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Medical Emergency Command Assessment and Security

By

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An Interactive Qualifying Project

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ABSTRACT

The need for a shortened response time is always a main goal of all EMS systems throughout the world. But how to obtain that objective is an issue standing in the way of this goal. In this report the MECAS Group will identify the main causes of the delayed EMS response time in the city of Worcester, MA.

Through a process of interviews, comparisons, and research the MECAS Group will come up with the causes for this delayed response time and use those causes to model our recommendation for the city of Worcester. By observing past incidents and present communication methods and dispatch command structures, we can vet Worcester Medical Services and improve their response time. Because of our proximity to the city, and its distinguished success in the emergency response time, the MECAS group is focusing on Boston to determine the ways to best improve the command structure and response time of Emergency Medical Services in the city of Worcester.

Through this active research the MECAS Group has learned and portrayed the best method to reduce the response time for Worcester. The MECAS Group will also identify the areas that might work for other cities like Hong Kong or Boston but that will not work in Worcester due to limitations of the city.

With months of research and evaluation behind us, the MECAS group has created a new command structure model for the emergency medical responders in the city of Worcester. By incorporating other response system strategies into that of the city of Worcester, the MECAS group is able to permanently reduce the overall response time for EMS units throughout Worcester and in turn, save lives.

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ACKNOWLEDGMENTS

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CHAPTER 1. EMS COMMAND STRUCTURE ASSESSMENT AND RESPONSE TIME IMPROVEMENT

The purpose of this report done by the MECAS group within the MIRAD Laboratory is to assess the current command structure of EMS services within the city of Worcester, MA. In order to fulfill this goal we research the command structure for EMS services that is currently in place. This includes but is not limited to collected data on the processes of the command structure, interviewing EMS service employees, and collecting data from previous studies relating to the issue at hand. We are also able to assess command structures of other significant organizations to compare efficiency and acquire knowledge for improvements. Once the research and analysis has been completed the MECAS group can derive, through the data, a series of proposals for improvement of the command structure that, in turn, will improve EMS response times.

In Chapter 2, we must justify our project. To do this we collect data on the current response times of EMS services in the area to portray that the need for some type of response time improvement is needed. Next we must link the response time to the command structure of the entire EMS services. The information gathered from interviews with EMS and hospitals in the Worcester and Boston areas will be evaluated. Suggestions from the EMTs themselves on how to improve response time give the MECAS group specific areas to focus on.

In Chapter 3, we present our series of suggestions and even an entire revamp of the current command structure of EMS services. We display our revamped command structure through flowcharts and diagrams. We can then simulate a call going through the system and identify any stall-points or shortcomings within our design. The data can be collected from running simulated phone calls through our revamped design and interpret it with many different metering techniques that include, but are not limited to, time per call station, scripting of questions, delay in answering, and traffic patterns.

In Chapter 4, the MECAS group describes the final segments of our project. These segments include analyzing the data that we collected throughout the project and applying that to our final design and suggestions. We also will describe the issues and problems that we encountered while accomplishing this project.

The main objective of the MECAS group is to assess the communications command structure of hospitals and EMS garages and improve it in as many ways possible. By focusing on the chain of command, the MECAS group can choose specific steps that can be shortened or possibly even eliminated. Through interviews conducted with EMS as well as hospitals, we are able to gain insight as to where the most critical problems occur, slowing down the entire process. We are focused on evaluating and improving the overall response time of ambulances in Worcester, MA as well as Boston, MA. By creating a new command structure, we are able to shorten the overall time it takes for an ambulance team to respond to an emergency call, and in turn save lives. Although this system is based on information gathered mostly in Worcester and Boston, the system will be created so that it can be implemented in cities worldwide.

CHAPTER 2. BACKGROUND, PROBLEM JUSTIFICATION, AND EXISTING SOLUTIONS

2.1 Current EMS Protocols

This section will provide an overview for the companies used to provide emergency medical services to the city of Worcester and its surrounding areas. Specifications and common information regarding the city of Worcester itself are also depicted. Through this section, the current system is discussed and explained, giving one insight as to the current conditions of the emergency medical services provided in Worcester, Massachusetts.

2.1.1 Overview

UMass Memorial Emergency Medical Service provides medical care for the entirety of Worcester and Shrewsbury. If necessary, UMass Medical expands their area of operation to the towns surrounding Worcester. These towns include, but are not limited to: Millbury, West Boylston, and Oxford. There are six ambulances available for deployment at all times, located in two different garages in Worcester. One location visited is at 23 Wells Street, Worcester while the other is positioned in Vernon Hill at 100 Providence Street, Worcester. At peak hours (before 10:00 pm), five of the ambulances are dedicated to Worcester alone, while the last is designated solely to the town of Shrewsbury. After ten o'clock at night, the number of ambulances available in the Worcester area drops from five to four.

UMass Memorial EMS provides service not only for the Worcester and Shrewsbury areas, but also several of the colleges in Worcester. Both Worcester Polytechnic Institute and Worcester State College use UMass Memorial as their go to Emergency Medical Service provider. The College of the Holy Cross, Clark University, and Assumption College all use private EMS services. If the call volume is too high, UMass Memorial can call these private services for backup. There are seven ambulance hubs in Worcester besides those of the hospitals. The two most popular back up Emergency Medical Services are Vital and MedStar Ambulance. The other five are Lifeline Ambulance, Ruggerio Ambulance Incorporated, Quality Chairvan Services Incorporated, Marlboro Hudson Ambulance Services, and American Medical Response.

There are two Emergency Medical Technicians in the ambulance at all times. One remains in the back of the ambulance while the other drives, switching off every call. Although there are three different levels of Emergency Medical Technicians, UMass Memorial Emergency Medical Service only has Paramedics, the highest level of EMT. Each paramedic works shifts of eight, twelve, or sixteen hours. With around forty three full time paramedics and forty per diem employees, there is an efficient mix of workers allowing for proper rest time between shifts

2.1.2 Worcester, Massachusetts

The current population of Worcester, Massachusetts according to the most recent census is 182,421, making it the second largest city in New England. Worcester has a land area of 37.6 square miles. This means on average, there are 4,857 people per square mile.

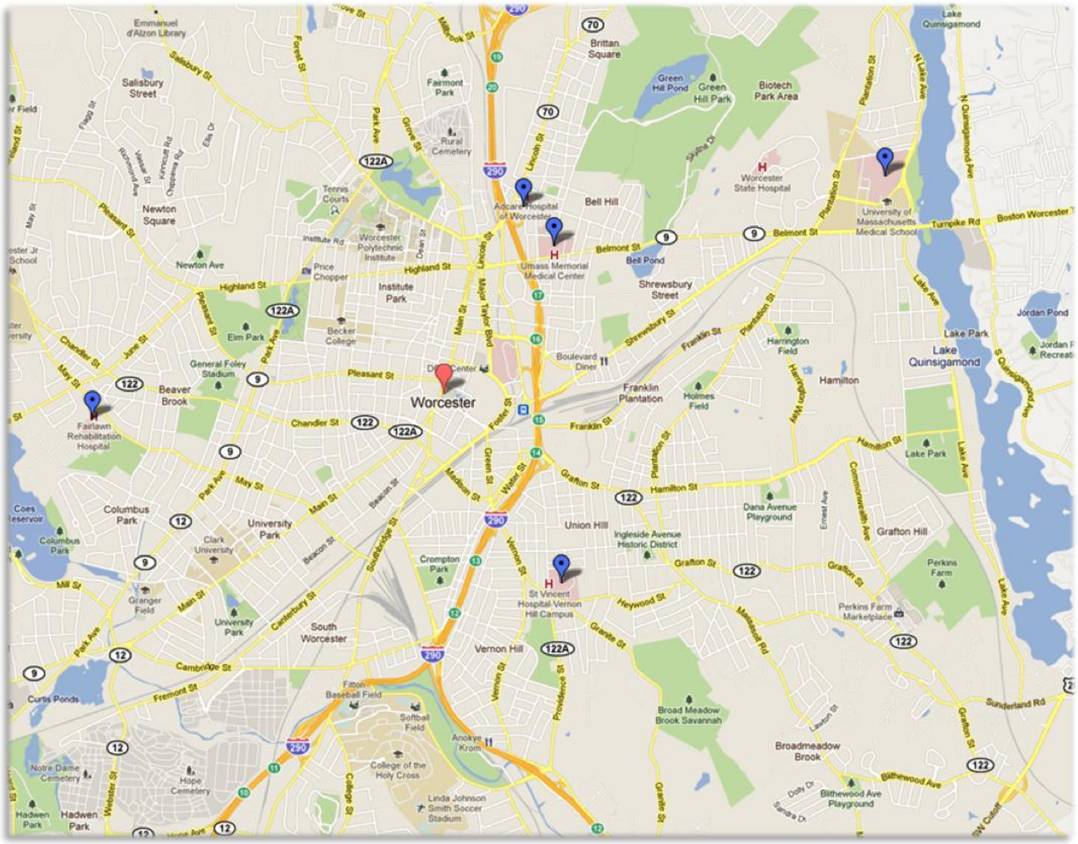

Figure 1: Map of Worcester (Hospitals Plotted)

There are five hospitals within the city limits of Worcester, Massachusetts. Of these five, only three have a trauma center. The hospitals with a trauma center include UMass Memorial Hospital, UMass Medical School, and Saint Vincent’s Hospital. The other two hospitals are Adcare Hospital of Worcester and Fairlawn Rehabilitation Hospital.

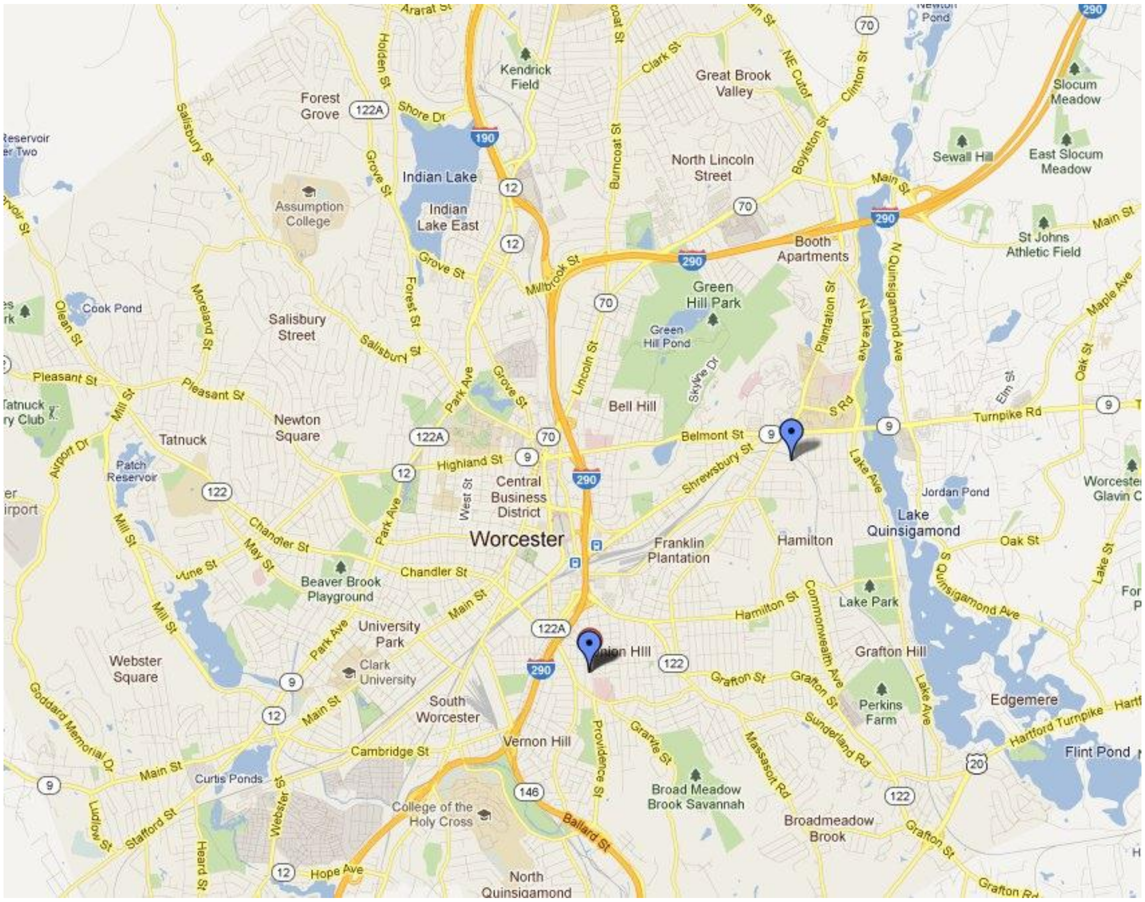

Figure 2: Map of Worcester (Ambulance Hubs Plotted)

2.1.3 Current Equipment

With between one hundred and one hundred twenty calls per day to UMass Memorial Emergency Medical Service, an average of eighty ambulance deployments happen daily. This averages out to about thirty five thousand calls per year. According to the Chief Paramedic Steve Hayness, around seventy five percent of the calls for patient assistance end up being transported. Because of this high call volume and the vast land area of Worcester, the UMass Memorial ambulances gain mileage quickly.

Every year, one to two new ambulances are purchased by the city for UMass Memorial Emergency Medical Service. Generally, an ambulance is replaced after one hundred thousand miles. The ambulances with mileage between 100,000 and 180,000 are used as back-ups.

Because of the wear and tear from Worcester roads and the constant mileage being put on the ambulances, the average lifespan of the UMass ambulances is generally only a few years. Below in Figure 3 and Figure 4 are images of Government Issued and Non-Government Issued Ambulances.

Figure 3: Government Issued Ambulance (UMass Memorial EMS)

Figure 4: Non Government Ambulance (Private - Vital)

The manufacturers of the ambulances vary depending on what the City of Worcester decides to purchase that year. From the visit with the UMass Memorial EMS garage located at 23 Wells Street, the trucks vary not only in brand but in size. One of the trucks is a GMC while the other two currently in the garage are a Ford F-350 and a Ford F-450. The actual cabin in the back is manufactured by Horton Emergency Vehicles. None of the trucks purchased have four-wheel drive.

2.1.4 Current Protocol: Worcester

In this section of Chapter 2 we outline the current protocol for handling emergency calls for the city of Worcester. This protocol is very similar to what the entire state of Massachusetts uses, with the sole exception of Boston. The city of Worcester Emergency Response Department falls into the EMS Region II within the state of Massachusetts. EMS Region II includes all of

Central Massachusetts. Below in Figure 5 is a map of the entire state and the divisions of the regions along with the plotting of level one-trauma centers in the state.

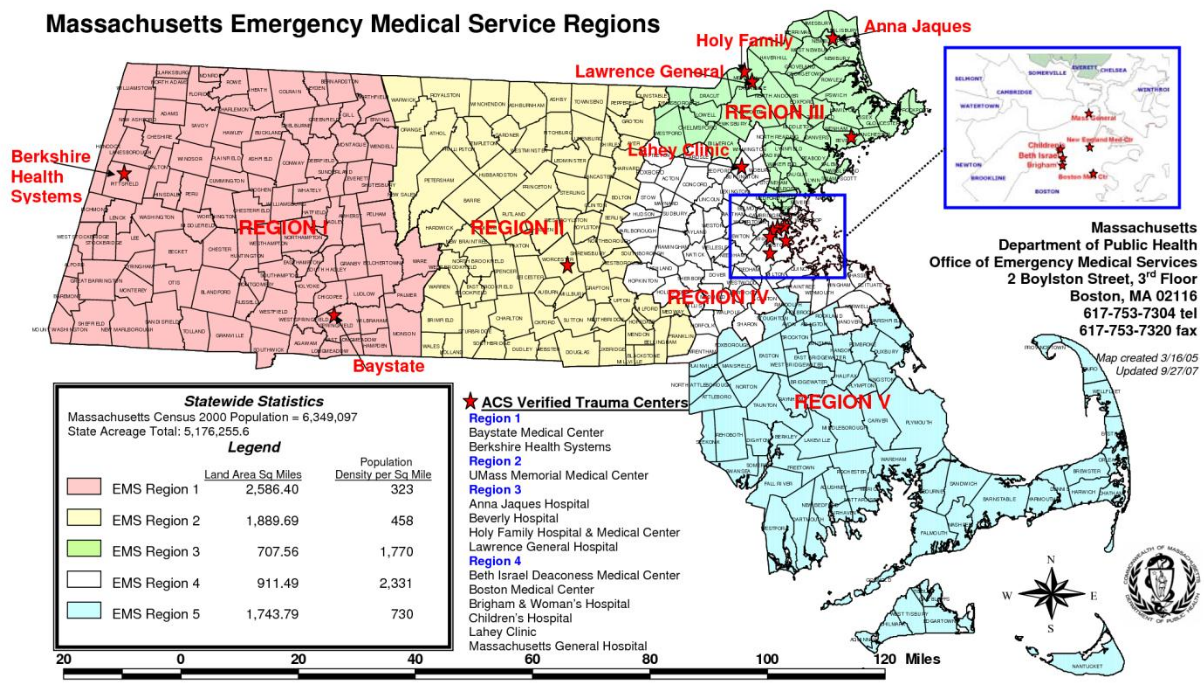

Figure 5: Division of EMS Regions in Massachusetts

All five of the regions in the state of Massachusetts follow The Massachusetts Department of Public Health. Every few years this department releases their Massachusetts Emergency Medical Services Radio Communications Plan, MEMSRCP for short. In this report are the guidelines for all EMS response methods. Including a flowchart diagram of what happens to every 911 call that comes in. Below in Figure 6 is the flowchart of what happens to every call.

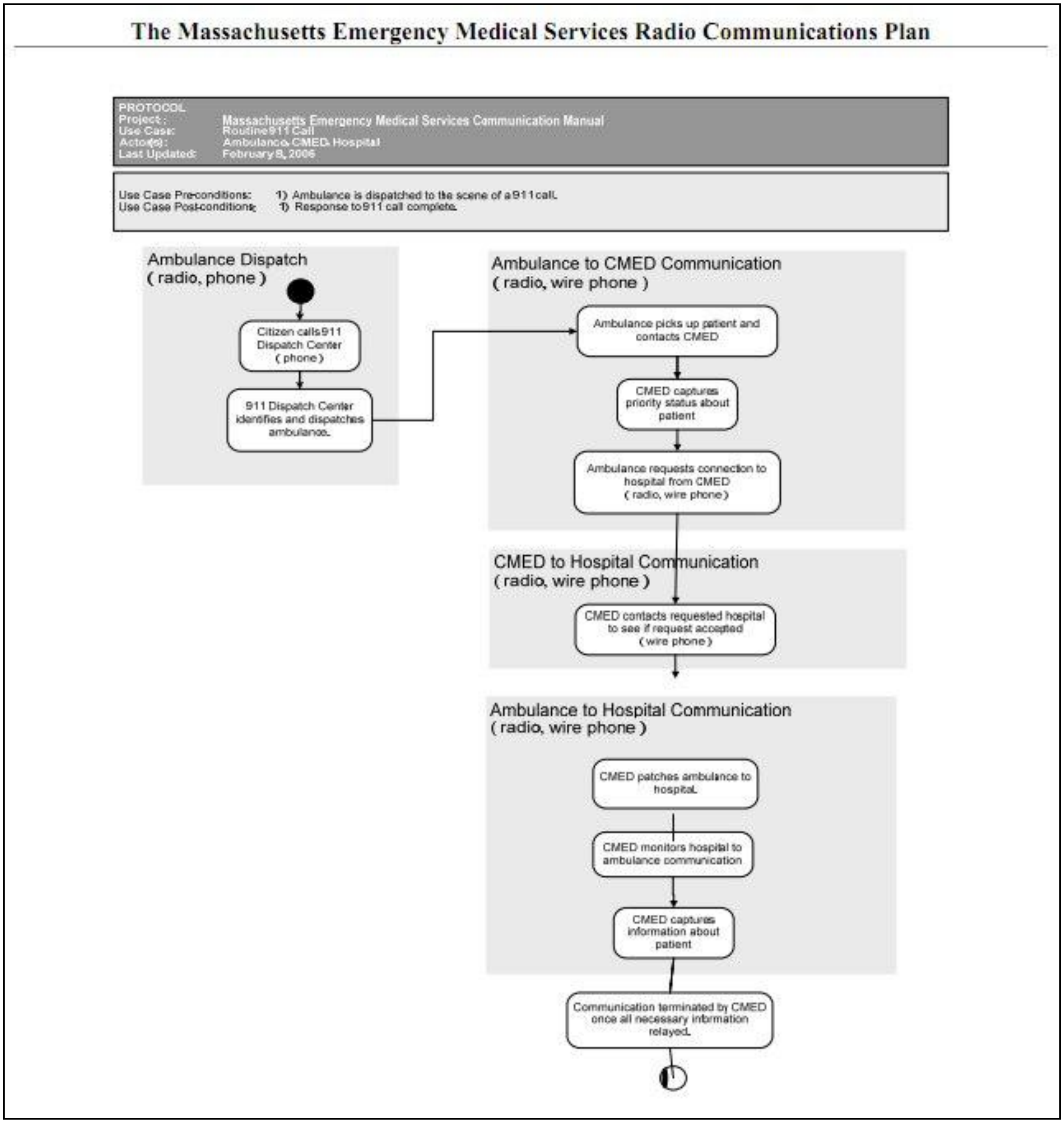

Figure 6: Flowchart of Massachusetts Emergency Calls

One can see from the flowchart above that the process is very straightforward. The call comes in to the dispatcher and an ambulance is dispatched to the scene immediately. Then, once the ambulance has picked up the patient, the ambulance contacts CMED (Central Medical Emergency Direction). CMED acts as an external dispatcher between the ambulance and local hospitals. CMED will be discussed further in Section 2.1.6. The ambulance then takes the patient to the directed hospital, where the hospital is expecting them and has been in contact with the ambulance and CMED. When the ambulance arrives at the hospital a report is handed from paramedic to doctor and the process then ends.

2.1.5 Boston, Massachusetts

The daytime population of Boston, Massachusetts hovers around 1.2 million people. With a land area of around 45.7 square miles, the population density is determined to be 26,260 people per square mile.

The Boston EMS unit employs 358 uniformed staff members and forty four non-uniformed workers. With 241 Emergency Medical Technicians and seventy paramedics, the Boston EMS team's seventeen different stations are constantly in use. Although there are nineteen basic life support units and five advanced life support units on the road at all times during peak hours, the Boston Emergency Medical Service owns over fifty ambulances. This allows for backup trucks to always be available regardless how many technicians are on the road at one time.

2.1.6 CMED

In this section CMED will be dissected and explained. CMED, which, as stated before, stands for Central Medical Emergency Direction, is a critical part to the radio communication plan put forth by The Massachusetts Department of Public Health.

CMEMSC is an external company that is run like a private company but it is actually a division of The Massachusetts Department of Public Health. CMED is a division of CMEMSC and one of its most important entities. The headquarters for CMEMSC are conveniently located in Holden, MA. This falls in EMS Region II (See Figure. 5.) in Massachusetts and is located in the town next to Worcester.

CMED holds a critical part in the process of getting the patient to the hospital from the time of the initial 911 call. Once the ambulance obtains the patient CMED is contacted. CMED takes information from the paramedics about the patients and determines the priority of the patient. Based on this priority, CMED then contacts the appropriate hospital for the patient. Once the hospital is contacted, CMED sees if the request for the patient to be sent there is accepted by the hospital. IF the request is accepted CMED then patches the ambulance to the hospital. From here the hospital is in constant contact via radio or wire phone with the paramedics in the ambulance but CMED still stays on the line and monitors the communication. CMED captures and documents the information about the patient and once the patient reaches the destination the communication with CMED is terminated (3). This process that was just described in words can be seen below in Figure 7.

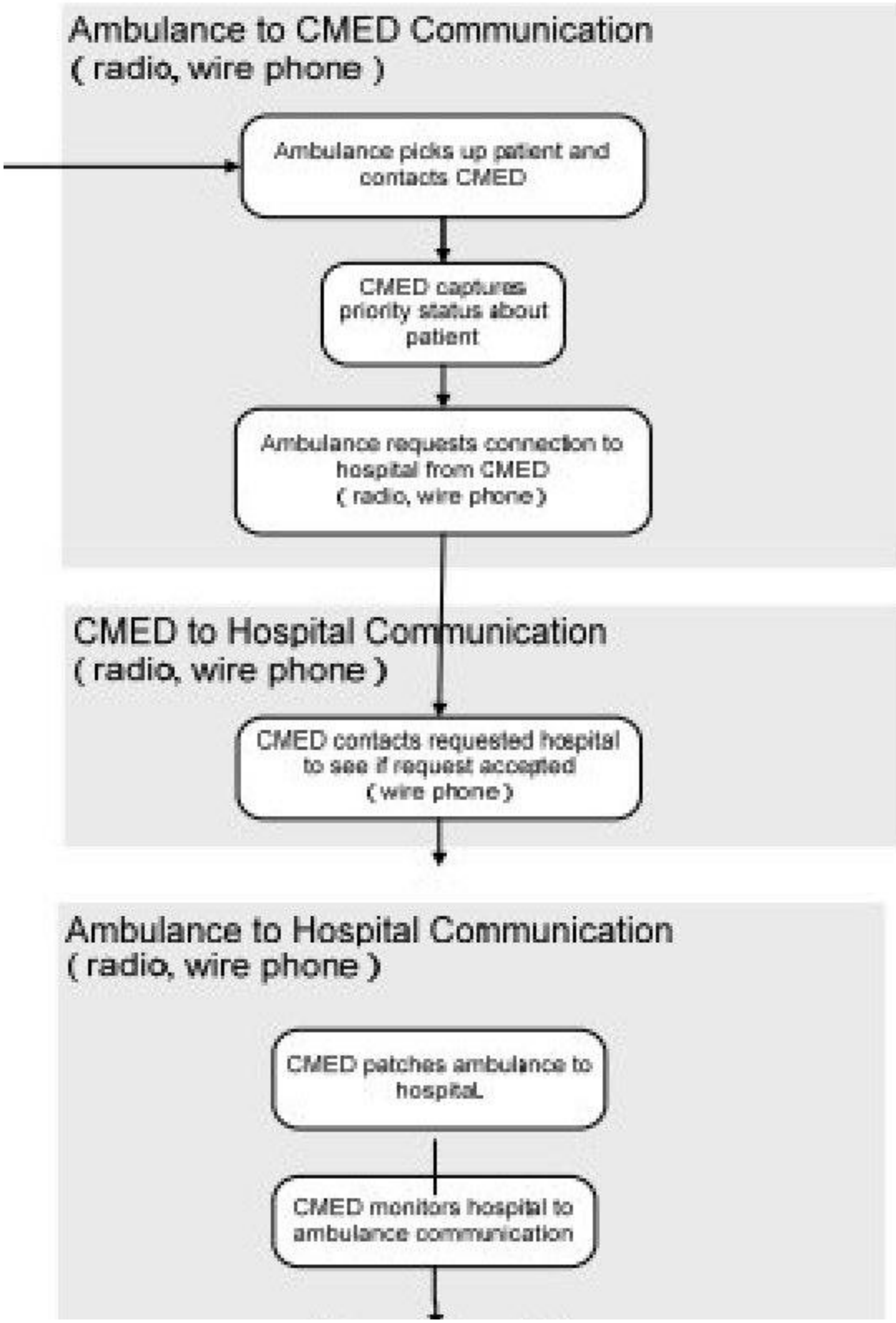

Figure 7: CMED Flowchart

Adding more to the formulation of the priority of a patient, there is an equation behind the very important priority. The priority determines where the patient should be transported to and which doctors to notify of his/her arrival. Below is a description of the levels of traumas that CMED has set forth.

Priority Call Guidelines

PRIORITY ONE (Immediate Life Threatening)

Cardiac Arrest

Unstable Cardiac

Major Head Injuries

Multiple Trauma

Unstable GI Bleed

Acute Pulmonary Edema

Respiratory Arrest

Airway Obstruction

PRIORITY TWO (Life Threatening)

Suspected Cardiac

CVA

Coma (unknown etiology)

Unstable Trauma

Unstable Medical (e.g., hypoglycemia)

Symptomatic Cervical Injuries

Suspected Fractures/Dislocated Joints

PRIORITY THREE (Non-Life Threatening)

- Stable trauma:
  - Minor Lacerations and Soft Tissue Injuries
  - Suspected Minor Fracture without Circulatory or Nervous System Compromise
- Other Non-Acute Medical Complaints

PRIORITY FOUR (Stable)

- Interagency Transfers
- Direct Admissions

One can derive that CMED is a very essential part of the current system for handling emergency calls. Without CMED, the transaction of information about the patient between the ambulance and hospital would be lost. CMED also catalogs all the information for each patient into a database that is used for records in the future and for the Massachusetts Department of Health productivity analysis.

CMED uses a network of radio towers throughout Central Mass., EMS Region II. Below is map of the regional towers; this map is referred to as Figure 8. (Central Mass EMS [7])

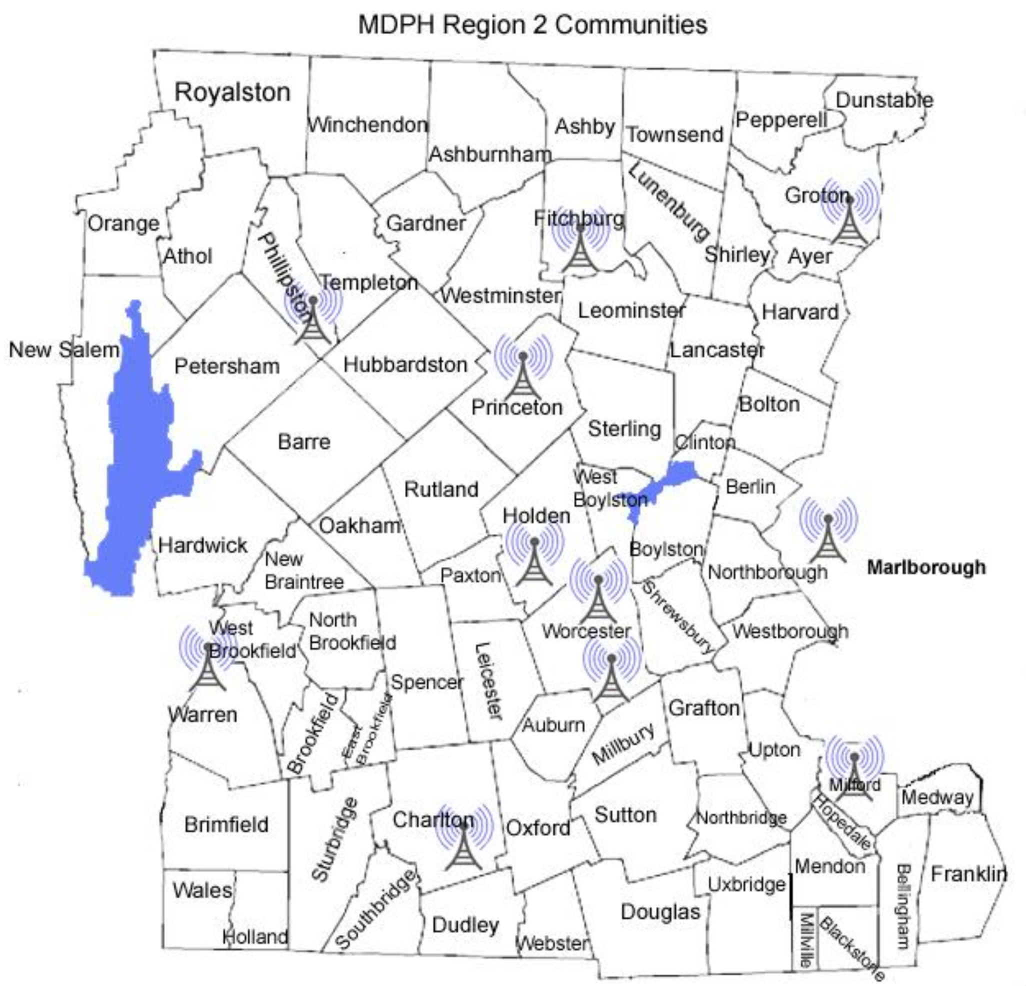

Figure 8: EMS Region II Radio Tower Map

2.2 Problems with Current System

There are many places for improvement in the current emergency response system. Some of these problems involve uncontrollable issues, like weather. Despite the fact that some of these complications are unrelated to the UMass Memorial Emergency Medical Service, others can be evaluated and improved upon.

In this section, we discuss problems with the current emergency response system. These problems are based on research, and are gathered prior to the interviews conducted with Emergency Medical Technicians, hospitals, and the police.

2.2.1 Navigation/Patient Location

Upon dispatch, the paramedics must know the most efficient way to get to the patients location. If the paramedic is unfamiliar with the area, a global positioning system (GPS) can be of use. Unfortunately, this only adds to the response time because of the time it takes to input the address into the system. Additionally, there is a chance the GPS might be faulty, or not give the most efficient directions.

Another factor in this equation is if the patient is unaware or unsure of their location. This will obviously inhibit the paramedic's ability to arrive within the set 8-minute response time.

2.2.2 Traffic

Being the second largest city in New England, Worcester's streets are constantly flooded with moving vehicles, regardless of the time of day. This poses a problem for ambulances because the more traffic there is on the roads, the slower the paramedics arrive on scene. Because actually driving to the location itself encompasses most of the response time, the faster an ambulance can move through the streets the higher the chance the patient will be safe. Despite laws implemented telling drivers they must pull over for emergency vehicles, the more traffic on the roads, the slower the ambulance must drive in order to prevent recklessness.

We have identified to high-volume areas in Worcester that have a vast effects on the overall response time, we can refer to these points in the city as ‘choke points’ from here on in the document. Below is a figure of a section in Worcester, Figure. 9. In the figure we have identified two choke points in the city with the highest impact. Also notice the coloration of highway 290W/E. Red coloration is a distinct mark of high traffic areas and green coloration means less traffic.

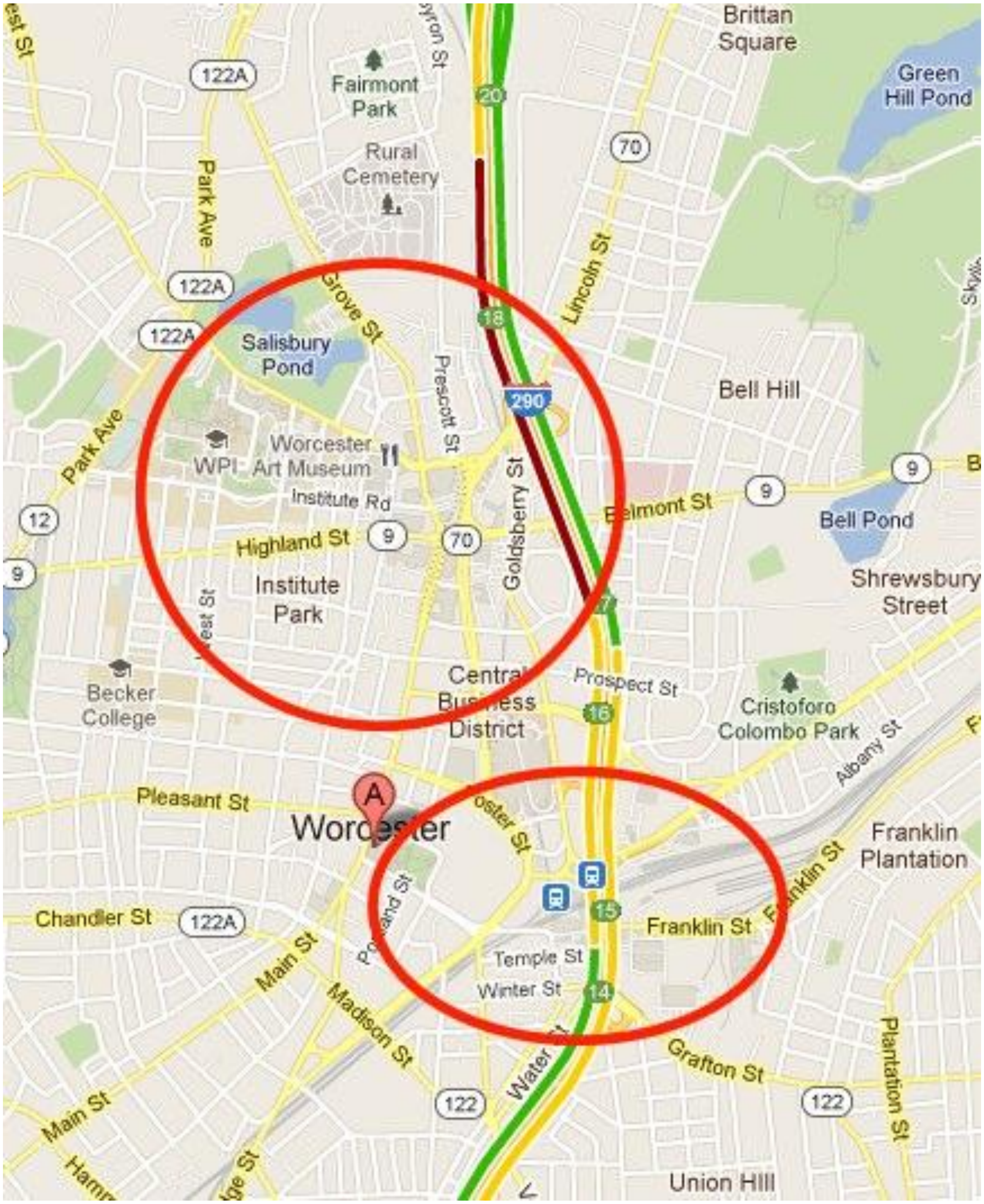

Figure 9: Map of Traffic "Choke Points" In Worcester

2.2.3 Weather/Road Conditions

Because we are located in New England, climate change plays a huge effect on driving conditions. In the winter, snow can seriously inhibit the ambulance driver's ability to arrive on scene within eight minutes. Ambulances without four-wheel drive would have significantly more trouble traveling roads slick with ice and snow.

In the summer, the damage done by the sand and salt applied to the roads in the winter takes its toll on the street of Worcester. This can cause particular streets to wear down and become much harder to drive on. In some cases, the streets with the most damage might have to be avoided, possibly changing ambulance routes.

2.3 Interviews

In this section, we compile and elaborate on the information gathered from interviews with many different medical sources. Through questioning the UMass Memorial Emergency Medical Services, the hospitals in Worcester, and the Worcester police, we are able to gain insight as to the problems faced by the people working on the inside. Suggestions made by people in any profession involving saving lives can only further benefit this project's outcome.

Before beginning any interview, research is done in order to provide a knowledge base for the interviews. Prior to each interview, a questionnaire is produced using the information from our research and what we still need to discover.

By extending our research past Worcester and into Boston, we are able to compare two different emergency medical response systems. Because Boston is a much larger city, there is much to learn from studying this much larger and intricate emergency medical service and response structure.

2.3.1 UMass Memorial Emergency Medical Service

Table 1: UMass Memorial EMS Interview Questions

Questions	Response
Name of Organization	UMass Memorial Emergency Medical Service
Number of Ambulances Available	6 (5 Worcester, 1 Shrewsbury)
Number of Drivers	2 (1drive, 1 in cab)
Average Calls per Day	100-120 (~35,000/year)
Number of Paramedics	43 full time, 40 per diem (all EMT-Paramedic)
Average Response Time	8-9 minutes
Ambulances Purchased per Year	1-2
Average Lifespan of Ambulances	1-2 years (replaced after ~100,000 miles)
Ambulance Manufacturer	Ford, GMC, Horton Emergency Vehicles
College Affiliations	WPI, Worcester State

The most common areas of focus for the UMass Memorial paramedics are the areas with heavy gang activity. Vernon Hill produces the most calls, and Belmont Hill is another popular area for gang violence. Fortunately for the UMass Memorial Emergency Medical Service, their 100 Providence Street location is situated in Vernon Hill. This close proximity allows for quicker responses to the most popular area for emergency calls.

Once the emergency call is placed to 911, there are several crucial next steps that all take place in a matter of minutes. If the caller is using a cell phone, the call is directed to the Massachusetts State Police Department, and then from there it is transferred according to the seriousness of the call. On the other hand, if the caller is using a Worcester or Shrewsbury landline, it is transferred to the Emergency Medical Service communication center. Regardless of where the call comes from, the next step is for the dispatcher to ask and decide if police and firefighters are necessary. Generally, firefighters are the first responders, arriving in an average of four minutes. The firefighters are followed by the Emergency Medical Service, whose average response time is between eight and nine minutes.

The dispatcher calls the appropriate Emergency Medical Service garage and describes the situation to the paramedic. The police station located at 911 Lincoln Street chooses whether it is necessary to dispatch police and firefighters as well as EMS. The paramedics are dispatched in their appropriate ambulance, and “sign off” the moment they arrive on scene. Dispatch also has the ability to provide instructions over the phone in order to help the patient. This is significant for situations such as one where a patient needs CPR.

Once the paramedics arrive on scene, there is extremely limited contact with the hospital. Because of this limited contact, all paramedics are trained to follow “Standing Order.” Standing Order is standard paramedic protocol, reflecting physician developed medical orders.

2.3.2 Boston Emergency Medical Service

Table 2: Boston EMS Interview Questions

Questions	Response
Name of Organization	Boston EMS (Boston Public Health Commission)
Number of Ambulances Available	150+ in total throughout Boston
Ambulances Available (type/day)	19 BLS/day (12-13 at night) 5 ALS/day (3 at night)
Number of Drivers	2 (1drive, 1 in cab)
Average Calls Responded to per Day	12-14 (10 hour shift)
Number of Paramedics	300 EMT-basic; ~150 EMT-Paramedic
Average Response Time	Priority 1: under 4 minutes All other calls: 7 minutes
Ambulances Purchased per Year	~10
Ambulances Retired per Year	~10
Average Lifespan of Ambulances	~3 years (75% have over 100,000 miles)
Ambulance Manufacturer	GMC, Braun
Hospital Affiliations	None (therefore no financial incentive)

Due in large part to Boston's large population, the Boston Emergency Medical Service runs at a much higher capacity than UMass EMS. With not only a greater population density, but also a much larger area to physically cover, the Boston EMS must be extremely efficient in order to be successful. There is a lot that can be learned from the way the Boston Emergency Medical Service receives and executes emergency calls.

To begin, each Emergency Medical Technician must go through several months of training at an Emergency Medical Service Academy in Boston. Regardless of where and how extensively each technician has been trained before, upon entering the Boston EMT force they must all go through the same steps in the academy in order to be a paramedic for the city of Boston. Each year, the academy produces a class of approximately thirty five new paramedics. Training in the academy includes classroom hours to learn and understand the rules and regulations of the different levels on Emergency Medical Technicians, but also includes weeks of on-site training to ensure the new EMT is able to handle any situation presented to them. Each EMT is also responsible for learning to properly and safely operate each of the vehicles provided to the Boston EMS staff at any given time.

The Boston Emergency Medical Service dispatch and command structure varies from that of UMass Memorial. Once the call is placed, it is sent directly to the 911 operator. At this point in time if there is a language barrier, the call can be sent to a translator from an outside service. The 911 operator decides whether to patch the call through to the Boston Fire Department, Police Department, or Emergency Medical Service. It is not unusual for more than one of these three departments to be called, particularly in situations like large accidents or places where violence is known to be common.

Once it is determined that the call must be sent to the Boston EMS, there are Emergency Medical Technician call-takers waiting to enter the call into the system. Here, a series of very specific questions is asked to the caller. Based on the answers the caller provides to these questions, the EMT call-takers place a call to a dispatcher. The dispatcher is also an EMT and they are the one who chooses what kind of care is necessary to send to the patient.

Although Boston EMS garages carry many types of emergency response vehicles, they can be broken down most simply into two categories: Basic Life Support (BLS) and Advanced Life Support (ALS). The City of Boston and Boston EMS give a basic definition of both of these terms:

- Basic Life Support (BLS): An EMT unit or the advanced procedures and skills performed by an EMT-Basic. At peak times there are typically nineteen BLS units in service, each staffed by two EMT's. BLS units are only able to administer about six different drugs to patients on scene.

- Advanced Life Support (ALS): A paramedic unit or the advanced procedures and skills performed by a Paramedic. At peak times there are typically five ALS units in service, each staffed by two Paramedics. ALS paramedics can administer over thirty drugs to the patient, as well as sedate or breathe for the patient, if necessary.

The Boston EMS force is unique in that they have a separate EMS garage for every single district. These ambulances are referred to as "district trucks" because they each correspond to a specific police district. This strategy allows an emergency technician to become extremely familiar with their surroundings. This is also significant because having an ambulance garage to correspond each police district allows the Boston Emergency Medical Service to break down the largest city in New England into smaller, much more manageable segments. (City of Boston [8])

Figure 10: Boston EMS Ambulance Garages

After interviews with Damien Brown and Kevin Hunter, two Paramedics with at least four years each under their belt with Boston EMS, insight can be given as to the different abilities of each of the ambulances and emergency technicians on the road. Kevin and Damien drive what is known as a "zone impact truck." On any given day, there are four of these zone impact trucks on the road in the city of Boston. Instead of being designated to one specific zone in Boston, these zone impact trucks roam Boston to help in any situation they can. Although there is no ALS zone impact ambulances, the drivers themselves can still be EMT-Paramedics (i.e. Damien and Kevin). Zone impact trucks are also significant because they arrive on the road before the district trucks despite the fact that their shift ends after the regular district ambulances. These trucks also allow for focus to be shifted on areas where accidents and Emergency Medical Service call volume are seemingly higher.

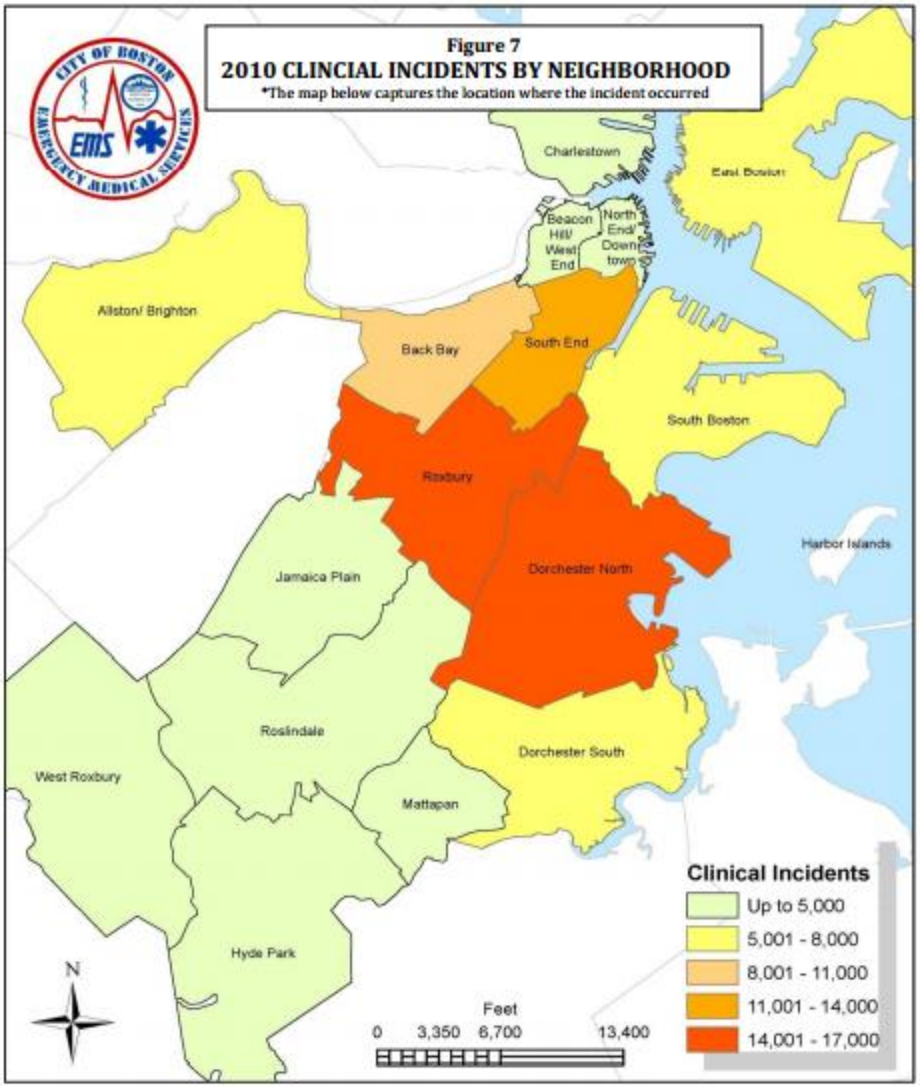

Figure 11: 2010 Clinical Incidents by Neighborhood

As illustrated above, some districts in Boston have three times as many incidents as others. Having stations in each of these districts, as well as roaming emergency medical technicians allows for focus to be shifted to districts where accidents are more common, if necessary.

The UMass Memorial Emergency Medical Service team mentioned specific areas where incidents and accidents are more common. Luckily, the two ambulance hubs they have in

Worcester are both located near these areas of high call volume. Because Boston is so large in terms of both land and population, there are many more ambulance hubs than in Worcester. Some of the ambulance hubs also contain the EMS station, but there are also a few emergency medical service stations found separate from the ambulance hubs. This is illustrated in the figure below.

As shown, many of the garages and stations overlap. It can be noted that in places like Roxbury, where call volume is highest, there is a station and garage together but there is also an additional station located on the other side of the district. As recent as July 2010, a new ambulance station was opened in Chinatown. This new position allows the city of Boston to locate two more ambulances in a densely populated are near downtown Boston, only increasing the accessibility of the emergency medical services.

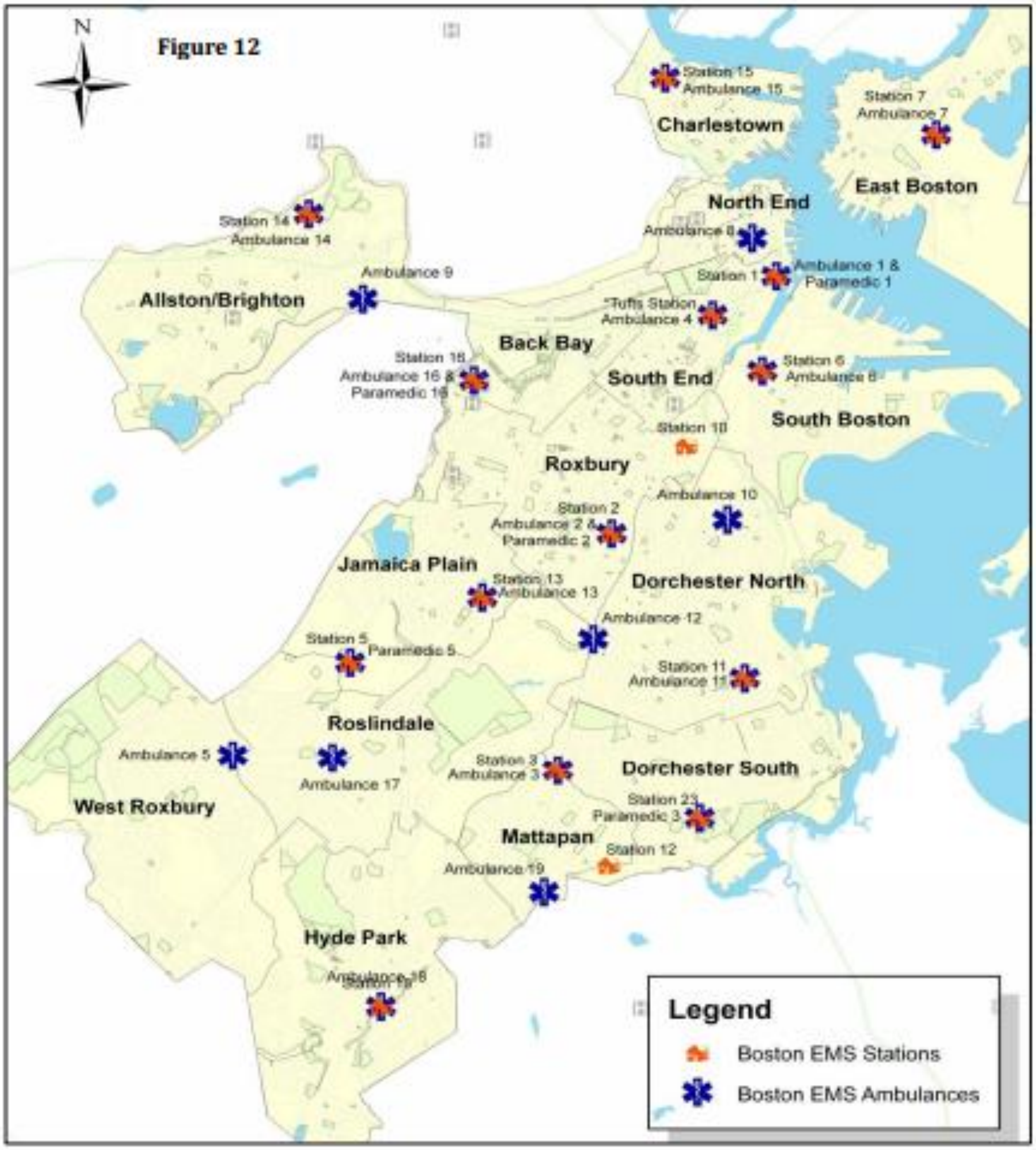

Figure 12: Boston EMS Stations and Ambulance Hubs

2.4 Most Prominent Problems (post Interviews)

After conducting interviews with the UMass Memorial paramedics, the Worcester Police Department, hospitals with trauma units in Worcester, and Emergency Medical Services in Boston, we are able to gain insight as to the problems faced by emergency personnel on a daily basis. Each division tells their own story, elaborating on their own difficulties and problems faced with the current emergency response system.

In this section, we compile the key problems demonstrated to us through the interviews conducted. By culminating these complications, we can better evaluate the current response system and therefore implement specific solutions to relevant problems faced by emergency personnel.

2.4.1 Long, Scripted Phone Conversation

The phone script the operator at the communication center has to follow is significantly long, considering the need for speed and efficiency. One suggested solution, given by Chief Paramedic Steve Haynes, is to find out who the caller is and immediately dispatch the ambulance. Once the ambulance has been dispatched, the operator can inquire further and finish reading the scripted conversation to figure out exactly what the caller needs. If it is ultimately deemed that an ambulance isn't necessary for the situation at hand, the paramedics can be recalled.

2.4.2 Response Time Discrepancy

The definition of "response time" is arguable based on the source. Any normal person would say that response time is simply the time the caller picks up the phone to the time the ambulance arrives. On the other hand, an Emergency Medical Technician would argue that response time shouldn't begin to be timed until the time Emergency Medical Service dispatch receives the call from the appropriate communication center. Another inconsistency in the response time measurement is the fact that the clock stops timing upon the ambulance arrival. This poses a problem, because once the ambulance arrives on scene, it could take several more minutes to get to the patient themselves. This problem is particularly prominent in the city, as there are many multiple story residences. It could take several extra minutes for a paramedic to get to a patient on the tenth floor of an apartment complex as opposed to a single-family house. Although there are no federal or state laws regarding Emergency Medical Services' average response time, most EMS committees establish an eight minute or less rule. This eight-minute-or-less rule is supposed to be met ninety percent of the time. While eight minutes may seem relatively quick, especially considering the fact that some ambulances have to travel several miles across the city, it still poses some serious problems. For example, in the situation of cardiac arrest (AHA), brain death and permanent death begin to occur within four to six minutes. The only chance to reverse this is if it's treated within a few minutes with electric shock and advanced life support (ALS). More importantly, the victim's chance of survival drops seven to ten percent every minute without defibrillation (ALS). With this in mind, it is easy to observe that the difference between life and death could be a matter of seconds. It is also important to note that eight minutes, in situations like cardiac arrest, might be too long if one wants to ensure the patient lives.

2.4.3.1 Boston Response Time Definition

While some systems calculate response time from call dispatch until the unit arrives on site, Boston Emergency Medical Service measures response time from call entry to the time it takes the EMT to arrive on scene. The call entry point is described as the point at which a calltaker determines the nature and location of an emergency and enters it into the computer aided dispatch (CAD) system.

Despite this discrepancy in response time definition between Boston EMS and UMass EMS, the Boston emergency medical force still shoots to be below the standard in response time.

2.4.3 Hospital Communication

Another suggestion made by Steve Haynes is the removal of a step in the patient delivery process he considers unnecessary. Once the patient is finally packaged up, the paramedics must call the hospital to give a description of the patient's condition and an estimated time of arrival. Haynes suggests that this step of calling the hospital should be removed because it is considered a waste of time by the UMass Memorial paramedics. As one paramedic is driving the ambulance, the other's sole job is to focus on the care of the patient. If the paramedic in the back of the ambulance is on the phone with the hospital, they cannot give their full attention to the care of the patient. Also, because the hospital is generally extremely busy, they usually aren't ready for the patient upon delivery anyways.

2.4.4 Underutilization of "Neighborhood Health Centers"

A major complaint from the Boston Emergency Medical Service and its technicians comes when the call volume is greater than the ambulances on hand. No emergency medical service is allowed to deny an emergency call. This can become frustrating when call volume is high and someone calls in for a minor injury.

Boston employs Neighborhood Health Centers throughout the city in an attempt to keep low priority calls from clogging up the phone lines. Although these clinics are specifically designed to treat people with minor ailments in order to decrease emergency call volume, many residents still call in an emergency instead.

When calls outnumber the ambulances on hand, the calls have to be prioritized. If the low priority callers referred to a Neighborhood Health Center instead of calling 911, there would be a significant decrease in call volume, in turn increasing the availability of all ambulances and paramedics in the city.

2.4.5 Technology

By comparing the Boston Emergency Medical Service to that of UMass Memorial, it becomes clear that the technology being used in the emergency medical field can always be improved upon. Everything from the type of equipment used for communication between emergency technicians and headquarters to the global positioning systems in the ambulances can be improved upon.

The Boston EMS force has begun to improve the GPS technology inside the ambulances. Upgrades like these can significantly contribute to a decrease in response time. As shown in Figure 11 below, there are several different electronic devices attached to the dash of an ambulance. The large silver box above the center console is an improved global positioning system installed in many of the Boston EMS ambulances. It can also be noted the several different radios located around the center console and dash. These forms of communication have been in use for decades, leaving much room for improvement.

Figure 13: Boston EMS Ambulance (Interior)

2.5 Justification

Response time is crucial to the survival and wellbeing of the patient in distress. A few minutes could mean the difference between life, brain death, or death itself for the patient in trouble. Therefore, it is important to maximize Emergency Medical Service's efficiency when it comes to saving these patients.

The issue of response time has been a topic of discussion and study for years. In this section, we explain the significance for a minimized response time using documented scenarios from past events and studies done in the area of Emergency Medical Services and response time improvement.

2.5.1 A Geographic Information System Simulation Model of EMS

In a study conducted by the Trauma and Emergency Medicine Research Unit in part with the Harvard School of Public Health, ambulance response times in two different districts in Israel are evaluated. Here, the term "The Golden Hour" is discussed, which is derived from the idea that if a patient receives in-hospital treatment within an hour of injury, their chance of survival is significantly increased compared to those who receive hospital treatment after one hour has elapsed. A main factor in this dire need for a speedy response is cardiac arrest, discussed previously.

It is important to note that although there are various national strategies developed for increasing the quality of Emergency Medical Service, there is still the universal benchmark for an eight minute ambulance response time in most countries, not just the United States. The two districts evaluated in this study are vastly different from each other. Carmel is a major metropolitan area with urban neighborhoods and industrial zones. Generally Carmel has heavy traffic loads, although they vary, and has three hospitals. One hospital has a level one trauma center and another has a level two trauma center. Lachish on the other hand, is much more rural, agricultural community. While it has a level two trauma center, the closest level one trauma center takes between thirty and sixty minutes for an ambulance to travel from.

The results of the one year experiment are telling, as it becomes clear that the emergency response system currently implemented in these two counties does not meet the eight minute response time, ninety five percent of the time, requirement.

Table 3: Response Time of Emergency Response Teams (Minutes)

District	Mean ± Standard Deviation	Median	5th Percentile	95th Percentile
Carmel	12.3 ± 9.5	10.1	3.9	26.5
Lachish	9.2 ± 8.2	6.8	3.0	23.0

With eight minutes set as the standard for response time, it is clear that a new solution must be implemented. Regardless of the districts' traits (i.e. urban, traffic, size, population density), it can be observed that the response time numbers do not fit the requirements by any means. In the Carmel district, only 34% of the calls were responded to within the eight minute time frame. In the more rural Lachish district, only 62% of the calls were responded to effectively in less than eight minutes. This data also implies that while urban areas may be smaller in size, they are much harder for ambulances to travel through efficiently and quickly.

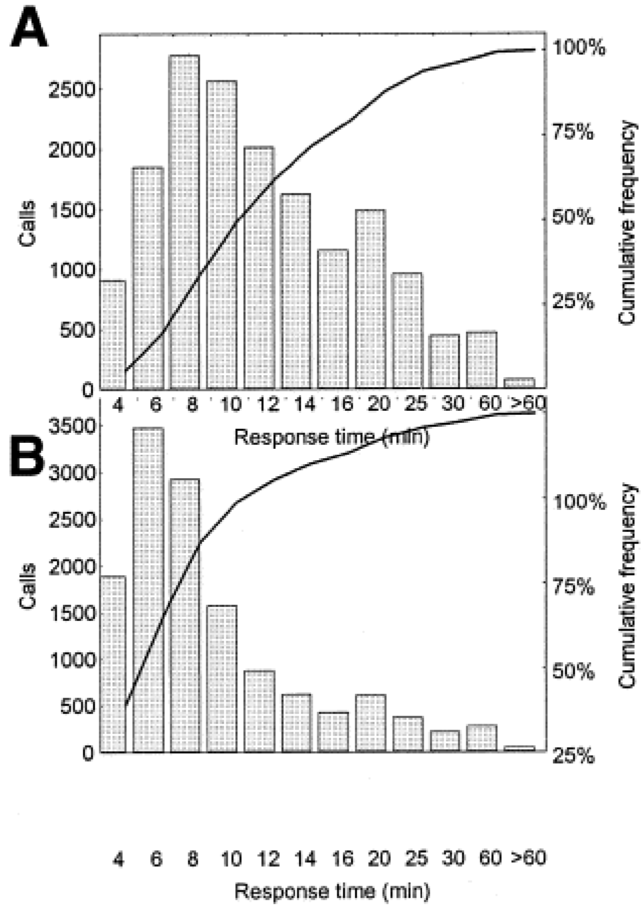

Figure 14: Distribution of Response Times

From Figure 12 it can be observed that while the mode response times fall around the eight minute mark, there are an enormous amount of calls that take much longer than eight minutes to respond to. In some situations, it took ambulances over an hour to respond. In serious situations like cardiac arrest, the patient would be dead long before paramedics arrive. (Peleg, Kobi, and Pliskin [21])

2.5.2 Relationship between Time of EMS Arrival and Survival

Cardiac arrest victims are one of the main reasons for the need to improve emergency medical service response time. In 2010, a study was conducted by the University of Washington School of Public Health and Community Medicine on the relationship between response time and patient survival for victims of cardiac arrest. Using logistical regression, they were able to determine the absolute probability of survival per minute of EMS arrival time.

Using a database of treated cardiac arrest patients kept by King County EMS since 1976, the University of Washington is able to compile information on cardiac arrest patients for recent decades and evaluate the success based on response time.

Table 4: Decline in Survival over Time of EMS Arrival

Time from collapse to EMS arrival	ObservedNo. surviving/total *n*% surviving [95% CI]	Absolute probability of survival using continuous term for time[a]	Absolute probability of survival using spline modeling[a]
1 min	26/6143% [31–55%]	46%	58%
2 min	79/15950% [42–57%]	38%	56%
3 min	183/41844% [39–49%]	32%	54%
4 min	285/70640% [37–44%]	26%	52%
5 min	260/72336% [33–40%]	22%	40%
6 min	162/53930% [26–34%]	18%	31%
7 min	79/30326% [21–31%]	15%	24%
8 min	32/16320% [14–26%]	13%	19%
9 min	21/9422% [15–32%]	11%	15%
10 min	4/439.3% [3.7–22%]	8.8%	11%
11 min	4/3213% [5.0–28%]	7.3%	4.1%
12 min	0/60% [0–39%]	6.1%	1.7%
13 min	0/90% [0–30%]	5.1%	0.6%
14 min	0/20% [0–66%]	4.2%	0.2%
15 min	0/50% [0–43%]	3.5%	0.1%
Average decline in survival per minute	3.0%	3.0%	4.1%

After observing the table above, it is clear how important a rapid response time truly is. For the first six minutes, the probability of patient survival drops at least four percent every sixty seconds. In an eight minute response time, which is the current response time standard for UMass Memorial EMS in Worcester, the chance of a cardiac arrest patient surviving is merely eighteen percent. Through this study, it becomes apparent just how important each minute is. If it is possible to reduce the average response time even one minute, hundreds of lives could be saved every single year. (Gold [12])

2.5.3 Paramedic Response Time: Does it Affect Patient Survival?

In 2008, a study was published in *Academic Emergency Magazine* discussing the effects of response time on patients' survival. This study is based on the general standard eight minute response time, but also focuses specifically on the first four minutes after the patient faces symptoms. Once again, cardiac arrest is a significant topic of conversation, and a driving factor in this study.

This investigation is performed in an urban 911-based ambulance system, much like the one we have implemented here in Worcester. All patients are transported by paramedics to one urban county teaching hospital. Every patient transported to the urban hospital is recorded from January 1, 1998 to December 31, 1998. Of the 34,111 calls that were placed to the Emergency Medical Services in this urban county in 1998, 11,078 patients were transported and studied. One important factor in this study is that the patients are categorized based on their level of illness severity.

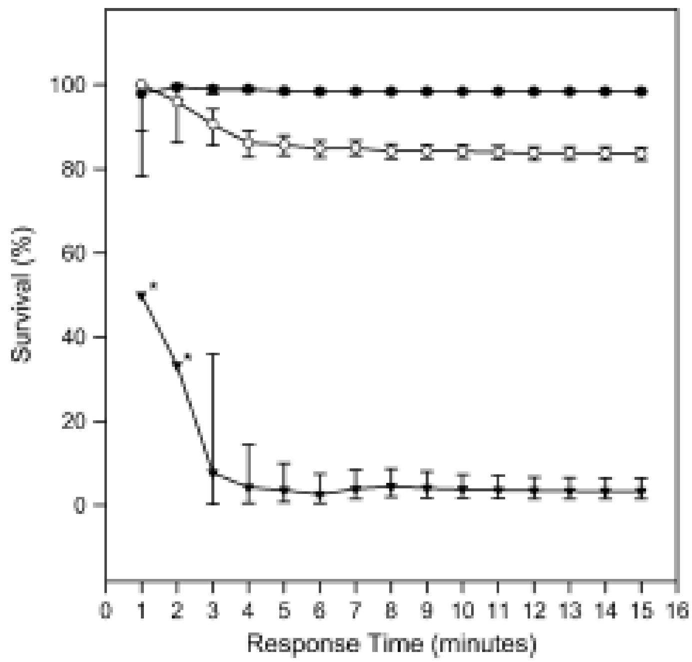

Figure 15: Survival Percentage Based on Response Time

This graph separates patients' illness severity into three distinct categories. The solid circles (top line) represent patients categorized as "low risk," the empty circles (middle line) represent patients categorized as "intermediate risk," and the upside down triangles (bottom line) illustrate the "high risk" group. Any patient suffering from cardiac arrest is placed into the high risk group, while the intermediate group encompasses all suicide attempts, accidental exposures, and unconscious patients.

The low risk patients' chances of survival are extremely high, as represented by the nearly straight line at 100% survival rate. The significance of response time comes into play when we begin to observe the intermediate risk group. Over the course of the first four minutes, the patients' chance of survival linearly decreases from approximately 100% to around 85%. The plot flattens after the four minute mark, with the survival percentage remaining around eighty five.

The magnitude of the first four minutes of response time is truly illustrated after observing the plot of survival rates versus response time of the patients classified as high risk. In the first three minutes, there is an exponential decrease of survival percentage from around fifty after one minute to below ten percent at three minutes. This category includes cardiac arrest patients and is therefore seriously affected by these statistics. It is also important to note that after four minutes of response time for the high risk patients, the plot plateaus at very close to zero percent survival.

This study is a testament to the importance of the first four minutes after the patient faces symptoms of illness. With the standard response time set at eight minutes and even higher in some places, it is crucial that a new system be designed and applied as soon as possible. (Pons [24])

2.6 Currently Implemented Solutions

Before coming up with our own solution to improving response time, it is important to study what has already been attempted in the past. In this section, we discuss previously employed methods for improving the response time of emergency personnel. By studying these previous methods, we can discern what problems people have faced in the past and avoid unnecessary obstructions.

2.6.1 Analysis of Response Time in Carmel and Lachish, Israel

As discussed in the previous section, a study was done on response time of ambulances to emergency situations in two differing districts of Israel from 1996 to 1997.

These two regions are chosen because they cover a range of factors affecting ambulance response time, including distance, traffic, and population density. For a twelve month period between 1996 and 1997, local ambulance calls were recorded for the districts of Carmel and Lachish. Prior to this year, a flow chart was developed to maximize the number of calls with a response time of eight minutes or less. This new method is tested during this twelve month experiment.

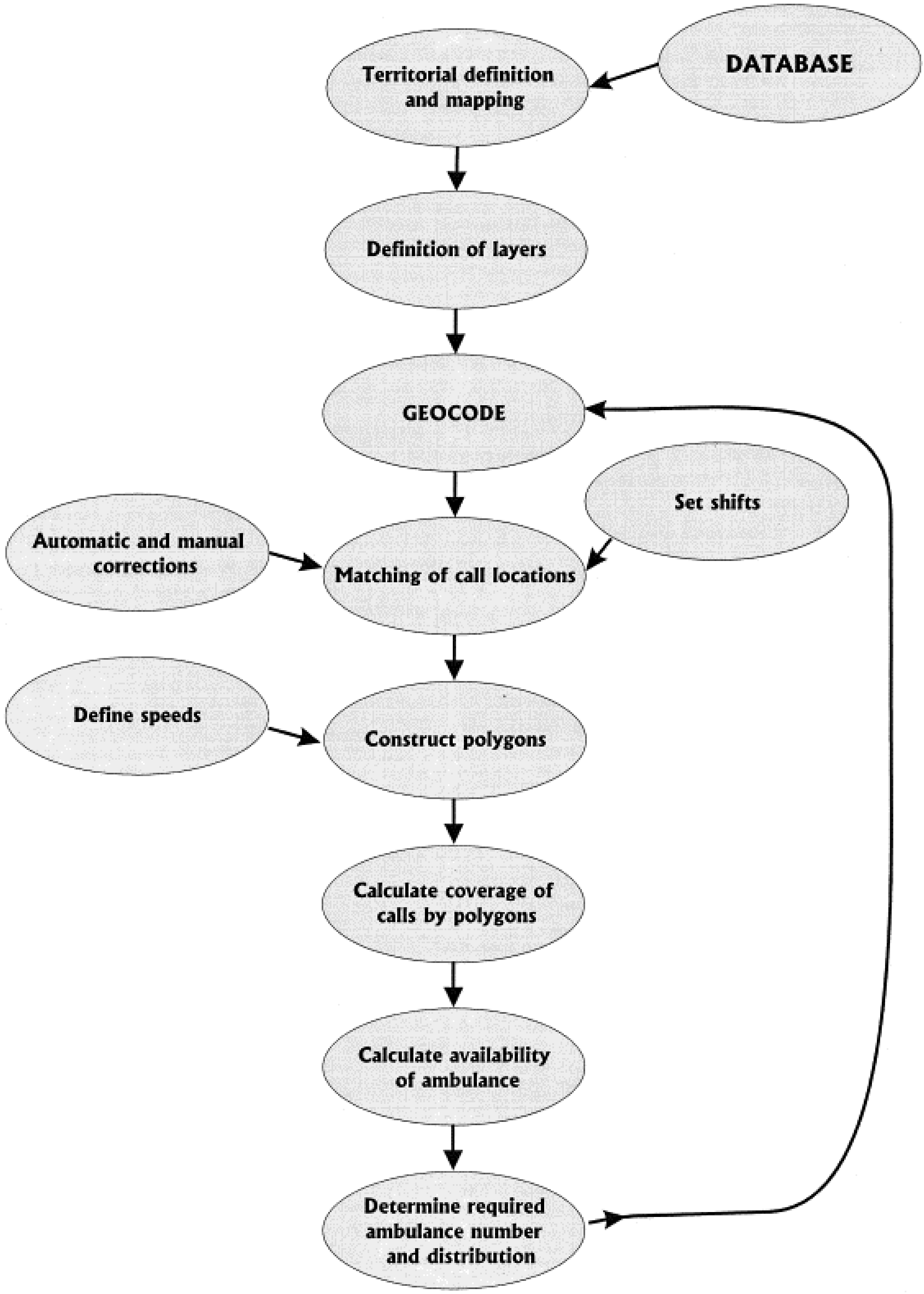

Figure 16: Flowchart to Maximize 8 Minute Response Time

It is important to note that in this study, only emergency calls were analyzed. This means that non-emergency calls like minor trauma or transporting pregnant women are not taken into account.

Unfortunately, after the one year experiment was complete and the statistics were evaluated, only a slight improvement in the eight minute response time was found. Even after this system was implemented, the mean response times for both districts remained above eight minutes (See Table 2). Only 34% of the calls were responded to in Carmel in less than eight minutes, and only 62% in Lachish were responded to in less than eight minutes. (Peleg, Kobi, and Pliskin [21])

2.6.2 EMS Systems in Hong Kong

From 1970 to 2006, the average number of requests for emergency assistance in Hong Kong, China has increased from 110,000 to 575,666 annually. This is due, in part, to exponential population growth in recent decades. Unlike most other countries worldwide, the average response time standard in China is set at twelve minutes.

As Hong Kong was a British colony until 1997, they use the "999" telephone number as the universal emergency number. This number is linked to all emergency services, including police, fire, and ambulances. Unlike in America, the Fire Services Communication Center is responsible for mobilizing all ambulances. In 2005, this center was upgraded to a new computerized mobilizing system using advanced telecommunications, called the "Third Generation Mobilization System." This new system is set to improve the efficiency of emergency operations by enhancing the identification, location, and mobilization of ambulances and emergency personnel.

Also unlike the UMass Memorial Emergency Medical Service, each ambulance carries three emergency personnel. This is significant because it allows for two paramedics to be in the back caring for the patient instead of just one.

Another significant part of the Hong Kong emergency response service, particularly in the more densely packed areas, is the implementation of ambulance-aid motorcycles (AAMC). First introduced in 1982, these motorcycles provide a quicker means of transportation to the patient on the small, busy streets of the city. These AAMC's significantly shorten response times in many scenarios because of their ability to weave through traffic. All ambulances and AAMC's are equipped with automatic external defibrillators (AED).

Mobile casualty treatment centers (MCTC) are stationed strategically around Hong Kong. In situations where a large number of people are injured and in need of medical assistance, MCTC's are summoned. In contrast to a regular ambulance, mobile casualty treatment centers are equipped with bountiful quantities of more sophisticated equipment. More importantly, they also include a small clinical area which can be used to operate in, if necessary. As shown in Figure 17, the size contrast between a normal ambulance and a MCTC is vast.

Figure 17: Mobile Casualty Treatment Center

Although the response time standard in Hong Kong is twelve minutes instead of eight, the success of their system is shown through their results. In 2004, 91.1% of calls were responded to within twelve minutes, with 89.6% in 2005 and 92.5% in 2006. (Graham, Cheung, and Rainer [14])

2.6.3 Region of Waterloo EMS

In 2010, the Region of Waterloo's Emergency Medical Service was evaluated by graduate student Kian Aladdini. Region of Waterloo EMS (ROWEMS) is the only licensed provider of pre-hospital emergency care in the entire region. Here, call volumes have increased 36.5% since 2000, causing serious problems given their current resources. A larger organization than UMass Memorial Emergency Medical Service in Worcester, ROWEMS employs eighty six full time employees and sixty six per diem paramedics. With eighteen ambulances, five emergency response units, one emergency command post, and three multi-casualty incident trailers, they are prepared for the tens of thousands of calls they receive every year. All EMS calls, resources, and emergency personnel are dispatched through the government owned Cambridge Central Ambulance Communications Center (CACC). Figure 18 illustrates the strategic locations of the eight ambulance stations in the Region of Waterloo.

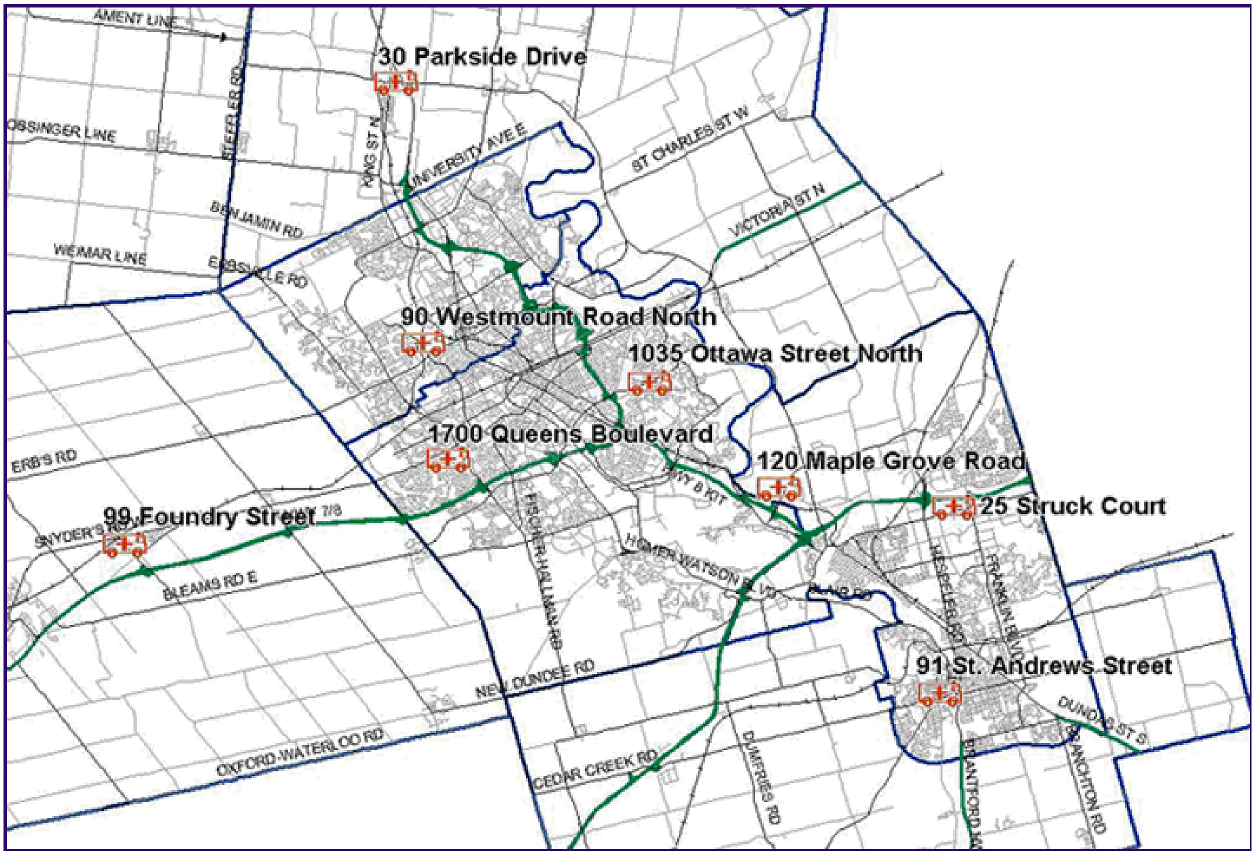

Figure 18: Region of Waterloo Ambulance Hubs

Between the years 2001 and 2010, the Region of Waterloo followed three specific performance standards. First, the response time standard was set at ten minutes and thirty seconds, and was expected to be achieved ninety percent of the time. This requirement is government legislated. Response time is measured from the moment the EMS crew is notified of a call until the moment the ambulance arrives on scene.

The ROWEMS paramedics themselves set their response time standard to nine minutes, region-wide. This version of response time is measured from the moment the citizen places the call for help until the ambulance arrives at the scene. The final standard is that every ambulance sent in response to an emergency call must contain an advanced care paramedic.

In 2010, these three guidelines were edited to improve the efficiency of the Region of Waterloo EMS. Now, for the highest priority emergency call when both the fire department and EMS are required to respond (i.e. Priority One: cardiac arrest), one of the emergency response units must respond within six minutes with a CPR or defibrillator resource. Then, regardless of who the first responder is, an EMS ambulance capable of transporting a patient must arrive within ten minutes and thirty seconds. Both of these response time standards are expected to be met ninety percent of the time.

For all other high priority emergency calls, the standard paramedic response time must be under ten minutes and thirty seconds. This ensures a paramedic on site as soon as possible to care for the patient. Then, within fifteen minutes, an EMS ambulance capable of transporting a patient must arrive. Once again, these response time standards are expected at least ninety percent efficiency. For lower priority calls, the region is allowed to set its own response time standards.

By further breaking down the priority of the calls, ROWEMS allows themselves to focus most specifically on patients whose lives are in the most danger. Separating the highest priority calls, like cardiac arrest, from the rest of the high priority calls, illustrates the significance of a quick response in a dire situation.

Also, requiring units without patient transportation to arrive on scene first further ensures patient safety. This allows paramedics with smaller vehicles to arrive on the scene faster in order to perform CPR or use defibrillators on a patient in need. The few minute difference between the first responder and the transportation unit considerably improve any dying patients' chance of survival.

Also cited in this study is an equation to estimate the average travel time of a vehicle, created by Kolesar and Blum in 1973.

Equation 1: Estimated Average Travel Time of a Vehicle in an Area

$$ET = b_0 + b_1 \left[\frac{A}{n - \lambda ES}\right]^{b_2}$$

Here, A is the area of the region, n is the number of ambulances stationed in the area, λ is the arrival rate of calls, ES is the expected service time for a call, and b_0, b_1, and b_2 are parameters to be determined. Although this equation assumes vehicles only respond to emergency calls in their own area, this equation is effective at estimating the time of travel given the parameters. Equation 1 allows one to compare the relationship between the number of vehicles available, the call arrival rate, and the area of the region itself. (Aladdini [1])

2.6.4 Boston EMS

After visiting one of the Boston Emergency Medical Service garages and interviewing several of their emergency technicians and paramedics, it becomes apparent that some of the problems UMass Memorial EMS faces can be solved simply through observing regular Boston EMS protocol. Because Boston is a much larger city than Worcester, their Emergency Medical Service must account for a much larger population and land area. This great population density leads to a greater demand for flawless emergency medical services.

Technological improvements have brought the Boston EMS force a long way in recent years, with upgrades to their global positioning systems and installation of Opticons response times can only improve. Other differences between the two cities' EMS organizations include the distribution and strategic arrangement of ambulance hubs. The following sections will elaborate on several aspects of Boston EMS that surpass those of UMass Memorial's Emergency Medical Service.

2.6.4.1 Opticon

Opticon is one of the first companies in the world to commercialize and manufacture bar code scanners. Since then, their range of products has expanded exponentially. Today, Opticon manufactures thousands of different types of automatic identification and data collection equipment.

Boston Emergency Medical Service has recently employed an Opticon device that wirelessly transmits to a receiver on traffic lights throughout Boston. Due to this wireless connection, the emergency technicians operating the ambulance can access a traffic light before they arrive at the intersection. Ambulances with this Opticon device can change the colors of the light at the upcoming intersection, turning their direction green while every other direction immediately becomes red. Being able to change the colors of the traffic lights from a distance allows the ambulance drivers to speed up the traffic in front of them, decreasing congestion upon arrival at the intersection.

While sirens are usually enough to get cars to pull over, this can become a problem at a crowded intersection. The Opticon device newly installed in many of the Boston EMS ambulances allows the EMT's to access the traffic light before they pull up to it. Turning the light green in the ambulances direction only speeds up the flow of traffic blocking the ambulance. This permits it to pass through the intersection sooner, in turn shaving precious seconds of the emergency technicians' response time.

2.6.4.2 Zoning

As shown in Figure 10, Boston EMS ambulance garages are each designated their own specific district. Each ambulance hub corresponds to a different police district throughout the city of Boston. The wide distribution of ambulance garages throughout all the city's districts allows for a higher efficiency in response time due to the closer proximity of the emergency technicians to the scene of the problem.

Furthermore, the EMT's are able to better learn their respective districts. The better the emergency technicians know their territory, the faster they will be able to navigate themselves through the crowded city. By being assigned to a specific district, ambulance operators can gain insight as to the choke points and highly congested areas in their respective area. Learning where and at what times traffic is the slowest and densest gives the emergency medical technicians the option to avoid points they know they will have a problem traveling quickly through.

In addition to the district drivers, there are also the four zone impact trucks that are always on the road. These zone impact ambulances aren't assigned to any police district in Boston; instead they roam the city to the aid of the busiest district at the time. These roaming ambulances and their drivers run an extended ten hour shift. Zone impact ambulances are on the road before the district ambulances despite the fact that their shift ends after. Having the zone impact trucks as backup further prevents call congestion because these ambulances are readily available for any district in need. (City of Boston [10])

2.6.4.3 Dispatch Satellite Access

Once the EMT dispatch receives the call from the EMT call takers, dispatch must choose what is necessary to send to the scene of the emergency. The Emergency Medical Technician dispatch then radios in to the appropriate ambulance to explain the situation. Along with radio communication, the dispatcher also has access to a satellite global positioning unit located above the center console in the ambulance. With this access, the dispatcher can input the coordinates to the GPS and they are immediately uploaded to the computer in the ambulance.

Figure 19: Ambulance Interior (See GPS Computer)

2.6.4.4 No Hospital Contract

Boston Emergency Medical Service is run by the Boston Public Health Commission. This means they aren't contractually obligated to any hospital, unlike UMass Memorial EMS which is run by UMass Memorial Hospital. This lack of contract between the Boston Emergency Medical Service and the city of Boston's hospitals allows for a much simpler decision to be made when it comes down to which hospital to take a patient to.

Instead of choosing a hospital based on financial incentive, the Boston EMS simply chooses the closest or most plausible hospital. These choices are either based on patient or weather conditions, ambulance and hospital positioning, or a patient's history with a given hospital. In a situation where efficiency is necessary, the best way an ambulance driver can chose a hospital is quickly and logically.

2.6.4.5 No Hands Calling

A suggestion made by one of the UMass Memorial Paramedics to improve response time is reflected in the command structure of Boston EMS. Steve Haynes, a Chief Paramedic at UMass Memorial Emergency Medical Service, suggests the emergency technicians should skip calling the hospital once they pick up the patient. UMass Memorial emergency technicians must contact UMass Memorial Hospital once they get the patient in the car and on the road. Haynes believes this step is inefficient because not only does it take the care and attention of the emergency technician away from the patient, but the hospital is usually busy and unprepared when they arrive with the patient anyways.

Boston Emergency Medical Service has eliminated this step from the process. The emergency technicians generally do not call the hospital once they get in the car so they can focus on the patient in trouble. On the rare occasion where there is a special circumstance with the patient in which a call must be made to the desired hospital, the emergency technician can use their knees to dial the hospital. This no-hands strategy and technology allows the EMT to have both hands free to handle the patient at all times.

CHAPTER 3. INITIAL PROBLEM DESCRIPTION, REACHABLE OBJECTIVES AND LIMITATIONS, RESULTS MIGRATION

3.1 Introduction

Throughout Chapter 2 we selected a handful of the current problems within the EMS systems in the cities of Worcester and Boston. This Chapter will assess those problems with a detailed description of each and then will conclude with the objectives that we believe to be reasonable and reachable. This analysis will adhere to the limitations that must be taken into account within each city. For example, Boston has many more resources at hand and the company, Boston EMS, is a contracted company by the city, whereas in Worcester UMASS Memorial is the hospital and the main EMS supplier.

3.2 Problem Description

The analysis of these selected problems is the most important part of identifying the correct solution. We need to establish a solid list of requirements and limitations for each problem so we can accurately assess the problem with a viable solution.

3.2.1 Worcester Problem Identification

Within the city of Worcester our team identified one major problem that we believe to be causing the delay that is usually seen in EMS response time throughout the city. This comes down to the call structure for a 911 call in the city. Currently a 911 call in Worcester goes through a series of checks depending on aspects such as if the call is coming from a landline or a cellular phone. These series of checks happen before the caller is even asked of his or her location and the problem he or she is reporting. These checks are followed by a long and scripted conversation between the caller and the EMS call operator. Only after this long scripted conversation is a decision made on who should be deployed to the scene. This does not even take into account the time needed to contact both the fire and police departments if needed.

The next problem that pertains to the city of Worcester is on the subject of zoning within the city. While our team visited the Boston EMS we discovered that they use a system of zones throughout their region of coverage and then have certain ambulances assigned to those zones. This helps their response time greatly because the ambulances are not all in a central location, but roaming around their specified zones at all times. One can look at Figure 11 in Chapter 2 to see these zones that are described for the Boston EMS Regions. Another aspect of this zoning that helps with reduction of response time is that certain zones have more ambulances due to population density and depending on the distribution of calls throughout the zones this would determine if more ambulances are needed in those zones. So as time goes on and Boston EMS can collect more data on their zones they can better ready themselves for call volume in certain zones. Another aspect of zoning that helps out greatly in Boston EMS is that the drivers in certain zones stay in those zones for a long period of time per year. This helps the drivers get accustomed to the traffic patterns throughout the different sections of their zones depending on variables such as weather, time, and holidays.

These summarize the problems that our team has identified for the EMS practices in the city of Worcester. In Section 3.3 the MECAS group describes our reachable objectives for the city of Worcester.

3.2.2 Boston Problem Identification

The Boston EMS department is a very advanced compared to all of the other EMS departments that our team researched. This made it hard for our team to locate some needed improvements to their system. We do believe that we have located a problem that could potentially reduce the already very low response time for Boston EMS. Currently the system in place for communication between ambulance and traffic lights is based off of an old radio frequency system. This system is extremely old and worn out, but it also has the advantage of already being in place.

3.3 Reachable Objectives and Limitations

Creating reachable objectives for these two EMS systems requires careful analysis of both systems and using research from outside sources, mainly EMS employee interviews and measurable data. With these two metrics in the decision process our team feels that we have come up the best suggestions for each system.

3.3.1 Worcester EMS Objectives and Limitations

Using the zoning that was described in Section 3.2.1 would greatly improve the Worcester EMS response time. It would hopefully bring it close to the average response times in Boston which can be seen here in Figure 20;

MEDIAN RESPONSE TIMES			
	2010	2009	Goals
Priority 1	5.4 minutes	5.5 minutes	6.0 minutes
Priority 2	7.0 minutes	6.9 minutes	7.0 minutes
Priority 3	7.1 minutes	7.1 minutes	8.0 minutes

Figure 20: Median Response Times

Also moving away from the long scripted conversation in the call flow of a 911 call in the city of Worcester would allow departing resources to know of the location and situation more quickly to improve response time.

We also have identified that Worcester should adopt the organizational hierarchy that Boston EMS has implemented currently. We identified this to work through our interviews with both a UMASS Memorial EMTs and Boston EMS EMTs. Below in Figure 21 you can see the chart.

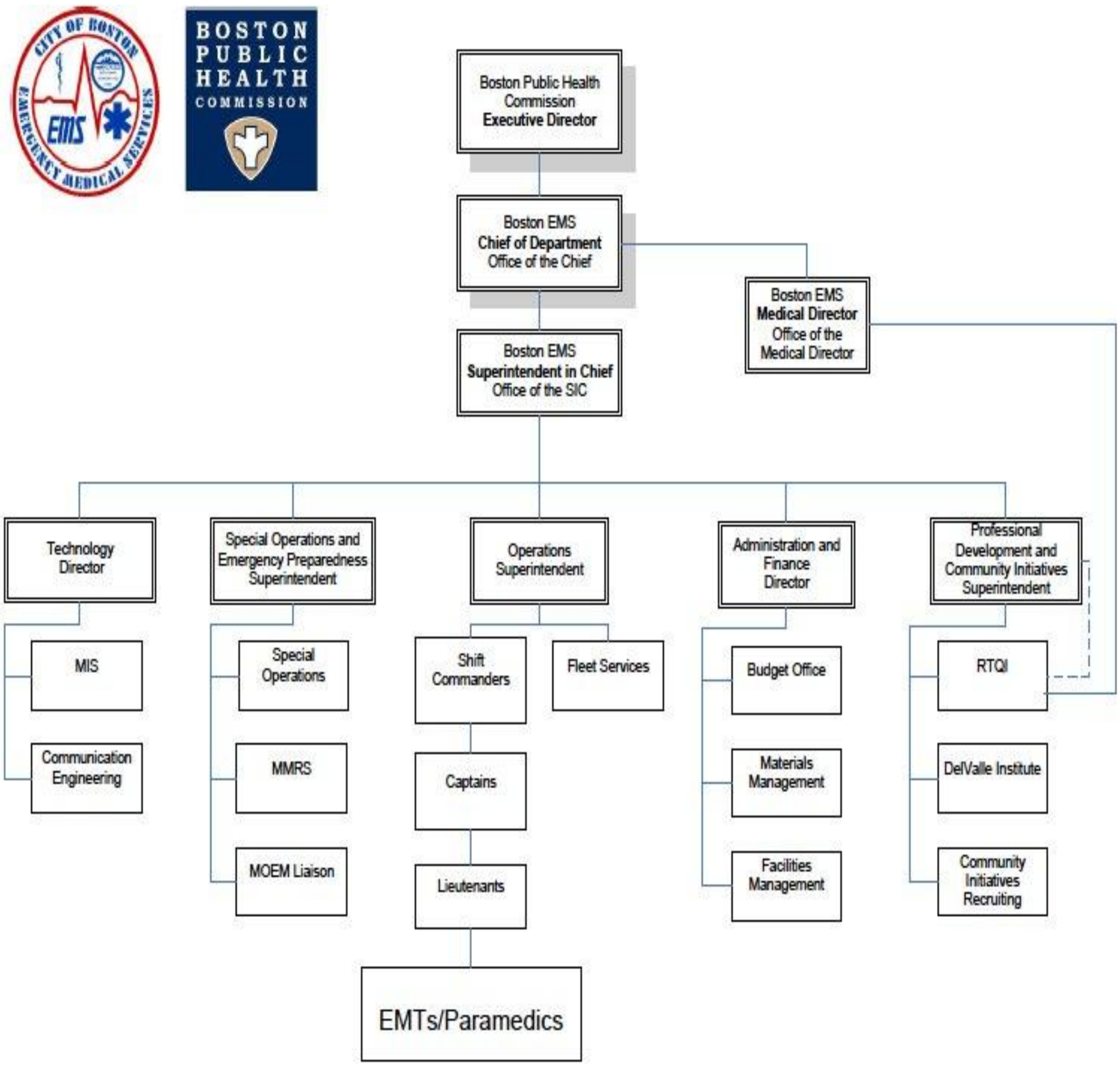

Figure 21: Organization Chart of Boston EMS

3.3.2 Boston EMS Objectives and Limitations

As stated before the only room for improvement in the Boston EMS system that our team identified was the infrastructure used for communication between the ambulance and the traffic light system. There is now a new technology that uses Wi-Fi to communicate with the traffic system to change the light in the direction that the ambulance is approaching from green and all the others red. This is done to push traffic through so a jam does not occur that would halt the flow of traffic and in turn the ambulance. This system requires an infrastructure to be installed throughout all the Boston EMS zones on the lights. This would be a costly project that might not be seen by management as beneficial enough to invest into now. This would increase the range of communication between the ambulance and traffic lights from about a few hundred yards to about half a mile.

3.4 Observations into Suggestions

When our team set out to seek ways to reduce the response time of the EMS system in Worcester we did not seek to expand into Boston but then when we were researching the best ways to improve Worcester's response time we noticed that Boston had set the perfect example for Worcester to follow. We then took our observations and made detailed comparisons between the two systems of EMS services. We then analyzed the differences between the systems and picked a few of them that we thought would impact the response time in Worcester the most.

CHAPTER 4. CONCLUDING REMARKS AND RECOMMENDATIONS

4.1 Our Recommendation

The solution to reducing the response time in the city of Worcester is to replicate the system in place in the nearby city of Boston, MA. This system has worked for the Boston EMS service in an extreme manner. The results that they produce yearly are much better than that of Worcester's, and Boston has three times the population to cover.

As illustrated in Figure 22 below, the Boston Emergency Medical Service rarely fails to complete their response time goals. The current response system they have in place can be used to remodel and improve that of UMass Memorial Emergency Medical Service. Most notable is the response time for Priority One calls, where the Boston Emergency Medical Service's response time is exceptional. During interviews, it was noted by several UMass Memorial Emergency Medical Technicians how important a quick response time is for priority one cases (i.e. cardiac arrest) due to the high risk of death.

Despite the vast difference in population and land area, the Boston EMS has the ability to respond minutes faster than the UMass Memorial service due to their more advanced response system. It can be concluded that several of the tactics used by the Boston Emergency Medical Service can, given the time and resources, be reflected by that of UMass Memorial EMS. These new strategies would only improve the capabilities of the emergency medical services of Worcester.

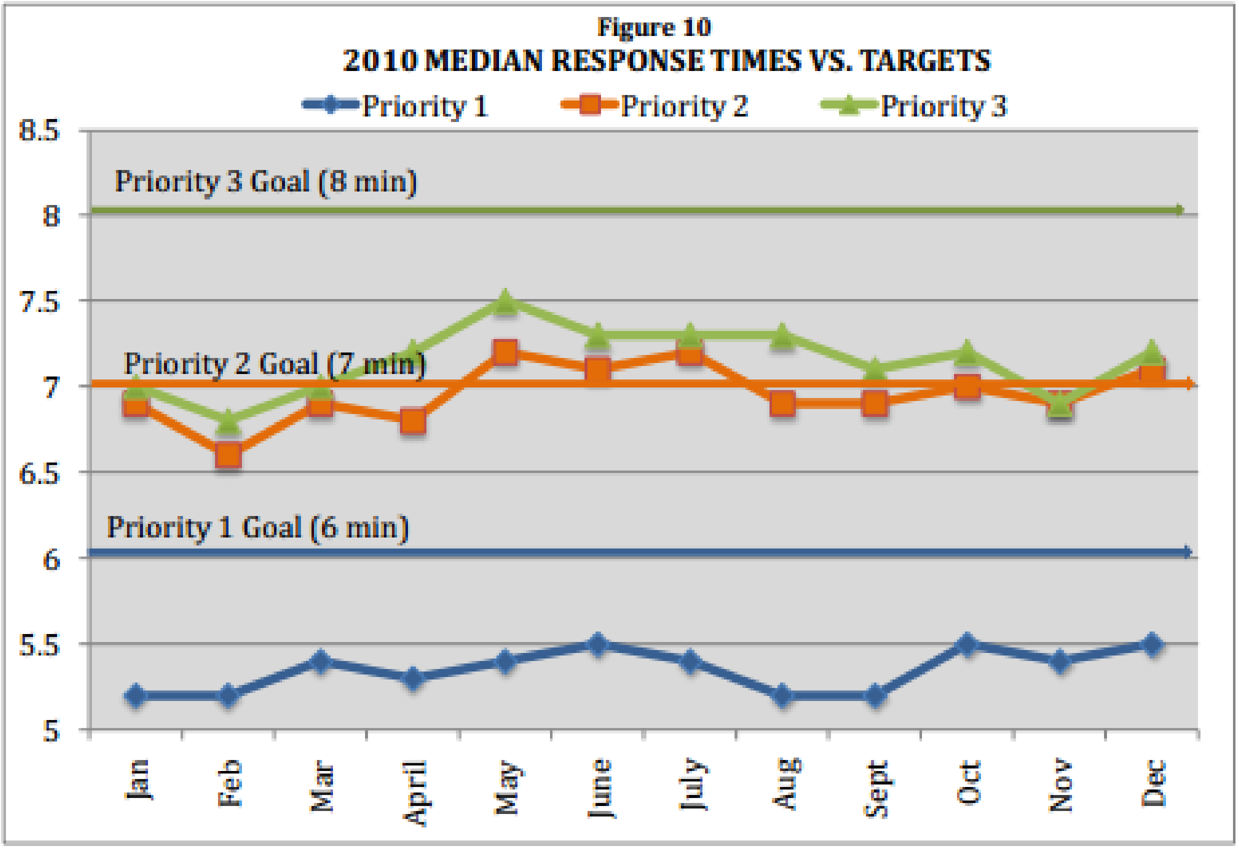

Figure 22: 2010 Boston Median Response Time vs. Targets

Figure 9		
2010 MEDIAN RESPONSE TIMES		
Priority Level	**2010**	**Goal**
Priority 1 (urgent/life threatening)	5.3 minutes	6.0 minutes
Priority 2 (serious/potentially life threatening)	7.0 minutes	7.0 minutes
Priority 3 (non-life threatening illness or injury)	7.1 minutes	8.0 minutes

Table 5: 2010 Boston EMS Median Response Times

The MECAS team has derived a new 911 call procedure for the EMS dispatchers and EMS themselves for the City of Worcester. The first event in implementing this flowchart is to create regions of the city where we can have roaming ambulances, replicating what Boston EMS is currently employing as a strategy. Worcester encompasses a larger than normal land area for a city and with this fact we recommend a minimum of 10 regions throughout the city. This would require ambulances to be assigned to these regions for a minimum of six month periods. This six month period would ensure that the drivers get a good knowledge of their region over the time they drive it. This would account for a small decrease in response time due to an immeasurable factor we like to call familiarity. This factor is a learning curve for the drivers as they are moved to each region. Then over years of practice the EMTs would have a great knowledge of the regions.

Once these regions are in place we can employ the following flowchart that represents a 911 call from start to arrival of ambulance on scene.

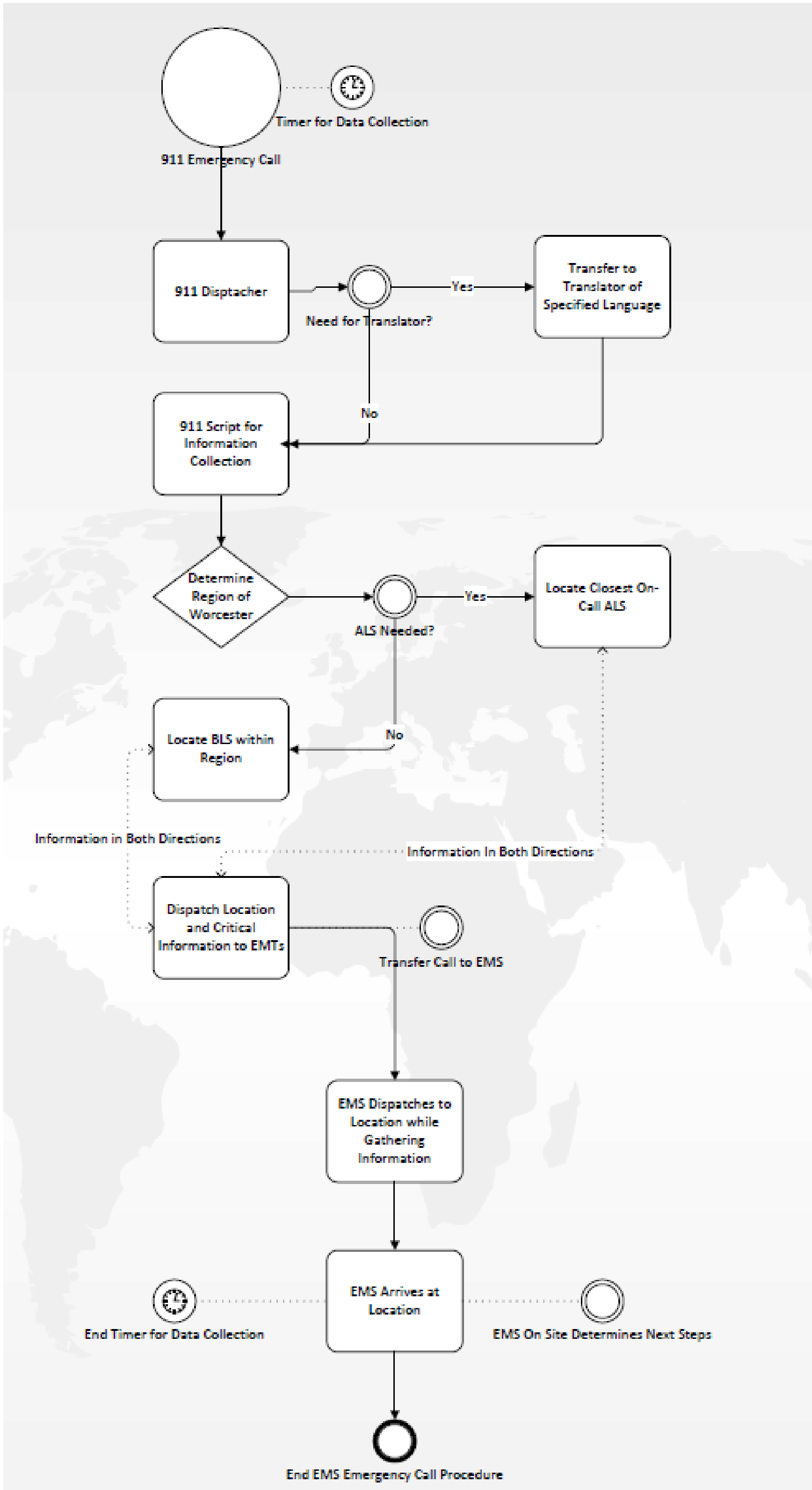

Figure 23: MECAS Recommended Flowchart

We see these improvements to the current call procedure as a great step in the right direction for drastically reducing the response time for the Worcester EMS Services.

4.2 The MECAS Team Experience and Issues

We did experience some issues in the process of the project. The main problem we encountered was contacting outside WPI resources for information. The process wasn't clear-cut and did not unfold the way we had expected it to. We did however get some good interviews in the Boston EMS Department.

The trip to Boston helped us greatly but it would have been great, for our project especially, if we had been able to see the Boston EMS Command Center. It really would have given us an idea of what the level of technology and training goes into the Boston system. Then we could have compared that to the Worcester system and possibly seen areas for improvement in Worcester that would reduce response time.

Another issue the MECAS team ran into on occasion was identifying the next step in our search for factors that could potentially reduce response time. A list of the basic contributing factors would have helped properly guided us through the project's steps.

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APPENDIX A: 911 Call Procedure Recommendation

The MECAS Team has built in certain measuring tools and changes into this flow chart that are explained in the following figures and text.

First the MECAS Team has implemented a start timer for live data collection on the duration of calls.

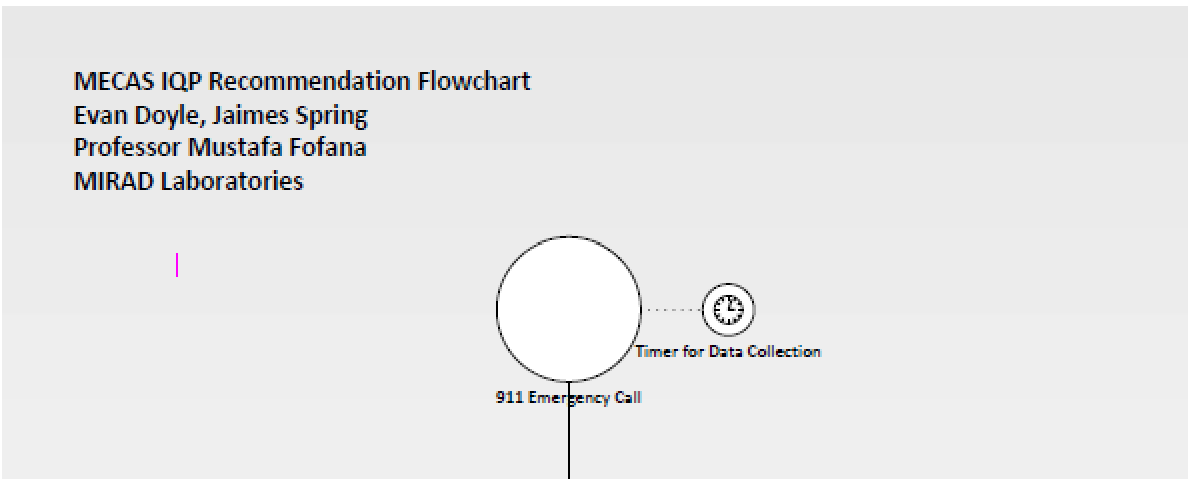

Figure 24: Live Data Collection Timer

Next we have ensured that early in the call there is an option for translators that will help understand and relay the information quicker.

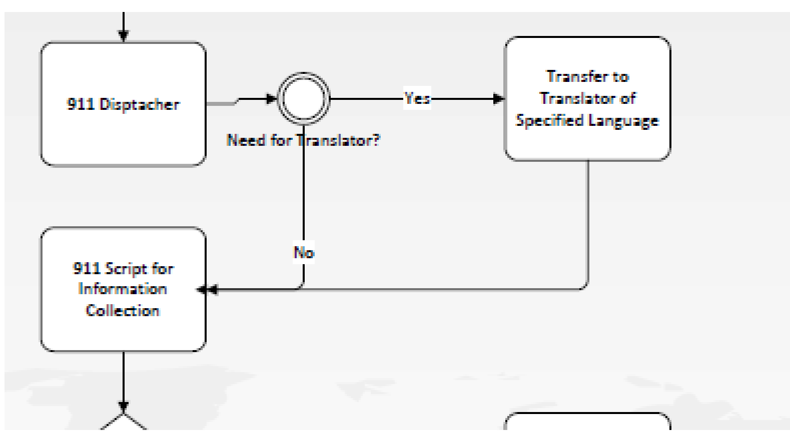

Figure 25: Option for Translator

We also wanted to make sure that there is a constant and easy form of communication between the EMTs and the dispatcher. We want to show the use of two way conversations in our flowchart to emphasize this aspect of our recommendation.

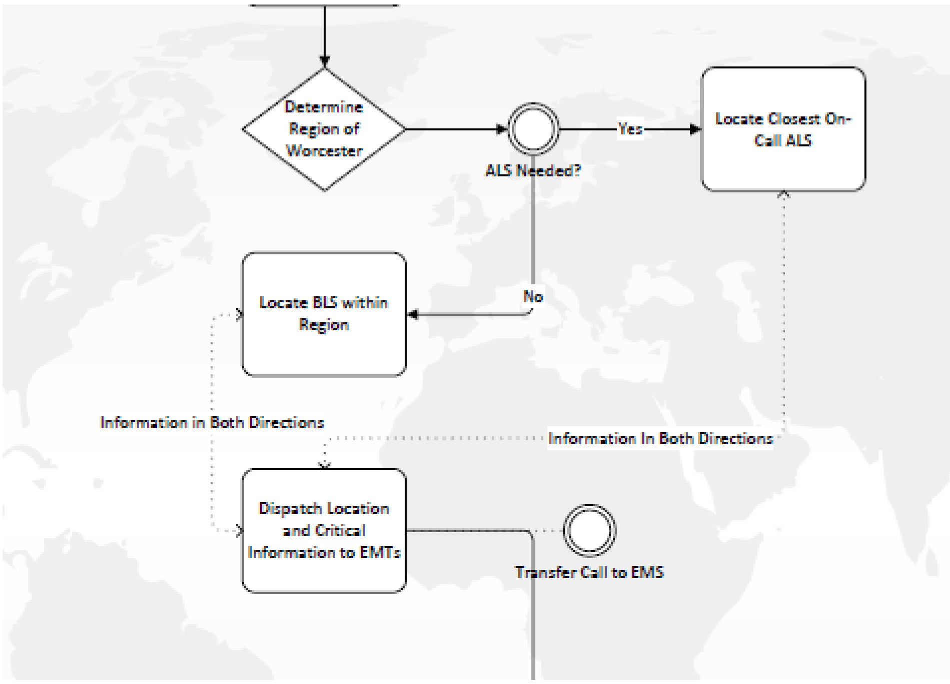

Figure 26: Two Way Communication/ ALS Vs. BLS

Figure 26 also shows the early determination of the need for an ALS Ambulance versus a BLS Ambulance. This is important because it will allow the dispatcher to dispatch the ambulances quicker because we got the information sooner from the caller. In turn, this should reduce the response time of the EMTs to the 911 Caller's location.