its current traffic load. It has residential neighborhoods and a school along its length. The heavy traffic load has put a strain on the resident's quality of life along Putnam Avenue. The traffic presents a danger to the young children that travel to school in the area, residents cannot get out of their neighborhood or local streets easily, there is increased noise, and the heavy and fast traffic flow is a safety risk. Cambridge experiences a great deal of heavy traffic, and the Cambridge Traffic, Parking and Transportation Department (CTPTD) utilizes traffic lights as a primary method of moving and controlling it: Lights are used to move traffic as efficiently as possible. Putnam Avenue has seven traffic lights along it and the norm in the CTPTD suggests that using lights is a way to improve traffic along the street. Its location, characteristics (traffic lights, long length, high traffic levels) make it a perfect collector street for testing traffic control measures.

While the method of traffic control in Cambridge has been well developed by the CTPTD, they have no set method for testing the effectiveness of measures taken. Many factors affect traffic in a given area, which makes it difficult to accurately judge traffic before and after changes have been implemented. Several variables such as time of day, week or year, weather, section of street, direction of traffic, etc. can all lead to uncertain or erroneous findings. The CTPTD has encountered difficulty in determining the best course of action to resolve issues like those on Putnam Avenue. Views within the department differ as to whether a certain traffic control practice will improve a situation, have no effect, or make it worse. Without a method for assessing efficacy, the CTPTD is handicapped in its functions, and has asked WPI for help with devising a method for evaluating the efficacy of traffic control measures, and the application of this methodology to Putnam Avenue, which will serve as a test case.

This project's goal is to design and conduct an experiment to accurately quantify the effect that a change in traffic light timing will have upon traffic flow, and use this methodology to evaluate a traffic control measure put into place. We will seek to control other traffic-altering factors in order to isolate the effects the change in light timing will have on traffic. In order to conduct this experiment our group will have to look at *how* each of these external factors affects traffic flow: For example, how traffic varies by day or week. We will assess how much of the traffic on Putnam Avenue is using the street inappropriately as a "shortcut," versus how much traffic is coming from the adjacent neighborhoods. The aim of the CTPTD is to correctly utilize the street as a collector (a medium sized roadway into which smaller residential streets empty). If we can identify all of these factors, then our research will yield two products: First, we will be able to assess, and thus eliminate, external factors as possible causes for changes in traffic flow after a traffic signal timing change has been implemented. A proposed plan: The lights will be timed in such a way that people traveling along Putnam will encounter a red light at every signal. The second product will be a method created for the CTPTD to accurately assess traffic control measures. Using these factors the CTPTD can be more effective in implementing change that will have impact on other problem areas like Putnam Avenue all over the city. Using this study as a tool, the CTPTD could accurately judge the best way to manage traffic on all collector streets, and thus come closer to eliminating traffic congestion on neighborhood streets.

2. Background

Understanding the background information of a problem is a key identity before forming solutions. There are various areas of background information that must be discussed before addressing the problem at hand. The first topic that will be discussed is the geography, CTPTD, transportation and demographics of the city of Cambridge. Traffic engineering is a very important subject due to the innovations and new ways to record traffic flow and volume, and/or reduce traffic. The last topic in this section will be the current conditions of the Putnam Avenue area. These are the most important topics that will be addressed in the upcoming background information.

2.1 Understanding Traffic Congestion in the City of Cambridge

Cambridge was originally named Newtowne, with around 700 people settling down to live there. Of course there was no vehicular traffic problem at this time, but before they knew it, quite a situation had evolved (Shaver, 2003). The city of Cambridge is located adjacent to Boston, Massachusetts, along the Charles River. The traffic problem on Putnam Avenue is not unique to the city because people travel through it every day to and from their workplace. Its particular problem is that instead of using main roadways and highways, people have started cutting through the city on smaller roads such as Putnam Avenue. With the large population that Cambridge encompasses, there is no perfect solution to the vehicular congestion problem that the city faces.

When looking into the historical setup of Cambridge, Massachusetts, one must address all aspects that went into mapping the streets. Most of the roads in and around Boston, including Cambridge, used to be old horse paths, when vehicular travel had not been normalized. Instead of using a type of grid system as in New York or Los Angeles, these paths were turned into streets, thus creating the problem of congestion in the streets (Prudential Skywalk 2004). When looking for alternate routes of everyday travel, Putnam Avenue tends to be a widely used detour.

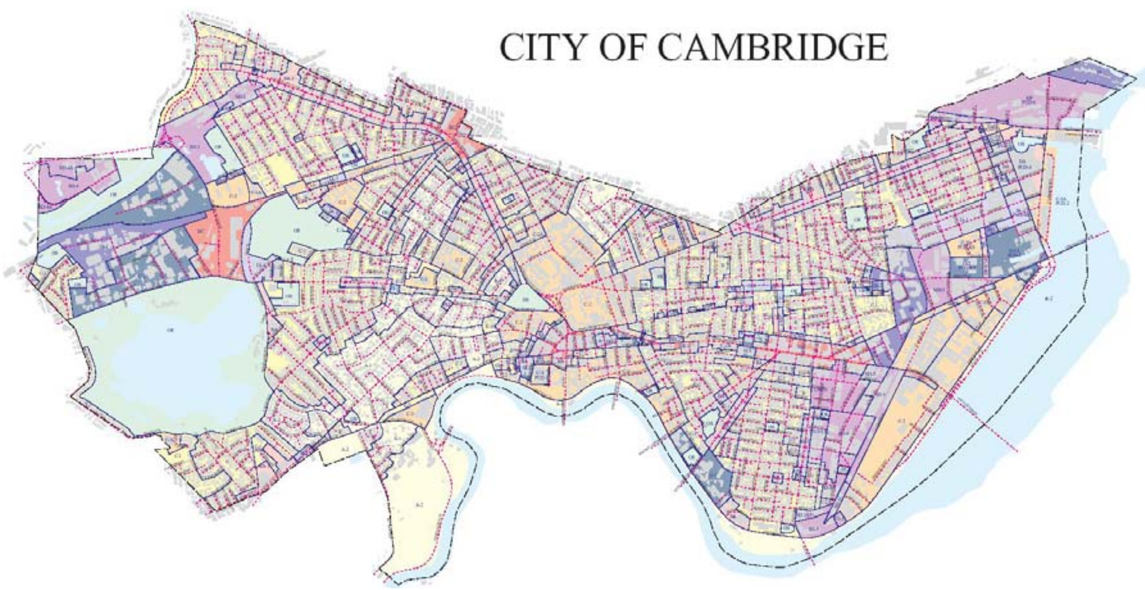


Figure 1: Map of the street layout in the City of Cambridge. Putnam Avenue is located along the river at the bottom of the map (City of Cambridge 2004).

Traffic is a problem when there are too many people attempting to travel in and out of the same area. The steady growth of population in Cambridge cannot benefit the situation on Putnam Avenue. With the nearly 115,000 people working in Cambridge, and the 101,400 living in the city, traffic is inevitable. Over the past decade alone, there has been close to a six percent increase in population, bringing the average number of people per square mile to over 16,000 (Shaver 2003). The large number of college students, about ¼ of the population in Cambridge, adds to this problem as well (Shaver 2003).

2.1.1 Geography

Streets were river centralized, because that was a main source of life early in the United States' growth. The Charles' River became a main factor when creating the streets by using a method of right angles. This way all of the streets could be easily navigated for minimal confusion. However, this did not turn out exactly as planned, because congestion seems to be a main problem not only on Putnam Avenue, but also virtually everywhere in the city. Putnam Avenue (Figure 1) is located east of Charles River. It seems as though the spillover traffic from Memorial Drive, which is right next to the river, is flooding Putnam Avenue daily. Memorial Drive has been a heavily congested street for many years, and as a possible solution for vehicles to save time, they use Putnam Avenue as a detour.

2.1.2 The CTPTD

The purpose for the CTPTD is to provide the city with services related to Public Safety. The department is responsible for making sure both motorized and non-motorized transportation along the city's streets is safe. The challenge the department faces is to meet the transportation demand for the city's residents, businesses, and institutions. The goal is to reduce "single occupant" methods of travel while protecting the quality of the city's residential and business environments (City of Cambridge, 227). Looking at the CTPTD's mission, it's clear why it would sponsor a project like this one. The problem is excessive use of Putnam Avenue by motorized transportation. The problem is characteristic of the challenges the Department faces in fulfilling their mission to give the city of Cambridge a quality environment and means of transportation. Furthermore, the problem also touches on the way traffic control is enforced in the areas. One of the Department's responsibilities is dealing with traffic management and making it more efficient (About Traffic, 1). The key to improving the situation along Putnam Avenue is more efficient management of the traffic along it.

The CTPTD is split into three divisions: traffic control, parking control, and support services (Figure 2)(City of Cambridge, 227). The purpose of the traffic control division (who we'll be working most closely with) is to install and maintain all of the traffic control devices. Furthermore, the division coordinates with other city departments and agencies on development proposals (City of Cambridge, 230). The parking control division is responsible for the parking meters, parking garages and enforcement of parking regulations (City of Cambridge, 233). The support services division is responsible for the administration of the entire department. It coordinates between the other two divisions as well as within each of the divisions (City of Cambridge, 236).

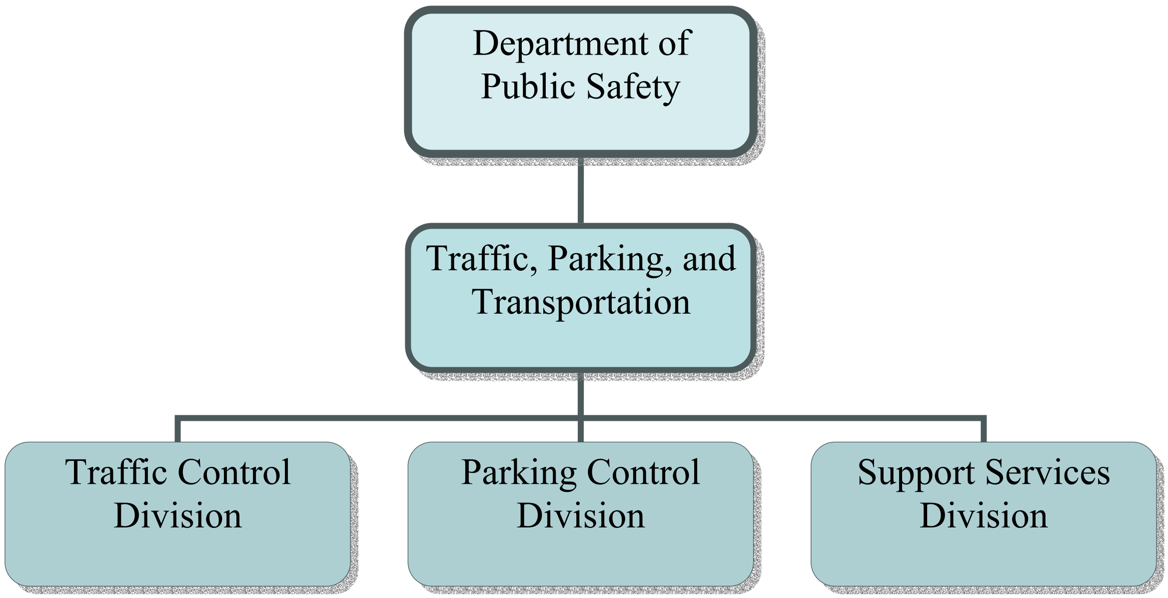


Figure 2: Organization of the CTPTD

2.1.3 Transportation in the Area

Public transportation and carpooling takes a number of vehicles off the road, but it is not utilized as efficiently as it should be. Working with the Cambridge Traffic, Parking and Transportation Department will be useful because they have watched the city grow and the streets evolve into their present state. Finding out when traffic on Putnam Avenue really started to pick up would be a key consideration. Also, investigating bus and train routes throughout Cambridge can help deter single-person-vehicle commuting. With all these alternatives looked into, other possible routes of transportation could be offered to the commuters of Cambridge and Boston.

Pedestrians use Putnam Avenue daily when walking, skating or biking. A major consideration to be taken into account will be the change of their patterns after an implementation. When a traffic calming method is instated, will this encourage more people to travel on foot rather than use vehicular means? These questions will be answered after going on-site and collecting the raw data needed.

2.2 Conditions around Putnam Avenue

Putnam Avenue is a 1.5 mile long two way street that runs perpendicular to several main arterial streets in Cambridge (see Figure 3, and also Appendix B: Detailed Maps of Putnam Avenue) (Geography Network Explorer). The street connects many local streets to the arterials that can take residents to and from main arterials, as well as points of interest in and around Cambridge. There are businesses, one school (Martin Luther King), and many residences along the street. The current method of controlling traffic flow depends on 6 traffic lights, designed to move traffic as quickly as possible.

The current conditions of Putnam Avenue will be explored in this section by explaining what current traffic situations are in the area. The following section will describe the area of Putnam Avenue emphasizing on factors that are along the street and located in the vicinity of it. Exploration into the current conditions the city of Cambridge faces with transportation will be addressed to give insight to traffic condition that continue to worsen. Furthermore, some of the reasons that have prompted the City of Cambridge to look at Putnam Avenue for remediation will be explained.

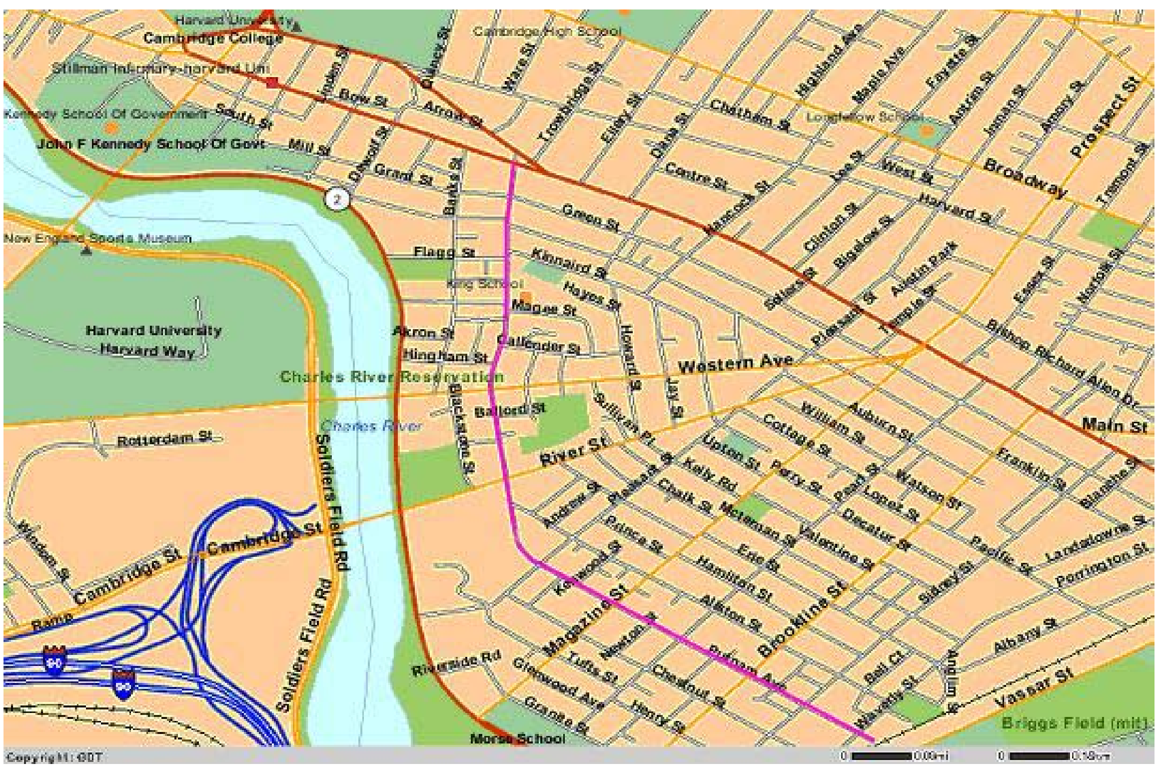


Figure 3: Map of Putnam Avenue, highlighted. (Geography Network Explorer)

2.2.1 Explanation of the Area's Situation

The area in which Putnam Avenue is located has two main one-way arterials crossing it, Western Avenue and River Street. There is a great deal of travel on these arterials since they are links to surrounding cities including Boston. A great deal of travel is done in and out of both the city of Boston and the city of Cambridge each day. Each of the main arterials, Western and River, sees roughly 30,000 cars per day going across their bridges in and out of Cambridge (Boston Metropolitan Planning Organization). Not only is commuter travel adding to an already traffic congested region, but Putnam Avenue has a school located midway along the street which has bus drop-offs and pick-ups during the day. Combining the local resident travel, the narrowness of the street, and the traffic looking to by-pass major arterials within Cambridge describes the problems seen. Cambridge is home to several major corporations and has a good deal of businesses that have offices in the city. There are approximately 5,300 businesses which have nearly 120,000 employees (Cambridge Chamber of Commerce). In addition to having large high tech and biotechnology companies, Cambridge is home for some of the leading institutions in the world. Harvard University and the Massachusetts Institute of Technology (MIT) call Cambridge their home. These two large universities both have large student populations. Harvard has over 16,000 students at all levels of study and MIT has over 10,000 enrolled. Both of the Universities have 96% of their undergraduates residing in Cambridge on campus. The majority of the schools' total enrollment is within the graduate schools (College Board Website). Graduate students usually do not live on campus making it necessary for them to travel to and from class from the surrounding area. A large source of commuter traffic is driven by a combination of the Harvard's and MIT's University Park. The park combines academic research labs and also high-tech and biotech research firms to have buildings in a concentrated area. The large corporations, thousands of employees, many students, and visitors' traveling on the major arterial of Massachusetts Avenue makes the use of Putnam Avenue as a detour increase.

The many attractions that are present in the city and the location of Putnam Avenue may also help explain the reason congestion is experienced. The hypothesis that commuters are using Putnam Avenue as a "shortcut" between arterials seems to be well founded. Looking at Figure 3 and Appendix B: Detailed Maps of Putnam Avenue, Putnam Avenue intersects 5 major arterials, suggesting there may be inappropriate use by commuters.

2.2.2 Reasons for Action on Putnam Avenue

One reason why WPI is a part of the project is because of the phone calls and letters that the CTPTD is receiving. The residents of Putnam Avenue do not feel that the road is a safe any more with the increased amount of use it is currently seeing. Many children live on or around Putnam Avenue since it is zoned primarily residential. Residents feel that it is unfair that commuters are using their street as a "cut-through or shortcut." These residents want the CTPTD to take action and make their street safer and used more appropriately.

Complaints from residents are sent into the CTPTD regularly via mail or phone call (Parenti). Investigation of the thoughts of residents is that they believe that Putnam Avenue is their street and that non-residents should not use it as a shortcut. The other compliant that is predominant from residents is the high speed at which cars will travel along it. The speed factor is one of great concern on a narrow street with many residences like Putnam Avenue. The project team hopes to incorporate the residents' thoughts into analysis of the problem on-site and also after the project is completed.

Furthermore, the greatest factor driving action on Putnam Avenue is that the current traffic control devices in place are proving to be ineffective at relieving the traffic congestion and the cut-through traffic situation. Investigation in the use of traffic signals shows that they can do more harm than good at relieving traffic problems such as cut-through (City of Phoenix). As previously stated, Putnam Avenue utilizes 6 different signal devices along it, a number very high for the streets use as a "collector" type. Problems like cut-through and congested traffic on the street are expected when signals are placed in a collector street environment like Putnam Avenue (City of Phoenix). The driving forces behind the project are the conditions seen and the City of Cambridge's goal to try and utilize the current traffic control methods. Traffic signals are not typically used to perform traffic calming; however, the goal is to use what is presently there in a more effective way to achieve this goal. A possible source of the problem (too many traffic lights) currently is going to be attempted to be used as the possible solution on Putnam Avenue.

2.3 Traffic Engineering

In order to comprehend traffic engineering, one must first understand the different types of streets. There are three types of streets in a city; locals, collectors and arterials. Each has its own specific job in how traffic flows throughout a city. A local road is supposed to be used solely for the purpose of residential traffic. Arterials are used for traffic to get in and out of the city, and are major roadways. Collectors, like Putnam Avenue, gather traffic from both local and arterial roads, and bring them to other major streets. In the following section, established practices and methods of traffic control, as well as complaints from residents on Putnam Avenue will be discussed.

2.3.1 Established Practices, Methods

The introduction of streetlights to the area definitely changed the amount of traffic and its flow. The traffic signal was invented in 1923, and has been used in Cambridge for a long time. The main reason for this invention is to increase safety on the streets. There are currently 144 full traffic lights, with many flashing lights as well (Annual Report 2003). Only time and research on site will allow us to assess the underlying problem of Cambridge's traffic, specifically on Putnam Avenue.

Currently, there are methods to slow traffic in neighborhoods, as well as to discourage cut through traffic. Some of these methods include horizontal shifts, vertical deflections, roadway narrowings and closures (Traffic Calming Measures 2004). These methods of slowing traffic and obstructing movement help discourage motorists from cutting through residential neighborhoods in order to lessen their commute time.

When a traffic problem on a collector street is established, the Bureau of Transportation System Management (BTSM) recommends several steps to solve the problem. The first step is called 'survey to proceed,' in which surveys are handed out to the residents of the street. At least thirty percent are usually returned and the majority of those feel a change should be made. Next is 'plan development,' which consists of four meetings at which the BTSM works with the residents to come up with an approach that makes the most sense. The third step, 'project ballot,' is a vote where most of the people responding are in favor of this change. Fourth is 'city council action' where a proposal is presented to the City Council so that a change can be implemented. The next step is 'design and construction/implementation' where the traffic calming devices are constructed on the street. Finally, the last step takes place six months after implementing the device(s) and it is called 'project evaluation' (City of Portland Traffic Calming). This shows whether or not the chosen method was useful.

2.3.2 Traffic Studies

Putnam Avenue has been previously studied using Automatic Traffic Recorders (ATRs) and Turning Movement Counts (TMC's) at several different locations. Out of the raw data that were collected, there can be several conclusions drawn. On average, the southbound travel tends to be heavier than the northbound traffic in the morning, but only by small amounts. During rush hour in the evening, the traffic pattern switches as the northbound route doubles the southbound (City of Cambridge 2000). These findings suggest that commuters using the Massachusetts Turnpike travel on Putnam Avenue when going to and from work each day.

2.3.3 Traffic Signals and Timing

A large portion of this project will focus on optimizing the traffic signals on Putnam Avenue in order to produce the goal of discouraging commuter traffic cut-through. Traffic signals' main goal is to allow safe travel and passage of cars and pedestrians in an intersection. There are several purposes and advantages to traffic signals outlined in Table 1 from *The Manual on Uniform Traffic Control Devices* (MUTCD):

They provide for the orderly movement of traffic.
They increase the traffic-handling capacity of the intersection.
They reduce the frequency and severity of certain types of crashes, especially right-angle collisions.
They are coordinated to provide for continuous or nearly continuous movement of traffic at a definite speed along a given route under favorable conditions.
They are used to interrupt heavy traffic at intervals to permit other traffic, vehicular or pedestrian, to cross.

Table 1: Advantages and Purposes to Traffic Signals (FHWA MUTCD 2003).

Traffic signals also have negative impacts when used; they are listed below in Table 2.

Excessive delay.
Excessive disobedience of the signal indications.
Increased use of less adequate routes as road users attempt to avoid the traffic control signals.
Significant increases in the frequency of collisions (especially rear-end collisions).

Table 2: Disadvantages to the use of Traffic Signals (FHWA MUTCD 2003).

Timing is determined by studying the travel of vehicle speeds and volumes across an intersection. The purpose of specific timing is to allow the optimum amount of cars across an intersection safely. Timing can be adjusted for different times of the day and can also be synchronized with other signals along the street. Our project is planning on exploiting the ability to change and control timing of traffic signals, and use them in a way that will discourage cut-through travel along Putnam Avenue. Setting up a control experiment and study along with the CTPTD's Traffic engineer, Jeff Parenti, we will implement a timing pattern that will attempt to achieve the projects ultimate goals.

2.3.4 Traffic Calming

There are many practices used to alleviate traffic congestion. There is a science that many traffic engineers use to perform "traffic calming," the slowing of traffic for safety purposes. The basic, widely used theory deals with the "3 E's," education, engineering, and enforcement (ITE and FHWA). There are different methods utilized by traffic engineers to achieve traffic calming. Different devices are used for different goals in achieving traffic calming on a particular roadway. Some of the goals that are associated with using traffic calming devices are: speed reduction, reduce traffic volume, pedestrian safety, bike safety, and crash reduction. Examples of devices used to achieve these goals include speed bumps, signs, and street designs (City of Portland Traffic Calming). In Error! Reference source not found., there is a selection chart which the City of Portland uses to determine severity of traffic and the need for traffic calming. The most common methods used in traffic calming for a neighborhood collector street are speed bumps, curb extensions, and slow points (areas in a street that narrow) (City of Portland Traffic Calming). Looking at how traffic calming has evolved over time can be helpful as well.

Comparing publications of the ITE shows that there are few significant differences in the methods applied as solutions for traffic congestion issues although the decision process to use them has changed. In the 1980 publication of *State of the Art: Residential Traffic Management* the process of alleviating traffic congestion begins with the identification of the problem and then analysis of possible solutions to the problem (FHWA Residential Traffic Management). The difference in thinking today comes after where the problem is identified: there are studies done on the conditions of the area (ITE and FHWA). Instead of the previous thinking of coming up with solutions and implementing them and seeing how effective they are, there are measurements and studies performed before solutions are presented. Studying the problem before the actual implementation of a traffic calming method will allow a more scientific and thorough analysis. It seems that the older practice of traffic calming has been used on Putnam Avenue due to the abnormal amount of signals present on the street. The method being explored in this study explores the possibility of using the signals to our advantage in coming up with an effective method to calm traffic, and also reduce the volume on the residential collector.

In order to be able to more effectively understand the problem on Putnam Avenue the background knowledge will be invaluable. Understanding the possible sources for the congestion down to the practices of Traffic engineering is needed to be able to solve this problem. Understanding of the city of Cambridge and the CTPTD, traffic engineering practices and theories, and what the current conditions are like will help the project succeed. The background which specifically relates to the problem will bring information that will aide in a more thorough method to collecting pertinent information about the traffic seen and towards the goal of alleviating the congestion.

3. Methods

This project's goal is to help the City of Cambridge discourage commuter traffic on Putnam Avenue by devising a method of traffic control that will bring their travel back on main arterials. The team will analyze current traffic data and conditions and then devise a controlled experiment that has a goal to reduce commuter travel and congestion along Putnam Avenue. The experimental results will be measured in an identical manner as the initial conditions were and then compared with each other. The team hopes that the change and our method of analyzing it, will be significant enough to not only help Putnam Avenue, but also other streets like it in Cambridge.

The project will go through three major phases: initial conditions measurement, experiment implementation and measurement, and then evaluation of the traffic control measure, comparing the conditions before and after the change in traffic control. Figure 4 shows an example of how the project will shape together and some areas of importance associated with each part.

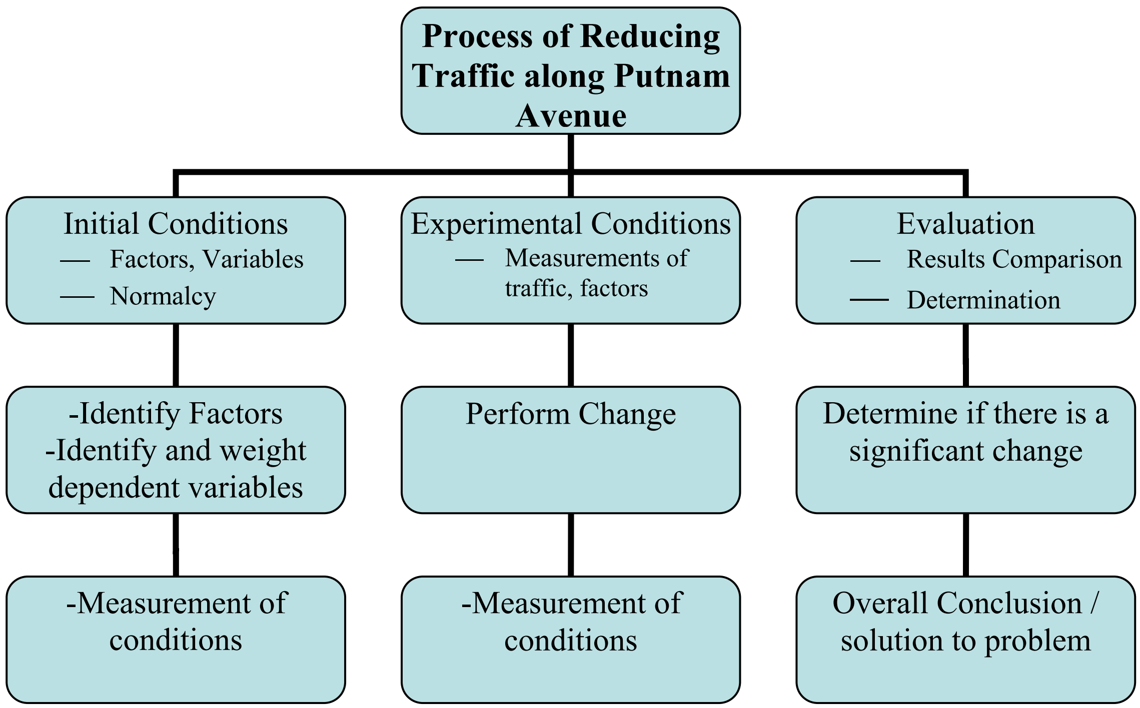


Figure 4: Organization of the Methods involved with reducing Commuter Traffic on Putnam Avenue

The objective breakdown relies on having initial or baseline data before we arrive in Cambridge. The data collected would then be analyzed and validated by the group. The analysis will determine which factors that are collected are the most significant to understanding the issues of commuter congestion. During the experimental phase we will use the factors identified and measure the changes (if any) that are observed by the traffic control change. The data collected in both the baseline collection and the experimental collection will be compared and statistically analyzed.

The project will take place in Cambridge, Mass. between March 14th and May 4th, 2004. The data collection and experiment will be performed on Putnam Avenue, which is located in the southeast corner of the city near the Charles River. The analysis of the data and the center of the project will be based out of the Cambridge Traffic, Parking, and Transportation Department's office. The project will be bound to a set schedule seen in Appendix C: Proposed Project Schedule that will have particular windows of time for testing, analysis of data collected, and drawing conclusions from the results.

The methodology of the project will begin by identifying what factors and methods of collecting and interpreting traffic information are available. Specific factors that will relate to not only the experiment but also the baseline data will be explored and discussed within the group and with our liaisons. The next phase in the project will be the collection and analysis of the baseline data and then subsequently the experimental data. The final phase of the project will be a comprehensive analysis of the data collected in both the baseline study and experimental phases. Conclusions will then be drawn from the data, and recommendations can be made.

3.1 Identify Data Collection and Interpretation Methods

In order to carry out the project successfully, a well-organized form of collecting traffic data and methods of interpreting the data must be established. Looking into the factors associated with the collection of the data will be the first priority. The understanding of intervening variables that will have impact on the collection of data throughout the project will be important. We have divided them into two groups: predictable and unpredictable variables. We will then look at the independent and dependent variables. Furthermore, an understanding of the types of tools and resources that will be used to collect any data in the project must be explored.

3.1.1 Independent Variables

Our only independent variable will be the timing of the traffic lights; Instead of timing lights such that a car traveling the length of the street encounters "green" at every light, the opposite will be done. A car traveling the street will encounter a "red" at every light. This method is hoped to discourage drivers from using Putnam Avenue for any longer than they have to. This may increase congestion at first, but a positive result is hoped for by the end of the experimental period.

3.1.2 Dependent Variables

In order to effectively rate the traffic on Putnam Avenue, a "congestion index" will be formed. This index will comprise of 4 measurements: Volume, delay, travel time, and use. Volume data will be gathered from the ATRs on the street; a measure of cars per some unit time. This will be our most important measurement. Delay can be defined as the average wait of a car at each light. The longer the delay, the longer the line of cars will be at each intersection (these two can measurements are equivalent). Travel time is the average time it takes to drive from one part of the street to another. This may be the entire length of Putnam, or just a segment of it. Use will be defined as the percentage of cars that are using the street inappropriately, as a bypass to main arterials.

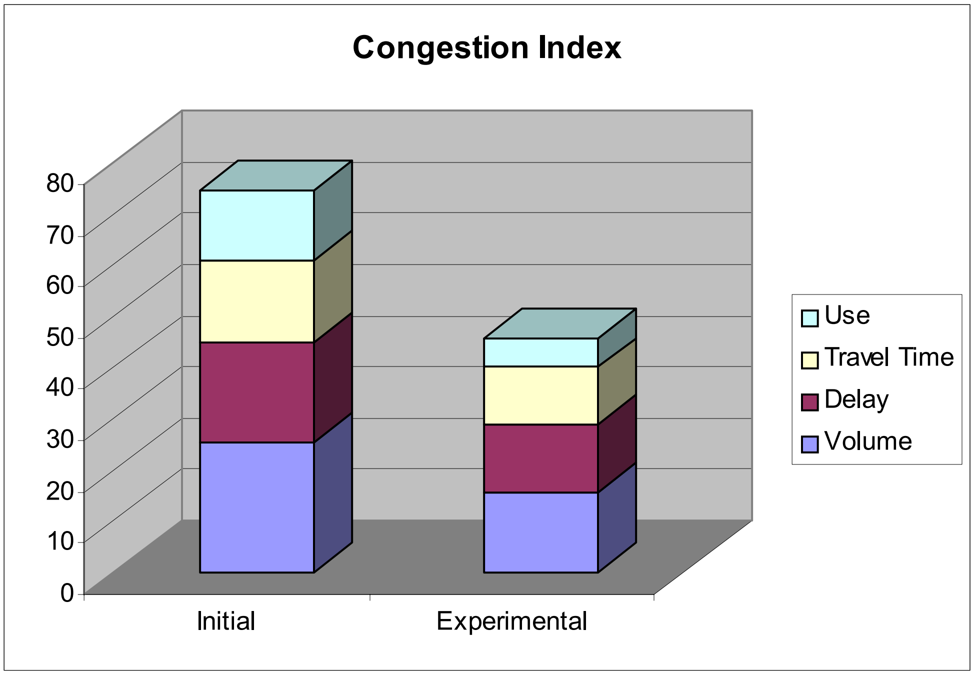
We will assign a weight to each of these variables, and then score each variable according to our measurements. Multiplying the scores with the associated weights, then adding all 4 totals will yield a congestion index. When we compare our two phases of measurement, this will be a very useful traffic evaluation tool. A sample of how this analysis might look can be seen in Figure 5.

Initial

Variable	**Score**	**Weight**	**Total**
Volume	85	0.3	25.5
Delay	77	0.25	19.25
Travel Time	81	0.2	16.2
Use	54	0.25	13.5
			Total Severity
			74.45

Experimental

Variable	**Score**	**Weight**	**Total**
Volume	62	0.25	15.5
Delay	45	0.3	13.5
Travel Time	55	0.2	11
Use	23	0.25	5.75
			Total Severity
			45.75



KEY
Score "delay" is directly proportional to intersection delay
Score "volume" is directly proportional to number of cars/hour
Score "travel time" is directly proportional to time spent on Putnam Ave. per car
Score "use" is directly proportional to % of cars using Putnam Ave. inappropriately

Figure 5: Sample Congestion Index Calculation

3.1.3 Unpredictable Variables

Unpredictable intervening variables are those factors affecting traffic rates that we have no way of anticipating. Weather is our biggest problem to conducting studies. While weather reports can lend some insight, we can't be sure of what the weather of a given day will do to traffic flow. Car accidents are a big threat: If an accident occurs on the street, it will foul the data for some time. Another possible factor would be gas prices. People may drive more or less in the short term depending on gas prices and these are rather unpredictable. Our only hope of overcoming this obstacle is to collect data over a time period in which identified unpredictable variables remain rather constant. For example, measuring traffic over 5 days in which the climate remains the same.

3.1.4 Predictable Variables

Predictable intervening variables are those factors that we can recognize and have some sway over, or ability to avoid, during the course of the experiment. If a street narrows at a particular section it may experience a slower rate of traffic. If we can effectively measure the way in which the bottleneck affects traffic quantitatively, we can factor that into any results we obtain from that area. Another variable is school schedules in Cambridge. If school is not in session during a certain week then traffic will be different in a school zone during that period when school is active. With this knowledge, we can either avoid this week for data collection or we can again see how school schedules alter the traffic flow, the former method being ideal. The factor's impact can then be included into our results once the change to traffic lights has been implemented. A table of major predictable intervening variables can be seen in Table 3.

Variable	Pertinent Data
Harvard School Schedule	Spring Break Mar. 27-Apr. 4
MIT School Schedule	Spring Break Mar. 20-28
Martin Luther King School Schedule	Feb. Vacation 16-20, no school on Mar. 17
Holidays	Easy to identify on a calendar
Construction	Cambridgeport roadways construction project on East side of Putnam
Part of Street	We can measure up to 3 places on the street using ATRs*
Direction of Traffic	Relates to time of day (direction of commute)
Large Business Openings/Closings	
Bus Routes	Available from City
	**ATR: Automatic Traffic Recorder: See Section 3.1.3*

Table 3: Significant Predictable Variables.

3.1.5 Tools and Resources

Understanding the tools we use to collect data will help us understand their benefits and disadvantages relative to accurately analyzing the data they yield.

Our major tool will be the Automatic Traffic Recorder (ATR). This is a device that lies on the street and collects lots of information about the number of cars/day, day of week, direction of traffic, etc. This tool will gather data for our Volume variable.

A secondary tool for measuring is less technical, a traffic turn count. This manual counting process determines how many cars turn on to, or off of a street at a given intersection. Once each major intersection on Putnam Avenue is analyzed, we can use it to score our Use variable.

License plate counts can be helpful for evaluating street use as well. Plate numbers are written down at one end (or section) of the street, and the same is done at another end (or section). The percentage of matching plates out of the whole will help us determine street use.

Drive-throughs will prove an invaluable tool. This type of test is a time study by driving a car while following the car currently in front of you. This will help us see how traffic is perceived from a commuter's point of view, determine Delay, and get a Travel Time. This, amongst other methods of human observation, will be simple but effective tools in our measurement processes.

Focus groups will be a good way to qualitatively assess traffic levels. Without telling any participants of the experiment at any time, we can talk to residents and/or commuters in the area before and after our experiment to see how they view the situation. This will be a helpful way of measuring perception of different groups.

A final tool that will be used is the traffic light timing. The timing is what will be changed in an effort to improve traffic on Putnam. Traffic light timing is actually a rather intricate process; lights must take cars into account going both directions on up to 4 streets. We will look at how this tool can help deter traffic from using Putnam along its entire length in collaboration with the traffic engineer assigned to the project, Jeff Parenti.

3.2 Collection of Initial Data

The data collected initially will be the baseline for the project. Baseline data will be collected by the CTPTD by the start of the project using ATRs and also by our group during the beginning of the project. The baseline will help us get an initial raw traffic count and identify factors affecting the situation on Putnam Avenue. The baseline also will serve as a tool to mark our success at the end of the project. If the conditions improve significantly on Putnam Avenue due to the implementation of a new traffic control method vs. the way they were (Baseline), it will indicate a success.

3.2.1 Creating a Baseline

The data to be collected at first will be gathered by the CTPTD using ATRs. In order to properly analyze Putnam Avenue's traffic volume, 6 ATRs will be used, measuring traffic in both directions in 3 locations. We have selected our 3 areas by looking at previous studies, as well as talking to our liaisons about where traffic is the biggest problem. These locations can be seen in Figure 6. This raw traffic count will be the rough measurement for the traffic situation on Putnam prior to the traffic light change.

Putnam Avenue is seen here in Orange.	
Our ATR placement locations are shown here as red circles.	
Full (green, yellow and red) lights at the intersections of Putnam Avenue and (from left to right)	
1.	Massachusetts Ave.
2.	Western Ave.
3.	River St.
4.	Pearl St.
5.	Magazine St.
6.	Brookline St.
7.	Sidney St.

Figure 6: Map of traffic light and ATR locations on Putnam Avenue (City of Cambridge Website)

In addition to the initial count, our group will evaluate and measure the significant predictable variables so that we can see how these data affect traffic. This process will be the most difficult element of our project. Once variables have been identified we must then devise a way to effectively rate how each one alters traffic flow, and try to assure conditions are similar for the base and experimental cases. The method used must be able to be duplicated for our data collection after the change in stoplight timing takes effect. We also must gather enough data in an effective enough way; this will ensure that our information is an accurate representation of the factor's impact on traffic.

3.2.2 Standard of Data Collection and Interpretation

When we collect data, we must use our methods as a standard for future measurements. When we later analyze these data we will also be creating a standard for the ways in which we interpret and analyze data pertinent to factors impacting traffic. Using these standards in addition to normalizing our two stages of data collection will, if successful, serve as a foundation for possible traffic studies in the future.

3.3 Collection of Experimental Data

The collection of experimental data will take place while the project group is located on-site. The baseline study will be an important model to follow for the collection of the data. The change in traffic control will be determined by using the data involved in the baseline interpretation and by observation taken along Putnam Avenue. The change performed will be done methodically and measured in an appropriate fashion so that it can easily be compared to the baseline study. Our experimental change measurements will rely entirely upon what actions we take in our pre-experimental change measurements.

3.4 Evaluation of Traffic Control Measures

The final part to the project will be combining all the information that has been collected in the initial and experimental studies and comparing them. Statistical tests and comparisons will be performed to measure the effectiveness of the change in traffic control along Putnam Avenue. From the data that are compared conclusions will be drawn as to whether the action of the experiment (traffic light timing change) was effective in achieving the goal of the project: Reducing the amount of traffic on Putnam Avenue.

3.4.1 Comparisons of Baseline and Experimental Data

Our variable studies will show their worth in this stage of the project. First, we will identify all the unpredictable factors that remained similar between the two phases: Was the weather the same for both studies? Was there a car accident during one interval that would throw off results? Our project will aim to eliminate as many of these uncertainties as possible, thus making these variables have no effect on the outcome. Next, we will look at all the predictable variables that remained constant throughout both stages of study, and these too can be rendered to have no significant effect. Finally, the team will look at how any predictable variables varied between the two projects. We will have already gathered data on the quantitative impact of all our predictable variables, so we can then scale the two sets of data accordingly. With these three steps accomplished, we will be left with two sets of data on traffic volume that will only be affected significantly by changes in traffic light timing. Now we can make an affirmative conclusion in regards to the traffic light change.

Some fail-safes must be in place, of course. For instance, in order to effectively rate any impact a variable has on traffic, we must understand exactly how it affects traffic, and leave a margin for error. A standard deviation is a useful tool for allowing some leeway. If a variable's "two sigma" variation is allowed for, we can make a much more educated conclusion from data (Glantz 14). This possible regression analysis may not prove to be necessary, but it's an important consideration.

In addition for allowing for variance, we can give different data collection techniques different weights for evaluating "traffic severity": That is, maybe 65% of our data will come from ATR counts. Another percentage could come from human counts of how many cars are traveling the entire length of the street, using it as a "shortcut." With these different data collection techniques rated for their value to our data set, we accomplish two things. For one, we create a system of checks and balances: If traffic is moving slowly bumper-to-bumper, the "congestion" on the street may be just as bad as before, but the number of cars going by could be much smaller according to an ATR count. We will have multiple ways to assess traffic. Secondly, we will have a much more comprehensive measurement of several vital statistics that the CTPTD will want to have: This will aid them in making decisions about this street and others in the future.

Comparisons using statistical tests and charts that best represent the data will be shown for all the data collected in each of the tests. The information displayed here will be very powerful in determining the success of the project and for use as a solid foundation for future studies.

3.4.2 Conclusions

The conclusions from the project will be drawn from the data collected and the analysis of those data. The significance of the data will be looked at and also if there was a significant change observed by the experiment performed on Putnam Avenue. The most important impact of these conclusions is their applicability in other areas of the city experiencing similar problems. Not only will this project quantify the effect of traffic light timing changes on traffic, but the methods in which we performed our study can also serve as a guideline for similar studies. This is a very significant tool for any traffic department to have.

4. Summary

Cambridge is a city that is home to large corporations, leading universities, several tourist attractions, schools, parks, and over 100,000 citizens. The city growth is one that matches with most developed cities in the country. Space is limited in Cambridge, so thousands of people each day travel in and out of Cambridge for people to get to work or school. The transportation method of choice for many is the car. The car with all its benefits for people who are "commuting" is a problem for the cities. Congestion, pollution, and negative effects come from the commuters' choice to travel by car. The problems in Cambridge are common to cities all over the United States.

Designs of streets in a city have a specific system and purpose. It is important for the traffic infrastructure for streets to have use that in based on their purpose and design. Putnam Avenue being a collector street purpose is not to be used as a shortcut but merely a connection for local street residents to reach arterials. The current use that is being exerted on the street is putting a strain on not only the residents but the travelers who legitimately use the street for its designed purpose. The problem is being seen all over the city however is particularly more of problem on Putnam Avenue due to its several arterial intersections.

The project team will establish an effective method of collecting and analyzing traffic data related to congestion on collector streets like Putnam Avenue. The group will also participate in setting up a controlled experiment that will help to discourage commuter use of Putnam Avenue as a "shortcut". Measurements and collection will be taken from the experiment and compared to the existing conditions to draw solid conclusions and recommendations from the study.

The Project group and the CTPTD work involved with Putnam Avenue have an ultimate goal of discouraging cut-through on Putnam Avenue. There is a larger problem that is to be explored throughout the project relating to collector street congestion. The project is trying to come up with a solution to a problem that has riddled many for years; how to effectively deal with traffic congestion. Using science and experimental data with comprehensive analysis the project hopes it will bring new solutions and policies to improving traffic conditions for those affected by congestion.

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Appendix A: Traffic Calming Selection Criteria

The following is the project selection criteria used by the City of Portland in choosing traffic calming along collector streets.

PROJECT SELECTION CRITERIA

Criteria	Points	Basis Point Assignment
Speed	0 to 30	Extent by which traffic speeds exceed 35 mph (2 points assigned for every 1 mph)
Volume	0 to 25	Average daily traffic volumes (1.667 points assigned for every 1,000 vehicles per day)
Residential Density	0 to 20	4 points assigned for every 100 dwelling units per mile
No Sidewalks	0 to 10	10 points assigned if there is not a continuous sidewalk on at least one side of the street
Elementary School Crossing	0 to 10	10 points assigned if marked school crossing exists.
Pedestrian Generators	0 to 5	5 points assigned if pedestrian generators (retail commercial uses, institutional uses, parks, or other schools occur along or within 1,000 feet of the street
Total Points Possible	**100**	

Speed is given the most importance, since high speed usually affects safety and livability the most. It is also the condition that can be most improved by traffic calming devices.

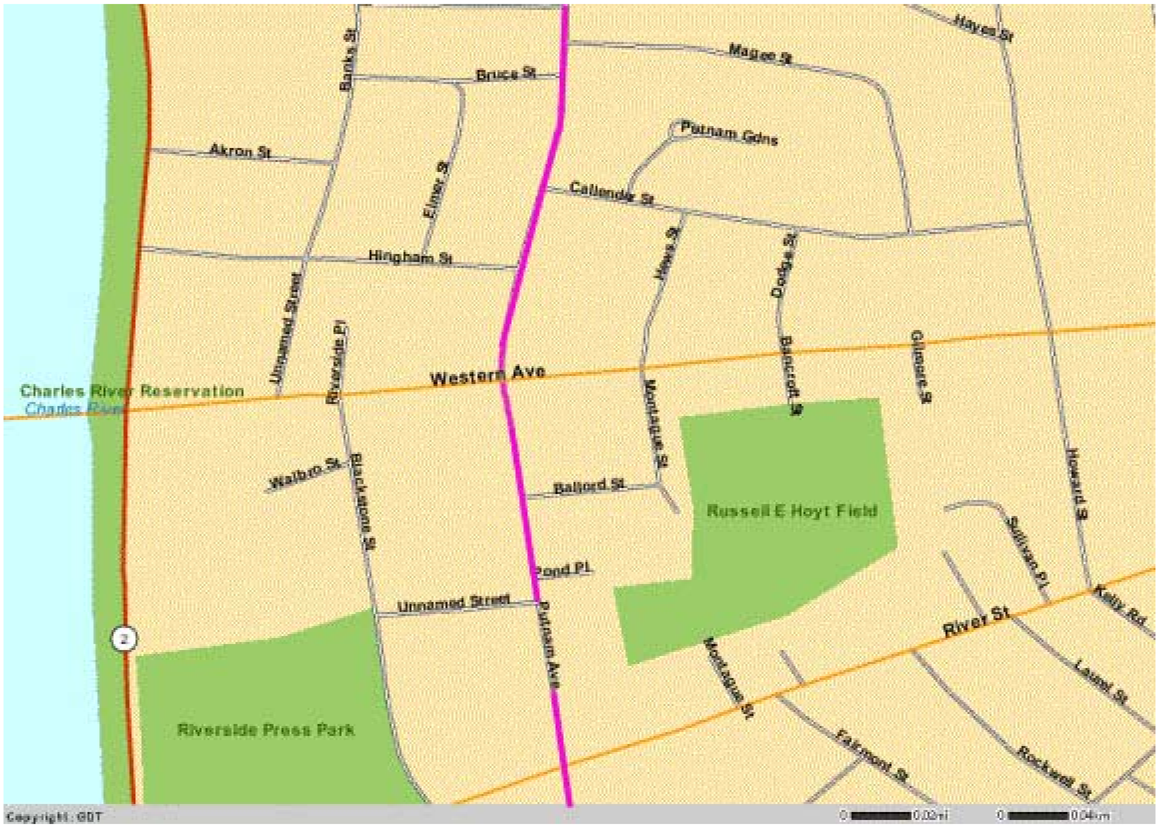
Volume is considered because it contributes to the general traffic conditions on the street. For example, conditions on a street with both high volumes and speeds will be worse than on a street with high speeds but lower volumes.

Residential density also affects general traffic conditions. For example, higher densities tend to generate more pedestrians and vehicle turn movements. In addition, projects on high-density streets benefit more people than projects on lower-density streets.

The other criteria - sidewalks, elementary school crossings, pedestrian generators - are important considerations because they relate to pedestrian safety.

Appendix B: Detailed Maps of Putnam Avenue

Putnam Avenue is highlighted in pink.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Bancroft St
Gilmore St
Western Ave
Charles River Reservation
Charles River
Montague St
Walbro St
Blackstone St
Balfour St
Russell E Hoyt Field
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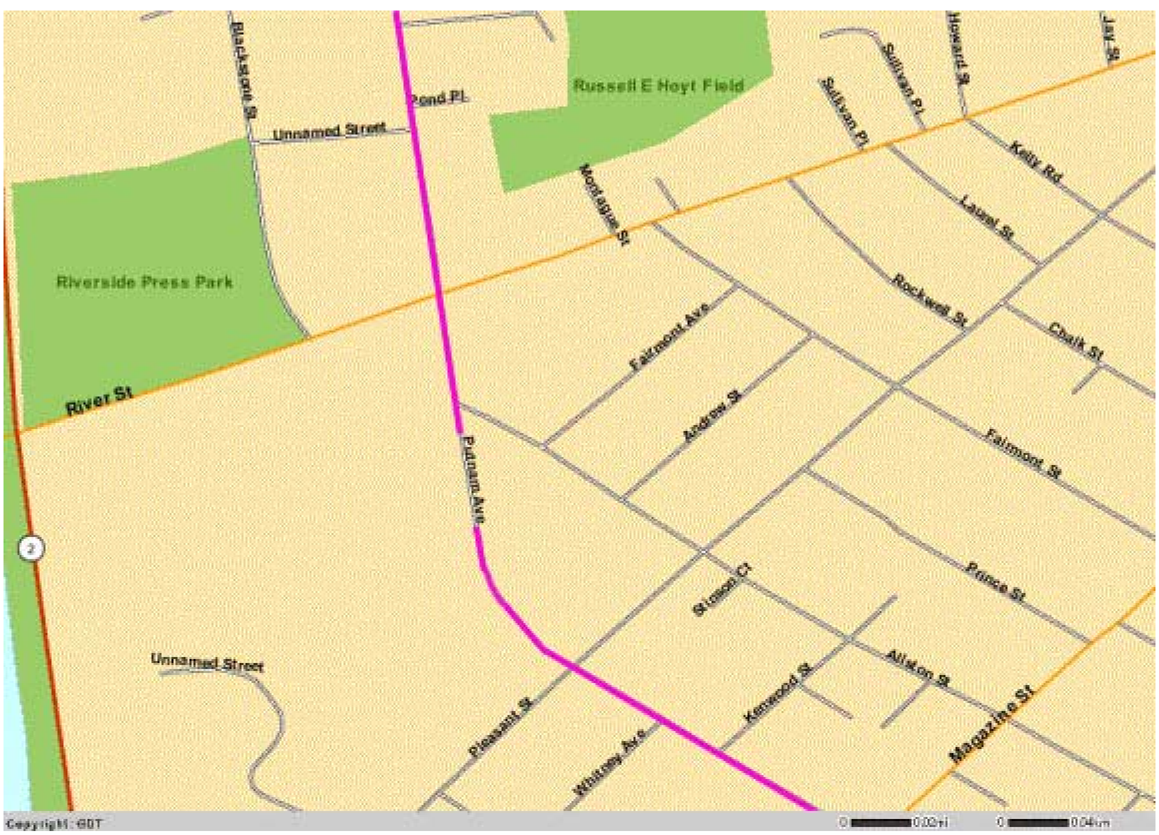
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Chalk St
River St
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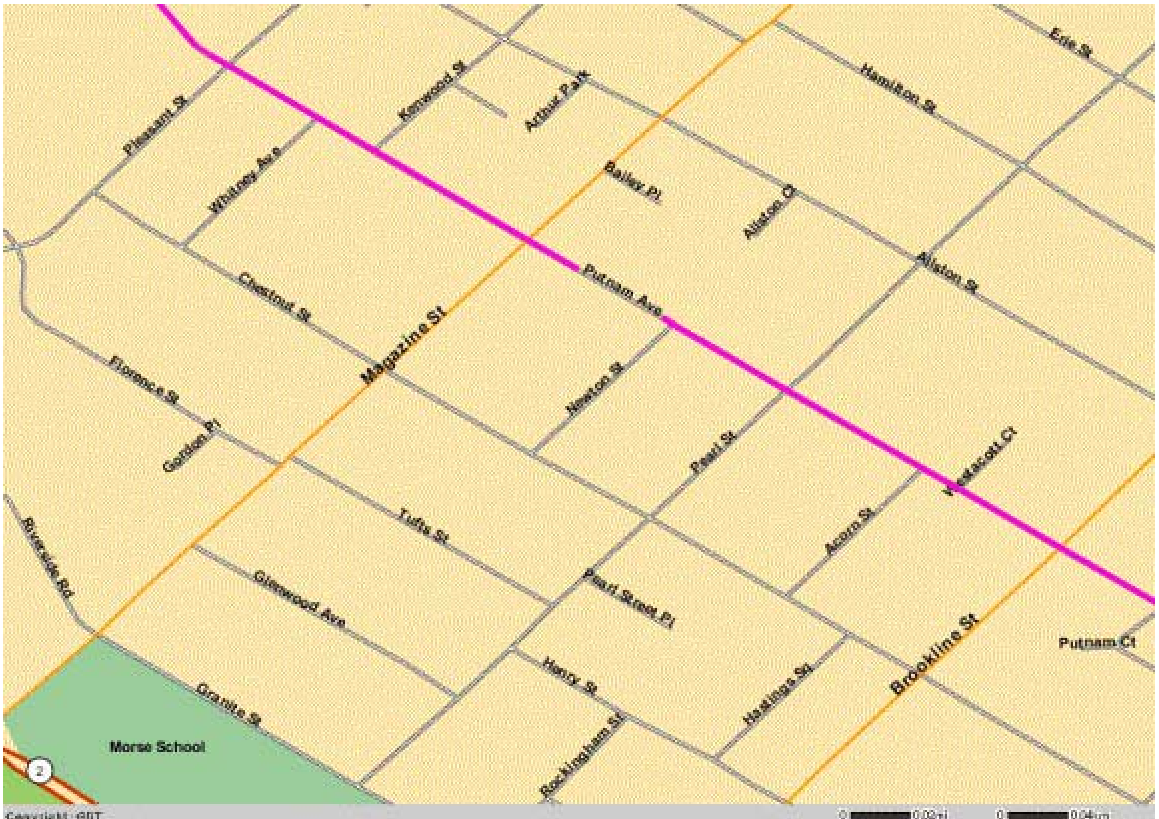
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Newton St
Gordon Pl
Pearl St
Acorn St
Tufts St
Riverside Rd
Glenwood Ave
Pearl Street Pl
Putnam Ct
Henry St
Hastings St
Brookline St
Granite St
Rockingham St
Morse School
Copyright: GDT


Allston St
Erie St
Hamilton St
Pearl St
Brookline St
Chestnut St
Acorn St
Peters St
Putnam Ct
Sidney St
Bell Ct
Waverly St
Reardon St
Grove Ave
Fort Washington Pl
Putnam Ave
Talbot St
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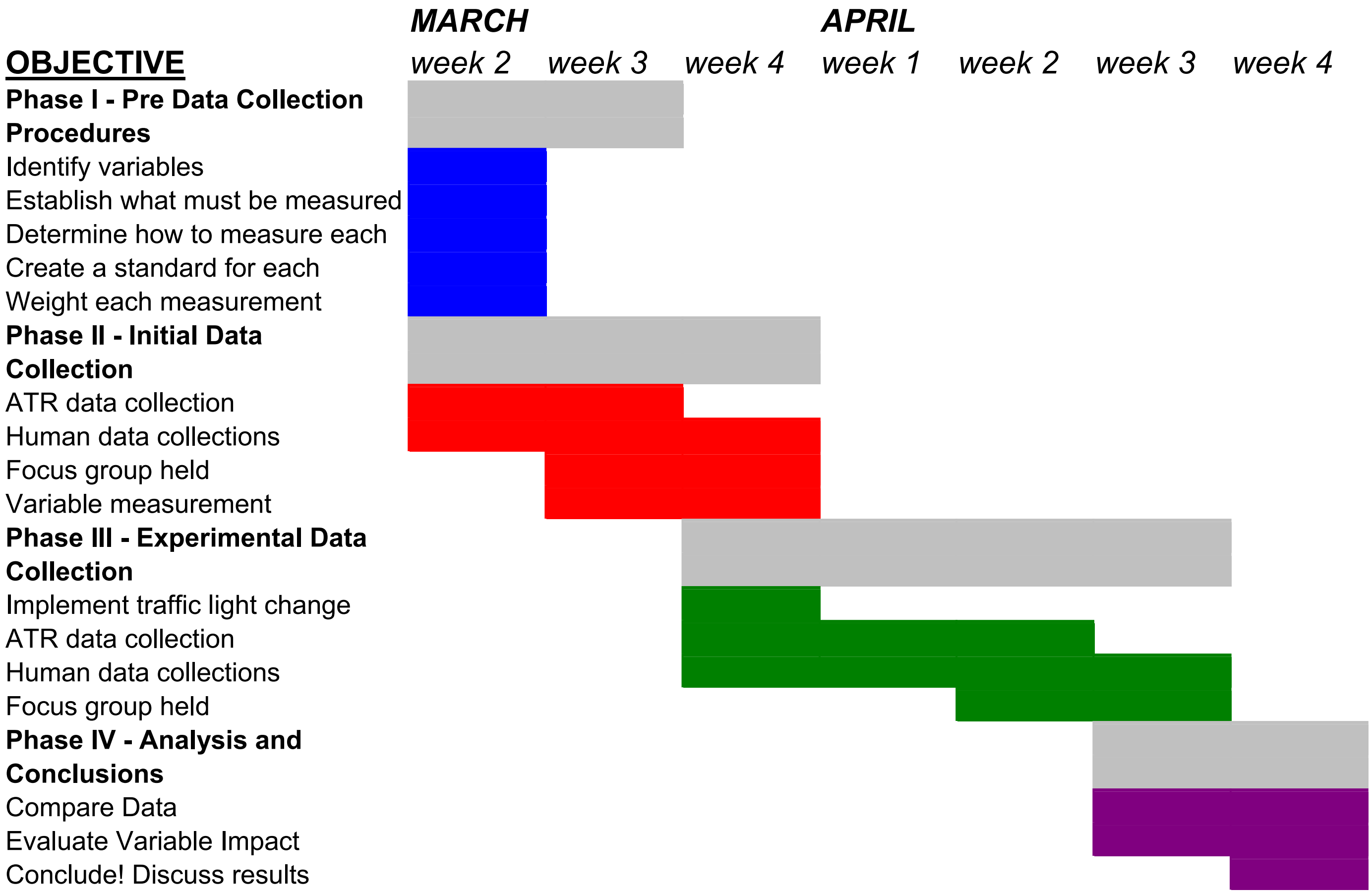
Mass Institute Of Technology
Audrey St
Copyright: GDT

Appendix C: Proposed Project Schedule

Cambridge Traffic Group D04



Legend
>Gray area indicates ideal time for section of project
>Colored areas indicate ideal time for particular task
Our report is assumed to be written throughout our time in Cambridge
Some initial ATR data may be taken before our time in Cambridge