An Evaluation of Technology to Locate lost Firefighters

An Interactive Qualifying Project Report

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Abstract

As buildings become more complex and dangerous for firefighters, the problem of missing firefighters has become more of a concern. Now there is a demand for technology to help locate lost firefighters in order to improve their chance of survival. This technology should be affordable so that it can fit into the budgets of most town fire departments. These devices should perform consistently to ensure reliability. This is important because if a device is not dependable it will not be used.

This IQP dealt with technology used to locate trapped firefighters in emergency situations, more specifically PASS devices, G.E.M. System, thermal imaging cameras, lifelines, Bernard easy exit systems, and radios. This study investigated how effective these systems are at locating lost firefighters and explored problems with this technology. Through evaluating these different devices, suggestions have been made on ways to improve devices for locating lost firefighters.

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1. Introduction

This Interactive Qualifying Project dealt with the effectiveness of different types of personal protection devices for firefighters that were available on the world fire service market. This document analyzed how these devices should be used, their costs, and the training necessary to use them. One goal of this project was to question how well firefighters were protected from liabilities and accidental deaths. Another goal was to research some current devices used to locate lost firefighters, listening to various opinions on the equipment, and researching new -found technologies, this study has discovered if there was a need to redevelop technology in this field. Fire officers all around the world will be able to use the information in this study to decide whether or not their department needs new equipment.

2. Literature Review

Firefighters use several types of safety devices to help insure their safety while on the job. This section discusses some of the latest safety devices used in the firefighting industry today. The following is an in-depth look at these devices. Topics considered are; benefit of use, cost, training needed, and overall effectiveness.

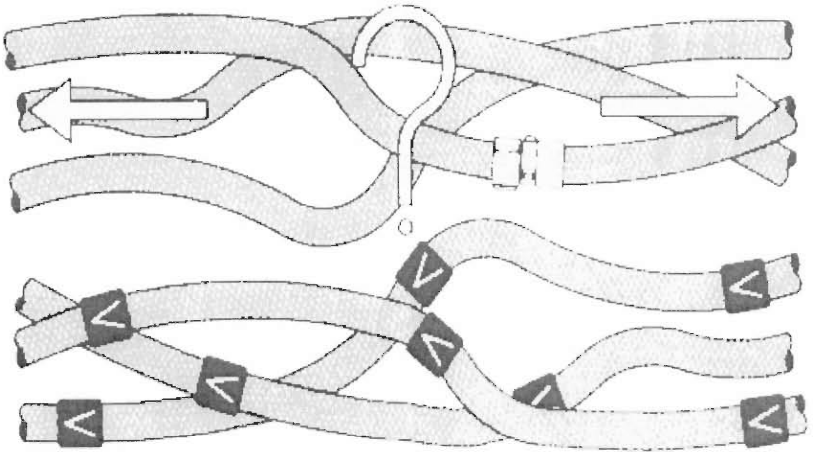
2.1 Simple Devices

2.1.1 The Bernard Easy Exit System

There are several small devices that firefighters carry which although simple, can greatly increase the chances of a firefighter coming out of a burning building alive. One is called the Bernard Easy Exit. This product is a round, fire resistant rubber sleeve, which fits onto the firefighters' hose every twelve feet. It contains a black band with protruding yellow arrows. The arrows are positioned so that they point in the direction of the exit. If the firefighter becomes disoriented, he can see or feel the correct direction out of the smoke filled environment by following the Bernard Easy Exit. [1]

Clifford Clement, an experienced firefighter, who has firsthand experience with the confusion that can occur in a smoke filled building, designed the Bernard Easy Exit. In October of 1987 Clement was involved in a search and rescue to find Lieutenant Paul Bernard. Bernard, while disoriented, followed the hose in the wrong direction further into the building. After his air supply was depleted, Bernard died in the line of duty. This accident caused Clement to think about the dangers of traveling into a smoky building and resulted in the invention of the Bernard Easy Exit System. On the following page is a diagram of the Bernard Easy Exit: [2]

Figure 2.1: Illustration of the Bernard Easy Exit System



Fire intensity increases rapidly; therefore, crawling in the wrong direction could be disastrous for a firefighter. Nearly 25 percent of all firefighter deaths result from being lost in a building and being caught by advancing fire or building collapse. Although there are couplings, which connect the hoses every fifty feet, a firefighter may not be able to find one nearby and travel fifty feet out of his way. With the Bernard Easy Exit System a firefighter is never more than six feet away from determining the correct direction out of the building.[3]

Since the introduction of the Bernard Easy Exit system more than twenty fire departments in Massachusetts and another twenty in Pennsylvania have implemented this product. The system has helped many firefighters in these departments find their way out of burning buildings[4]. There has been a favorable response to this system. Paul Hashagen, a writer for the Firehouse Magazine said," If it saves one life, it's worth it[5]." From this, one can see that Hashagen feels the system is worth having.

The Bernard Easy Exit is a very simple device, which is not difficult to use. It

does not require much additional training for the firefighters but they have to take the time to install the devices on the hoses. The system is inexpensive but is definitely a worthwhile investment. "Firefighters can and do get lost inside burning buildings. The ability to find a safe exit from a fire area should not have to be a spectacular occurrence. On the contrary, it should be as smooth, calm and effective as possible." (Hashagen, 1995) This is the reasoning behind the Bernard Easy Exit System. It is a great lifesaving asset for any fire department to have.[6]

2.1.2 Lifelines

Another simple device which fire departments employ from time to time is a lifeline. These are fire resistant ropes which firefighters use at a fire scene or emergency. These ropes must meet all requirements of NFPA standard 1983 and be inspected after every use to ensure safety.[7]

Lifelines have been used for different types of rescues in the United States for many years but they are not commonplace. They are usually used as a last resort if firefighters are lost in a burning building and a search party is being sent in for them. All of the firefighters are connected to the lifeline so that no one can get lost in the structure. The lifeline is also connected to someone on the outside of the building, ensuring that everyone finds his way out.

The main part of the lifeline is called a guideline. Another country that frequently uses lifelines is Australia. In Australia, the first crew on the scene of a fire to search the smoke filled area usually uses it. They can then follow the guideline out of the fire to safety, without becoming disoriented. In the United States the guideline is used at the discretion of the chief or incident controller.[8]

Attached to the guidelines are smaller pieces of rope called personal lines. These

ropes enable the wearer to follow the guideline but also search off of it. They can range in length from 1.25 meters to 6 meters depending on the fire situation. Sometimes Australian fire brigades will use these personal lines to attach firemen to each other when they are entering a building with a hose line so that no one will get lost.[9]

There are many positive reasons to use the lifelines. One is the large decrease in firefighter deaths. Since the firefighters are attached together they can never venture far away from the group inside the structure. Also, they can always find their way out because the other end of the rope is outside the building. Becoming disoriented and confused in a smoky environment frequently plagues firefighters who don't use lifelines. Another good reason to use lifelines is that they are rather inexpensive compared to other pieces of life saving equipment. Therefore, even smaller towns with lower budgets could afford these pieces of equipment.

Lifelines also don't require much maintenance or instruction. The ropes only have to be inspected for imperfections after every use to ensure no damage has been incurred. Firefighters don't require much additional training to use the lifelines; they are rather simple and self-explanatory. These requirements are few compared to the number of lives the lifelines can save.[10]

2.1.3 Radios

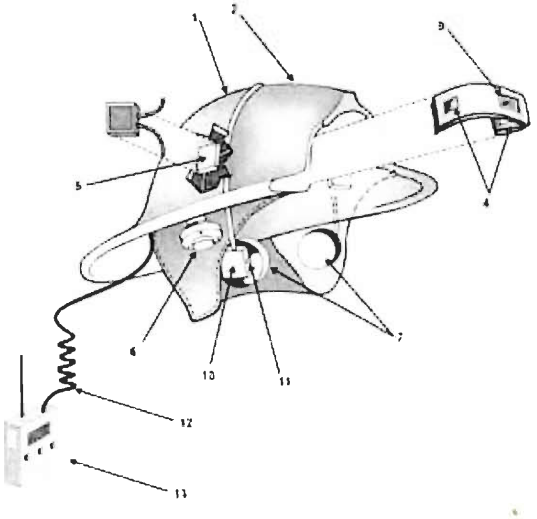
A third lifesaving device which firefighters frequently use is their portable radios. Most fire departments give a radio to each firefighter who enters the burning structure. By communicating with the men on the inside of the building, the chief can determine the location of the fire and where the firefighters are. If one of the men becomes incapacitated, he can radio in and describe his location to the chief. This makes it easier for a search party to locate and help the victim.

The radios that firefighters carry are light and convenient. They are easy to

handle and are not complicated to use. This simplicity makes the portable radio a popular life saving device among fire departments. The device doesn't require much extra training and it isn't very expensive.

The technology for firefighter radios is increasing rapidly. Frank Downs, an inventor employed by the Navy, developed a hands-free radio microphone for Navy Seals during Operation Desert Storm. This radio has now been adapted for use by firefighters and policemen. The radio microphone straps onto the forehead of the firefighter and gathers sounds from the vibrations transmitted through the skull. (Spice) Following is a diagram of the device: [11]

Figure 2.2: Radio



The microphone is a ¾ inch by ¾ inch square, which picks up a person's voice through vibrations. It can be fitted onto the front of the firefighters' helmet or be attached to a headband. The microphone is attached to an earpiece and a radio, which a firefighter wears on his or her back. There is also a flat push-to-talk switch that the operator wears on his forefinger. To operate the radio all the firefighter has to do is squeeze his thumb and forefinger together. The radio is also waterproof and can withstand high temperatures.[12]

The radio is simple to use because firefighters do not have to shout into it. They also can talk through it without taking off their air mask. This makes it convenient to use because if firefighters are in danger they don't have to go to a lot of further trouble to use their radio. Another benefit of this microphone is the fact that it almost eliminates all of the background noise. This decreases any delays for a rescue that might occur from interrupted messages.[13]

The hands-free radio microphone has been tested by several firefighters in a Pittsburgh, Pennsylvania fire department. Nothing but good reports has been heard about this device. Another great aspect of the hands-free microphone is the fact that it is not very expensive to produce. Downs believes that it may only cost only a couple hundred dollars for each microphone.[14] These three devices, although simple, are wonderful assets for any fire department to have. They greatly increase the chances of a firefighter coming out of a burning building alive. Most of these devices are inexpensive and easy to use, so every fire department including small towns can afford them.

2.2 Personal Alert Safety System (PASS)

The Personal Alert Safety System (PASS) is a safety device worn by all firefighters in the U.S. today. The NFPA requires all firefighters to use such a device while fighting a fire. While simple in concept, the PASS device has proven to be a valuable tool in recovering lost firefighters. It is the only safety device for locating firefighters in trouble being used by fire departments in the U.S.

The PASS device is a small rectangular object worn either on the coat or self-contained breathing apparatus (SCBA) unit of a firefighter. It is usually about the size of a bar of soap, approximately 3"x4"x2". Its purpose is to alert others if the firefighter is in a situation where he needs help. It accomplishes this task by sounding an audio alarm

when the unit senses that the firefighter is in distress. NFPA standard 1982 requires that all pass devices emit an audio signal of at least 95 dBA when measured at 10 feet. Some PASS devices also have LED displays which flash like a beacon to aid in search and rescue for the downed firefighter. There are no NFPA standards on these lights.

The Pass unit can be activated in several ways. One way is the alarm button. This is usually the largest button on the unit and is easy to access. If a firefighter finds him or herself in a dangerous situation and thinks he may need help, he only has to push this button to send the unit into alarm mode. The unit will then sound it's alarm until the firefighter disables the unit when he is out of danger. The advantage to this option is that if a firefighter becomes lost or disoriented in a fire, he has the ability to call for help before the situation gets out of hand and he places himself or his fellow firefighters in danger.

Another way the PASS unit can be activated is by its motion sensor. This is the primary safety function of the device, because it does not require the individual to call for help. When there is a lack of motion for approximately 18 to 23 seconds the unit will go into the Pre-Alarm mode and annunciate an audible Pre-Alert signal. If the unit is equipped with a LED, light signals may also begin at this point. After a lack of motion lasting approximately 30 to 35 seconds, the unit will go into the alarm mode. While in alarm mode, the unit emits a loud "siren-like" sound that may vary in pitch. At this time, any LED signals would flash to alert others of the firefighter's position. Once in alarm mode, pushing a reset button can reset the unit.

There are several different ways that PASS devices sense motion. Some PASS manufacturers use mechanical devices, such as a small metal ball to sense motion. The

random motion of the ball is converted into an electrical signal as long as motion exists. Another accurate method to sense motion is the closing of a mercury filled switch. Still another method uses a ball inside an infrared light chamber. The motion of the ball interrupts the light signal and is sensed as motion. Perhaps the most progressive method involves a solid-state accelerometer device that can sense a broad range of motion, and is not position sensitive.[15]

The benefit of this feature to firefighters is immeasurable. If the firefighter becomes immobile for any reason the unit automatically sounds to alert others of the situation. Because no action is required from the firefighter, the alarm will sound every time, making this a reliable tool to locate injured or trapped firefighters.

Some PASS devices are also equipped with a temperature sensitive device that will sound the alarm if a firefighter is exposed to high temperatures for too long. This is an optional feature, however, and not all pass devices are equipped with one. Exact temperature specification can be obtained from the product manufacturer. The benefit of this option is that a firefighter is alerted that he is in an unsafe environment. This gives the firefighter the chance to egress from the area before it becomes unsafe. It also protects the firefighter from heat exhaustion, which is a huge concern for individuals in the fire service.

A battery, usually 9 volts, powers the PASS device. This provides the user with about 300 hours of sensing time, not alarm time. Most PASS devices are also equipped with a low battery alarm, which alerts the firefighter when it is time to replace the power source.[16]

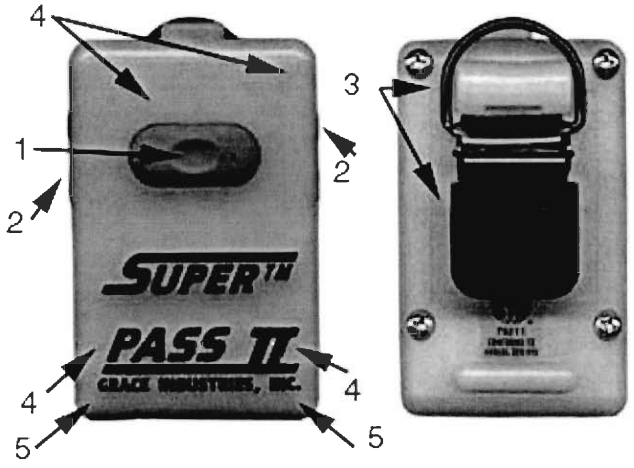
All firefighter are required to use the PASS device as specified in NFPA standard 1500,[17] so it is only logical that training on the device is given. Every firefighter who receives NFPA firefighter 1 certification is trained to use the PASS device[18]. The device is relatively easy to use and requires very little training. Once the unit is activated, the firefighter's job is over. This makes turning the device on the most critical aspect of training. The device obviously can't help if it is not armed. That is why it is important for firefighters to use the PASS device whenever they train. If the firefighter turns on the device whenever they drill, it will be more likely that the individual remembers to activate the device in a real situation.

One of the problems encountered when using this device is firefighters, for various reasons, don't activate the device when at a fire. Some more recent PASS devices attempt to control this problem by attaching the unit to the firefighters SCBA pack. With the unit directly integrated into the SCBA, the PASS automatically activates when the MSA Air Mask's cylinder valve is opened. Other PASS devices have a key, which is attached to the apparatus. When the firefighter arrives on scene and dismounts the apparatus, the key is pulled and the PASS device is automatically armed. This is similar to the pressure switch, but less expensive so more departments can use this technology.[19]

Most PASS units cost between $160 and $200, depending on what features the unit comes equipped with. While the individual unit is not very expensive, they can become expensive because every firefighter is required to have his own unit. Several different companies manufacture PASS devices, and price varies with each.[20]

The following figure illustrates a common pass device and explains the components:

Figure 2.3: A Typical Pass Device



1. Alarm Button
2. Reset Buttons
3. Grip Clip and "D" Ring
4. LED's cause the entire case to glow and change color
5. Sound resonating ports

Most of the information in this section was taken from manufacturers web sites. The manufacturer does not site specific tests or evidence. All PASS devices must meet the requirements of NFPA Standard 1982.

2.3 Thermal Imagers

Thermal Imagers allow firefighters to see images through smoke, track vapor clouds and detect temperature variances. This device's capabilities will allow firefighters to see images or bodies from as far away as 300 feet. In addition, Imagers can be wired

into a remote television, a feature that allows visibility inside and outside the fire simultaneously.

The IR-M700 from Mitsubishi Electronics is one of several high quality thermal imagers. It is capable of 801 x 512 resolution, yielding over 410,000 pixels; as a result, the manufacturer claims that the IR-M700 produces razor-sharp, crystal-clear images[21]. With an on-board microprocessor, serial communication can be established for greater flexibility of applications including reconnaissance, surveillance, and industrial process control. The IR-M700 also includes a cryogenic sterling cycle cooler for continuous operation and comes standard with a palm-sized wired remote controller for improved operability (with gain, polarity, auto/manual pedestal, and calibration functions), as well as camera setup. An RS-232C remote control interface is a standard feature. Here are the technical specifications for the IR-M 700[22].

Table 2.1:

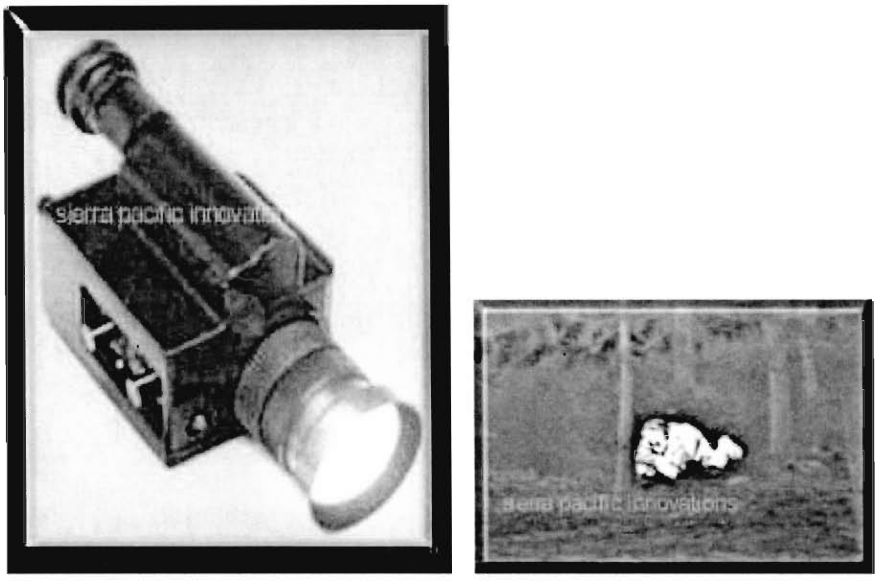
Technical Specifications for a Thermal Imaging device

Detector:	Platinum Silicide Schottky-Barrier IRCSD
Fill Factor:	61%
Resolution:	801 x 512 pixels
Detectable Wavelength Band:	Filter #1:1.2 µm to 5.9 µm
Filter #2:	4.0 µm to 5.9 µm
Window Material:	Silicon
Lens:	Infrared lens, 50 mm f:1.2 functionality
Temperature Difference:	(NETD)< 0.08°C (blackbody at 27degrees C using 50mm lens)
Field of View:	14° horizontal x 11° vertical (using 50 mm lens)
Field Time:	1/60 second
Cooling Method:	Sterling-cycle cooler
Image Display:	Monochromatic, 256 gray levels
Video Output:	RS-170 analog and RS-422 (10 Bit, 14.3 MHz)Digital
Wired Remote Controller:	Gain, polarity, pedestal (auto/manual)
calibration:	RS-232C remote control interface standard feature
Input Power Supply:	18 to 30 V, 45 W nominal
AC Adapter:	AC100/220 V, 50/60 Hz, 120 W
Environmental Conditions:	Operating temperature -10° C to 50° C

Standard Lens:	4.0" dia. x 2.95"(93 x 75 mm)1.5 lbs. (0.7 kg) AC
Adapter(W x D x H):	5.4 x 11.4 x 4.4"(136 x 290 x 114mm 7.4 lbs.(3.4 kg)
Wired Remote Controller(W x D x H):	2.8 x 8.6 x 1.1"(70 x 220 * 28mm) 0.83 lbs. (0.83 kg)
Standard Components:	Camera head Lens 50 mm, f:1.2 (3-5 µm)AC
adapter with 2m cable Wired remote controller with 5m cable	
Option Lenses:	25 mm (f:1.2), 100 mm (f:1.2), 200 mm (f:1.2),30-120 mm
Warranty:	One year

Figure 2.4 illustrates a typical Thermal Imaging camera. Although several different models are available, this is a good example. To the right is an image of a person trapped. This picture illustrates how a Thermal Imaging camera could be used to locate lost firefighters in a low visibility environment.

Figure 2.4: Thermal Imaging Camera and Its Display



In addition to these features, the M700 has freeze frame capability. This is a key feature for inspection and actions taken against the danger. With this freeze frame capability firefighters can go over a situation again to be sure they did not miss anything. A remote control also comes with the M700 giving the firefighter the capability of seeing other danger areas while not even being around the camera.

Thermal Imagers are not inexpensive. Model prices can range from eight to fifteen thousand dollars, with higher end products offering more user options. When fire departments invest in thermal imagers they usually have to bring the request to the city or town the department serves. Then the town or city council will see demonstrations of the imager and decide if the investment is worth it.

Another type of thermal imager uses infrared (IR) technology. The IR imagers perform the same functions as a regular thermal imager but the IR also displays the temperature of the object in focus. The IR imagers can also detect flammable liquids in drums and storage tanks along with all the other capabilities of a regular thermal imager. The price range of these IR imagers is similar to regular thermal imagers[23].

Thermal imagers are good to use when assessing a fire but when searching for your own firemen the thermal imager may not come in that handy. If a man or woman is down and completely covered by heavy debris where a PASS device can't be heard a thermal imager will be just as useless. A thermal imager may not be able to pick up the traces of heat coming from the downed individual. For most other situations a thermal imager is an effective way to find lost firefighters and civilians[24].

2.4 G.E.M. System

Grace Industries has developed a personal safety operating system that includes a new PASS device and a central tracking system for the PASS devices. This system is called the G.E.M. System[25]. The capabilities of the G.E.M. System include:

- Identity of the personnel operating on the emergency incident scene

- The On/Off status of T PASS II™ devices
- The identity of firefighters in alarm
- When firefighters have not checked in

The foundation of the G.E.M. System™ is based on a new PASS device. This PASS device is designed to eliminate false alerts by the use of a different type accelerometer to detect motion or lack of motion. Most other PASS manufacturers use a "roller bearing crossing contact points method of detecting motion, or a light chamber with a roller bearing that blocks the light signal to detect motion[26]." The new T PASS II™ uses a solid-state accelerometer.

"The solid state accelerometer uses the wearer's motion to generate an electrical charge that can be measured and timed. Similar to the difference between a solid state television tuner and a mechanical television tuner, the solid state accelerometer is more durable and less prone to false alerts."[27]

An alarm condition can be transmitted by pressing the alarm button, or if the wearer remains motionless for 25 seconds. A 7-second pre-alert sounds at 18 seconds allowing the wearer to reset the device if he or she is not in distress. When the command receiver processes a signal, these three things can occur:

- A vocal announcement sounds indicating that a firefighter is in distress.
- Two flashing lights on the lid of the Command Receiver indicate an alarm condition.
- The name of the individual in distress is prominently displayed on the Liquid Crystal Display screen.

"In order to achieve accurate and continuous accountability, an individually coded message is transmitted via spread spectrum radio technology to the G.E.M. System's™ Command Receiver where it is processed and translated into the emergency incident census. This radio technology was first developed for use in military and high-security applications because of the difficulty in intercepting and/or jamming the signal."

"Spread spectrum technology allows vast amounts of data to be transmitted accurately with little or no signal loss[28]." These spread spectrum radio signals are sent and received using frequencies in the 902 - 928 MHz band and processed in a microprocessor built-in to the Command Receiver. The Command Receiver sorts the signals with a proprietary processor that translates the signal into readable data and can be displayed on the Liquid Crystal Display screen and/or a personal computer or laptop. Here are the product specifications of the T PASS II™ and the GEM System:

Table 2.2:
T PASS II™ ALARM TRANSMITTERS[29]

RADIO	**Ultra Efficient Spread Spectrum 902-928 MHz band. No FCC license required.**
AUDIO OUTPUT	**95+ dBA with attention getting sound signature in mode.**
DIMENSIONS	**Only 2" wide x 3-1/4" high x 1-1/8" deep. Weight is 8 oz. with battery.**
VISUAL	**The entire case glows and changes color to indicate the mode of operation. (An invaluable aid in locating a downed firefighter!).**
MOTION DETECTOR	**Solid state accelerometer.**
POWER	**9 volt alkaline (Duracell MN 1604 recommended). Average battery life - 3 months.**
CASE	**High strength polycarbonate case.**

Table 2.3:
GEM SYSTEM™ BASE RECEIVER[30]

RANGE	Up to 1 mile depending on limiting factors and environmental conditions.
ALARM CONDITION DISPLAY	All models offer a vocal message and alarm warning lights. Personnel information is displayed on a Liquid Crystal Display screen (Command Receiver), or by specific channel indicators (T-2 thru T-16).
INTERNAL POWER	12 volt internal power supply provides 8 hours of continuous operation.
EXTERNAL POWER OPTIONS	120 - 240 volts AC, with auto charge feature. Also comes with 12 volt DC cigarette lighter type power plug.
CASE	Rugged, impact resistant ABS carrying case in Safety Yellow. Unit is totally portable.

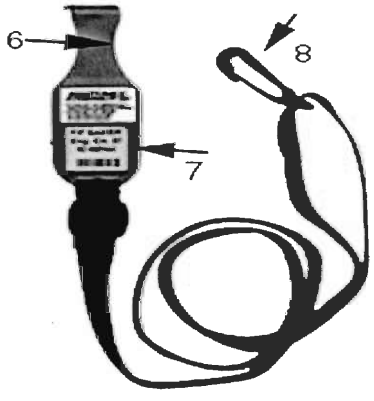
The incident history can be automatically stored onto a personal computer or laptop "using software that interfaces through a standard RS-232 port in the command receiver." The following information can be saved and retrieved from the command receiver:

- Time each individual reported on the scene.
- The time that each PASS device was activated.
- The names of individuals who go out of range, and the time that it occurred.
- The identity of an individual in alarm, as well as the time that the alarm condition occurred.

The GEM System can be used with any size department having 2, 4, 8, 12, or 16 channel configurations, based on personnel and response system requirements. For a department of 50 firefighters the price of the system is $29,000.

Below are some pictures of the T PASS key that once removed from the T PASS device will automatically arm the T PASS device, and the GEM System command center[31].

Figure 2.5: Accountability Tag with Tether



6. Accountability tag
7. Identification window for numbers, photos, bar codes, etc.
8. 6-foot Tether to anchor unit to a fixed storage position

Figure 2.6: G.E.M. Display

2.5 Unresolved Issues

In the previous sections some of the most widely used devices in the field of firefighter protection have been considered. These devices can help save lives, although there still may be unnecessary accidents occurring, which the authors believe could be avoided with some modifications to existing devices. The following will look at the flaws of existing technology. These problems should be addressed when looking at how to improve the technology used to locate lost firefighters.

One easily avoidable problem is the fact that many firefighters simply do not activate their PASS device. If the device is not activated, than it cannot perform its intended function. Once the device enters alarm mode, it emits a high-pitched noise with the intent of alerting others to the location of a possibly downed firefighter. As a result of this noise, some firefighters do not turn on their PASS device once they arrive on the scene. This mistake could cause problems if a firefighter enters the fire ground without activating this device and is injured.

Another problem with the PASS device is the fact that its alarm is audio based. In a fire situation, hearing is often impaired. Even though the audio alarm is loud, the

device can be drowned out by other fire ground activities. Some PASS devices are equipped with LED displays, but these signals can also be missed due to similar reasons.

The Bernard easy exit system has several faults, including the fact that the device sometimes cannot be seen because of blinding smoke. The arrow is also very small, and not easy to feel with fire equipment on. It can also be easily mistaken for a hose coupling. In the words of Chief John O'Donahue, of the Cambridge Fire Department, "It simply doesn't work[32]."

Communication at a fire scene is critical for safe operation. The problem with existing radios today is that many firefighters try to communicate on the same line, and unnecessary noise from background sources muffles clear communications. Chief O'Donahue said, "Firefighters had to go out to the stairwell to communicate because the noise was so bad on scene.[33]"

While Lifelines allow a firefighter to constantly be connected to an exit out, the can be more of a hazard than a help, especially in the dark. In today's structures, there are many corners and obstacles that lifelines can get tangled in. The lifelines inhibit firefighters mobility, a critical asset of every firefighter.

Thermal Imagers can be a great piece of equipment on a fire scene. They can see through smoke and help search for downed firefighters. The problem with this device is that it cannot see through solid objects. Since firefighters can be trapped under various opaque objects a thermal imager would be of no help in this situation.

While the G.E.M. System is one of the most comprehensive devices for locating lost firefighters, it too has room for improvement. The system is only compatible with

the T PASS device. Many departments already have PASS devices that are non-compatible with the G.E.M. system.

3. Methodology

In the previous section, the problems with existing devices were outlined. This study investigated possible ways to improve on the already existing technology. While this study relied heavily on survey input of individuals involved in the fire service, sources in government, training, investigation, and manufacturing, also were considered.

Six different surveys were distributed. This is because there are six groups that have relevant information on the subject. The groups were: firefighters, fire officers, town and city administrators, academy instructors, fire investigators, and equipment manufacturers. The goal of the surveys was to obtain the following information from each of these groups:

Fire Officers- Surveys were sent to one officer in every fire department in the state of Massachusetts. It was desired to learn what they like and dislike about the devices that their department uses. Also, it is relevant to find out the training that they receive on this equipment and the training that they give to the firefighters under their command. It was also necessary to find out any certification criteria in order to train their firefighters. If such certification existed, it was inquired as to how often firefighters were required to retrain.

Firefighters- Surveys were sent to one firefighter in every fire department in the state of Massachusetts. The survey sought to learn their likes and dislikes about the devices that their department uses. This was important because the line firefighter is the person who is the primary user of these devices. Their experience in using these devices is the most valuable asset that they offer. The type of training they received with these devices and how often training occurred was

also considered. It is also significant to take into account any thoughts that they had on what equipment their department lacks and changes in equipment that could be made.

Fire investigators- Surveys were sent to several investigators in the New England region. Because fire investigators are in charge of investigating accidents after the fire has occurred, they have a unique view on how well the technology works. It was asked if they feel that the technology is doing its job, which is helping to locate lost firefighters. Any specific instance in which the technology was unable to locate a lost firefighter, and the impact of this was determined. The surveys also found out if there were any instances in which lost firefighters may have been found more efficiently if existing equipment was utilized.

Administrators- One survey was sent to every town office in the state of Massachusetts. It was desired to learn about the budget given to different departments, and also what percentage of this budget was allocated towards devices for locating lost firefighters. The survey also discovered if any existing technology was not available to a certain fire district because of cost.

Equipment Manufacturers- Surveys were sent to ten different equipment manufacturers in the United States. The surveys sought to find out the cost of the equipment they manufacture, and what kind of departments most of their sales go to. The survey asked how long this equipment has been in use and the life expectancy of the product. Also, the testing that the manufacturer performs on the equipment was considered.

Fire Academy Instructors- Surveys were sent to several instructors at the

Massachusetts State Fire Academy. It was desired to find out what kind of equipment firefighters were trained to use and also how much time was allotted for training on these devices. It was also necessary to learn what kind of test each firefighter is required to pass before becoming certified. The training that the instructor must go through in order to teach this to other firefighters was considered.

This data was compiled and analyzed in order to find out which problems occurred most frequently, and what the most effective change would be. Some personal interviews were also conducted in order to gather more comprehensive background data that is too specific to ask in a general survey.

4.0 Analysis

4.1 Fire Officer

The fire officers' information that was obtained was helpful in several ways. From the eighty surveys received back from this group one can observe trends in training and equipment effectiveness. Appendix B contains the complete data set. The following questions were asked of the fire officers:

- Do you feel the current equipment is effective?
- Are you lacking any necessary equipment?
- Are you responsible for training firefighters?
- If so, how often is training given?
- Do you feel current training techniques are adequate?

The rest of this section will address and analyze each of these questions individually.

One question asked of the fire officers surveyed was "Do you feel the current equipment is effective?" The equipment in question was the Bernard Easy Exit system, Lifelines, PASS device, Thermal Imagers, and Radios. The surveys were restricted to these devices because they are the only devices considered in this study. Only these devices were considered due to time restraints of the study.

In order to prove the statistical significance of this data, this study will conduct a test for proportioning. At the start of this project it was hypothesized that a majority of fire officers would feel that current equipment is adequate. For the null hypothesis the chosen value is 0.50, signifying a 50% satisfaction rate among fire officers surveyed. They gave the following responses:

Table 4.1:

Do you feel the current equipment is effective?	
Yes	75%
No	25%

Based on the information presented in table 4.1 the alternative hypothesis says that 75% of fire officers feel current equipment is effective. This should be accepted as true because a statistical analysis has provided a significance level less than 0.001, well within acceptable limits for a 95% confidence interval. This means that if a larger population was surveyed, there is a 95% chance that over 50% of the population surveyed will say that the equipment is effective.

Although most said that the current equipment is effective, some comments given suggest that there is a need to improve this equipment. One respondent said, "Current equipment is not adequate." Another said " (it's) hard to find exact location of downed firefighters with current equipment." Several comments were also made suggesting a Global Positioning System (GPS) would be very beneficial. One fire officer said, "Equipment is not very technologically advanced." Another comment reveals, "Equipment is out of date and lack necessary facilities for training." Although the survey responses show the majority of fire officers believe current equipment is adequate, there is still proof to the extent that further technologies need to be developed.

The second question asked of fire officers was "Are you lacking any necessary equipment?" It was hypothesized that a majority of fire officers would feel their department was lacking necessary equipment. Once again, the null hypothesis was set at 0.50 to signify a slight majority. Their responses are as follows:

Table 4.2:

Is your department lacking any necessary equipment?	
Yes	66%
No	34%

From table 4.2 it is evident that the more of the surveyed group believed they are lacking necessary equipment. When a statistical analysis was performed on this data, a p-value of 0.002 was obtained. This signifies that in a larger population, the majority would agree that their department was lacking necessary equipment.

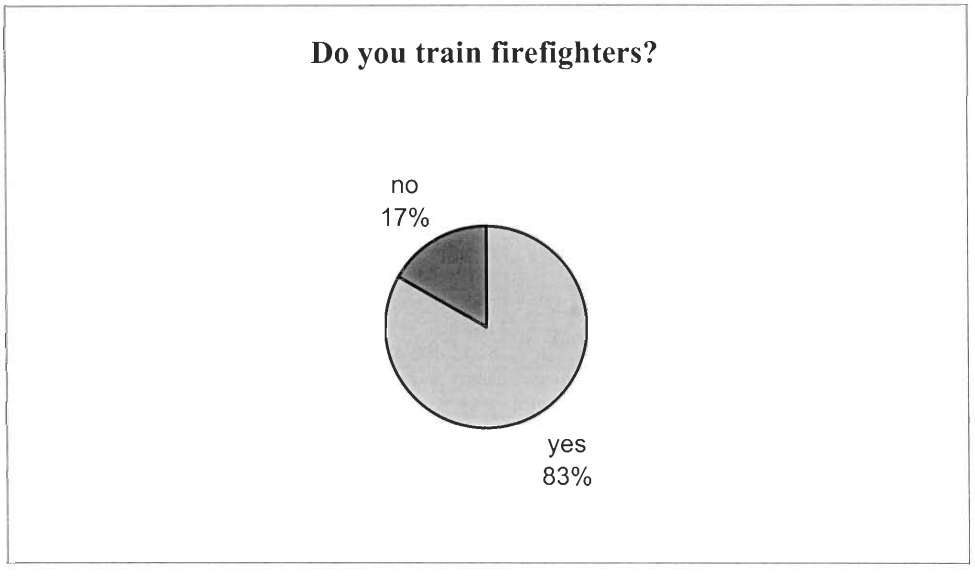
Many of the respondents of the survey offered reasons for why they felt that their department was lacking equipment. Comments suggest that the piece of equipment that is missing in most departments is the thermal imaging camera. This can be seen in several comments, such as "Need thermal imaging camera but too expensive," and "Need handheld thermal imager and GPS." Another reason some departments feel that they are lacking necessary equipment is due to available budgets and the high cost of some devices. One officer said, "Cost of technology is too high for many small departments." For more information on budgets see Town Administrator Analysis section. Despite the fact that departments do not have the same budgets one officer said, "There is no reason any dept. shouldn't have PASS, radios, and thermal imagers." Another comment that supports this idea is, "The advent of the MA firefighter safety equipment grant will greatly help increasing the amount of safety equipment available to firefighters."

The relationship between these two categories should also be considered. Of the officers who felt their current equipment was effective, 60% felt that they were still lacking some necessary equipment. Of the officers that felt there current equipment was

ineffective, an overwhelming 94% felt they were lacking some necessary equipment. This information could lead one to believe that satisfaction with current equipment, has an impact on whether or not the feel they need new equipment.

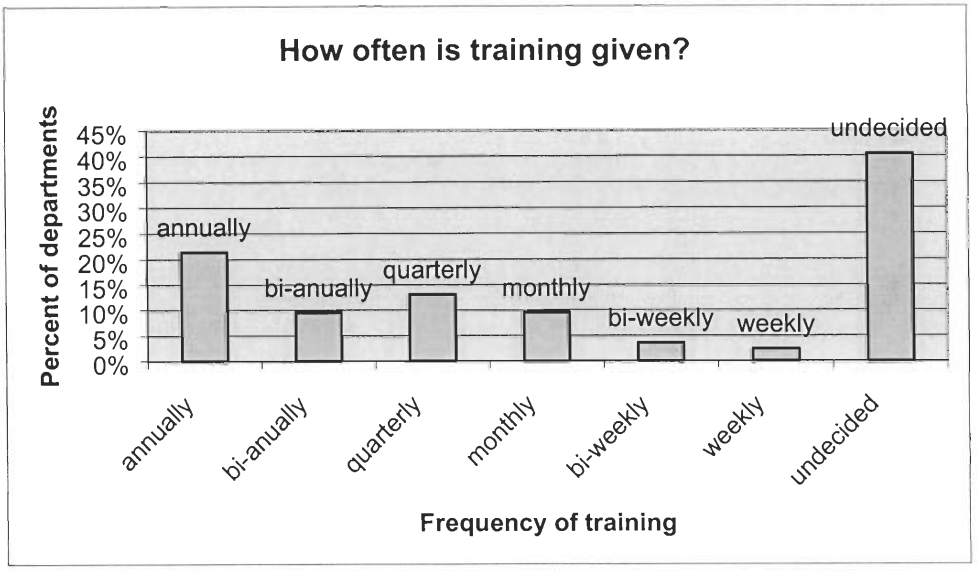
The third question asked of fire officers was "Are you responsible for training firefighters?" The following graph represents the percentage of fire officers who are responsible for training their firefighters.

Figure 4.1:



As can be seen from the preceding chart, a large majority of the surveyed officers have some training responsibility. Now that it is known that the majority of the surveyed group is responsible for training on devices used to locate lost firefighters, it is also known that their opinions on training techniques were relevant. The first item examined was how often training was given. The results have been broken down in figure 4.2.

Figure 4.2:



From this figure it can be seen that training varies significantly in this sample group. A statistical analysis was performed on the data and a mean value of 6.97 was calculated. This means the average department surveyed trains around seven times per year on the devices used to locate lost firefighters. It was originally hypothesized that training would occur quarterly for the average department. When comparing the calculated mean of 6.97 to this alternate hypothesis, a p-value of 0.034 is obtained. This is within the acceptable limit of 0.05; therefore, the data is significant to the population.

Since most departments do not train often, the quality of training should be taken into account. The surveys inquired what the fire officers thought of current training techniques. The results are shown here in table 4.3:

Table 4.3:

Do you feel current training techniques are adequate?	
Yes	55%
No	45%

From this table one can see only a slight majority feel current training is adequate. When performing a statistical analysis of this data, the hypothesis of a majority agreeing with this statement was tested. The analysis yielded a p-value of 0.843, which suggests that this data is not applicable to the entire population.

To better understand the feelings of respondents, one can consider some sample comments. Some suggested that current training techniques are not adequate. These were, "Always a need for more training," and "Hard to teach older members new techniques." These comments suggested a need for more training and new techniques in training. One comment, "Training and proper use of equipment are big parts in finding lost firefighters," shows how important training is. A comment that revealed a possible reason for the lack of training was, "Firefighters are not required to retrain annually."

One can also see correlations between this data. Consider the categories pertaining to training. Of the departments that train once a month or more, 80% of the respondents felt that training techniques were adequate. Of departments that trained 2 times a year or less, the satisfaction rate drops to 48%. This data can be interpreted that officers in general feel that training more often is more effective. Of the officers that were responsible for training, 53% felt that training techniques were adequate. Of the officers that were not responsible for training, 50% felt training techniques were adequate. Since

these values are so similar, there does not appear to be bias from officers who train their own firefighters. If there was an overwhelming amount of officers that trained firefighter who thought training was adequate, then one might be concerned that there was a bias. From the fire officers surveyed, one could find general trends in training on equipment used in locating lost firefighters. Generally, one sees that most feel current equipment is effective, but they also feel that their department is lacking some sort of necessary equipment. Most of these officers train firefighters on how to use this equipment, but training does not occur very often. When it came to training techniques, a slight majority agreed that current training techniques were adequate, but not enough to dismiss the idea of restructuring training techniques. Those that trained more often, at least once a month, were more likely to be satisfied with their training. See section 4.2 for a comparison of opinions between firefighters and officers on training.

4.2 Firefighter

From information provided by the sixty-five surveys, the likes and dislikes of firefighters and the effectiveness of their current equipment were determined. In addition, the amount of time different departments spend on training and retraining firefighters was observed. The questions asked of the firefighters were as follows:

- Is your current safety equipment effective?
- Do you think that changes need to be made to the current equipment?
- Are you lacking any necessary equipment?
- Do you feel that the current training is adequate?

The first question asked of firefighters was "Is your current safety equipment effective?" The following table shows the responses that they gave.

Table 4.4:

Is your current safety equipment effective?	
Yes	87%
No	13%

From table 4.4, one can see that there was a large majority of firefighters who felt that their department's current safety equipment is effective. The null hypothesis for a statistical analysis was set at 0.50 to represent a majority. An alternate hypothesis was used to test if the population would feel that their department's safety equipment was effective. Upon completion of a statistical analysis of this data, a p-value of less than 0.001 was obtained. This signifies that this data is very significant to the population as a whole.

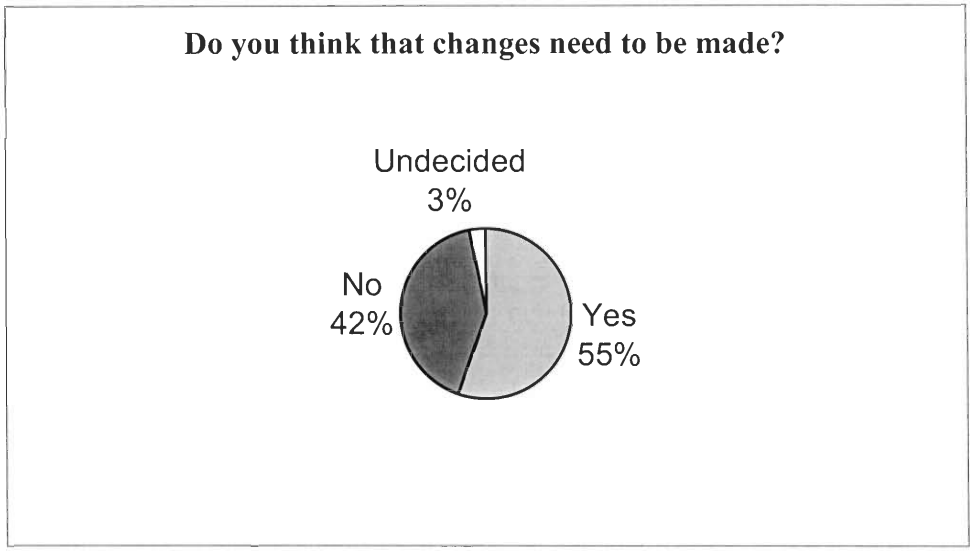
From this table it is evident that most firefighters believe that their department's current equipment is effective in locating lost firefighters. The survey did not indicate whether or not the firefighter had ever used any of the equipment in question in an actual fire situation. Therefore, this question may reflect the opinion of an individual that has only used the device in a training situation. This is obviously a much different scenario than an actual fire scene. Although an overwhelming majority felt that the equipment is effective, some firefighters who were surveyed strongly disagreed. For example one firefighter commented, "Equipment is only effective if fire conditions allow it to be used." Many firefighters believe that current technology should be implemented into the

fire service. "With new technology such as GPS and grid patterns, loosing a firefighter could be nearly eliminated."

This same question was asked of fire officers (see sec 4.1, table 4.1). In both cases, a majority of firefighters and officers feel that their current equipment is effective. Since in both cases the p-values obtained were smaller than 0.001, it is evident that this opinion is very likely to be found in most departments.

The next question asked of firefighters was "Do you think that changes need to be made to the current equipment?" This question helped to determine if more equipment needs to be developed or if the current equipment is adequate. The graph of the data is as follows:

Figure 4.3:



From this figure it is apparent that a slight majority of firefighters felt changes need to be made to current equipment. This was tested to see if a majority of firefighters believed that there was some need for change to the devices. A statistical analysis

yielded a p-value of 0.263. A p-value of greater than 0.05 indicates that this data cannot suggest a similar opinion would hold true in the general population.

Many of the firefighters offered helpful suggestions towards developing new types of equipment. One that occurred frequently was to invent a type of GPS tracking device so that firefighters could be followed at all times while they were in a burning building. Another comment was to "Utilize equipment and technology used for the locating of lost military personnel and further develop it to help firefighters." For more comments, see Appendix B.

The third question on the firefighter survey was, "Are you lacking any necessary equipment?" This question was asked in order to determine if a fire department was deficient with any of the safety equipment that is currently available. The answers to this question are displayed in the following table:

Table 4.5:

Are you lacking any necessary equipment?	
Yes	50%
No	50%

The above data shows an even split of opinion on this issue. An analysis of these figures was conducted, using a hypothesis that a majority was lacking necessary equipment. This test resulted in a p-value of 0.550, which is outside the acceptable limit of 0.05. Therefore, this data cannot suggest what the opinion of the entire population would be.

Of those who felt their department was lacking necessary equipment, most did not

have a thermal imaging camera. Because of the high costs of this device, it is difficult for many small towns to be able to afford one. Also, many times when equipment was lacking, the department needed more lifelines or safety ropes. Many of the respondents stated that they were able to secure grants from the federal government in order to buy necessary apparatus.

This question was also asked of fire officers, (see section 4.1, table 4.2). In the case of the fire officers, a larger percentage of respondents felt that their department was lacking necessary equipment. Recall, the p-value from this analysis was 0.002, which suggested this data was significant to the population, unlike the firefighters' data, which was deemed insignificant. Due to an in discrepancy with this question, it may be prudent to conduct further tests on this question.

The final question asked of firefighters was, "Do you feel that your current training is adequate?" This question was of great importance because it helped determine if there is a link between firefighter deaths and lack of training. The following graph illustrates this data:

Table 4.6:

Do you feel that your current training is adequate?	
Yes	65%
No	35%

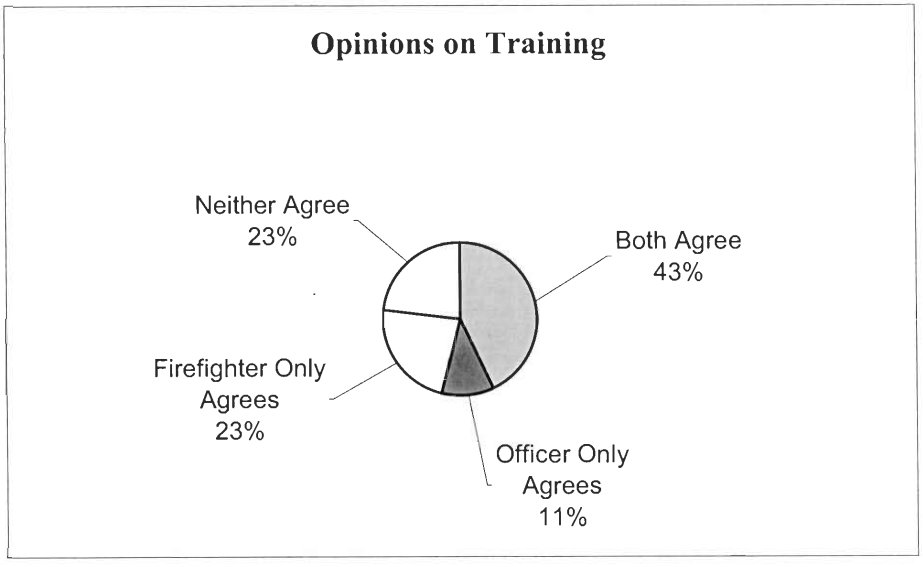
This data was used to conduct a statistical analysis. It was originally hypothesized that a majority would say that their current training was adequate. Due to this, a null hypothesis of 0.5 was compared to an alternate hypothesis of greater than 0.5.

Using these parameters, a p-value of 0.015 was calculated. This is well within the acceptable limit of 0.05, which suggests that this data is significant to the population as a whole.

Many of the thirty-five percent who answered no to this question had very strong views that training should be changed. Many said that one person in the department should coordinate training, so that every unit operates under the same procedure. Others believed that more lifelike fire training should occur and not just classroom lessons. Many others thought that no matter how much training occurred it is never enough. This last suggestion is probably true because the techniques and equipment are always changing and firefighters need to update their knowledge on a daily basis.

In order to assess the accuracy of the opinion on training in a town, one needs to look at the responses from both the firefighter and officer. In figure 4.4 on the next page, the responses of firefighter and officers from the same departments are shown. In the surveys, the respondent was questioned whether or not they felt the current level of training was adequate. The chart is set up in such a manor to show the percentage of firefighters and officers with similar opinions or different opinions.

Figure 4.4:



From the chart one can see that 66% of the responding firefighters and officers from the same department had similar feelings on training. Since two separate people both feel the same way on training, it shows an accurate depiction of the training situation in that department. There was a difference of opinion for the remaining 34% of respondents. This is troublesome because it is not possible to ascertain which person has the more accurate viewpoint. Therefore, one can anticipate a slight margin of error due to the fact that the surveys did not give a totally truthful depiction of the departments' training.

If one looks at the survey responses more carefully, you can see that there are some definite correlations between different questions. In table 4.7 on the next page, relationships between questions have been explored. For example, 94% of the firefighters who felt that their current equipment was effective also felt that their department was not lacking any necessary equipment.

Table 4.7:

Correlated Responses		
Question 1 with Response	**Question 2 with Response**	**Percentage of Firefighters who felt this way**
Yes – Is your current equipment effective?	No – Do you think that changes need to be made?	89%
No – Is your current equipment effective?	Yes – Do you think that changes need to be made?	56%
No – Is your current equipment effective?	Yes – Are you lacking any necessary equipment?	89%
Yes – Is your current equipment effective?	No – Are you lacking any necessary equipment?	94%
Yes – Do you think that changes need to be made?	Yes – Are you lacking any necessary equipment?	61%
No – Do you think that changes need to be made?	No – Are you lacking any necessary equipment?	67%
Yes – Do you think that changes need to be made?	No – Do you feel that current training is adequate?	74%
No – Do you think that changes need to be made?	Yes – Do you feel that current training is adequate?	78%

Out of the people who answered no to the question "Do you think that changes need to be made" eighty-nine percent also answered yes to "Is your current equipment effective". This shows that most firefighters who do not feel that changes should be made to the current equipment also feel that their equipment is effective. On the other hand, of the firefighters who answered no to the question, "Is you current equipment effective" fifty-six percent felt that changes should be made to the current equipment.

Another direct connection between survey responses was with firefighters who felt that their department is not lacking any necessary equipment. Ninety-four percent of the firefighters who felt this way also felt that their current equipment is effective. The opposite is also true. Of the firefighters who answered no to the question "Is your current equipment effective" eighty-nine percent felt that their department is lacking necessary equipment.

A third correlation was between the questions "Do you think that changes need to be made" and "Are you lacking any necessary equipment". Sixty-one percent of the firefighters who felt that they are lacking equipment also felt that changes should be made with the current equipment. On the other hand, sixty-seven percent of the firefighters who did not want changes to be made also did not think that their department was lacking any equipment.

One last connection between responses was with "Do you think that changes need to be made" and "Do you feel that current training is adequate". Seventy-four percent of the firefighters who felt that their current training is not adequate also believed that changes do need to be made with the current equipment. The opposite was also true. Seventy-eight percent of firefighters felt that changes were not necessary for the current equipment and that their training was adequate.

4.3 Town Administrator

Several town and city administrators were surveyed and asked the following questions:

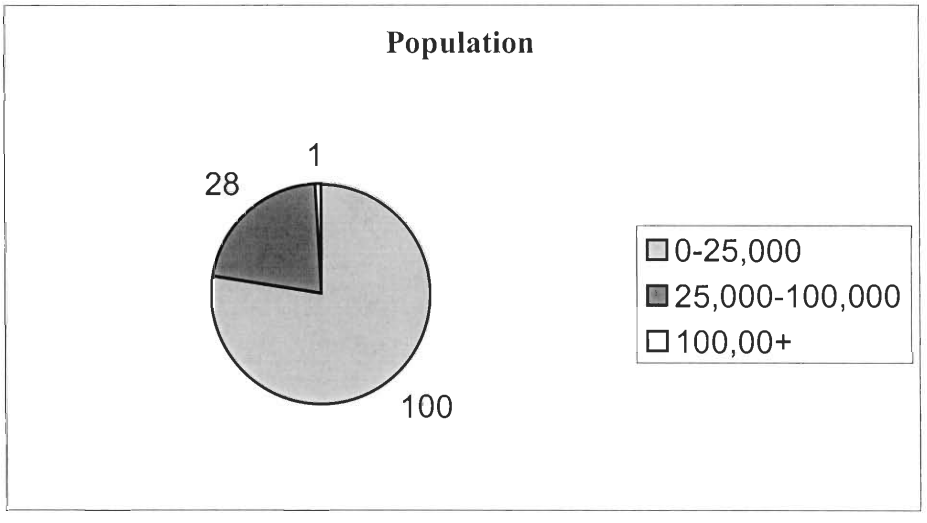
- What is the population of the town you represent?
- How much money is allotted for your fire department in the town or city budget?
- How many employees in your fire department?

It was assumed that the information received from these questions would give answers to questions such as, "Do fire departments have enough money for new equipment?" and "Do they have the funding to keep up with present fire fighting techniques?"

The information obtained though the town administrator surveys was used as reference data for the previous two sections. This study relied mainly on the viewpoints of the different firefighters and officers surveyed, and not on the town administrators'. Therefore, this section does not lend itself to a statistical analysis as previous sections did.

The first question asked was, "What is the population of the town you represent?" This question was asked to see the relationship formed by the town's population, the funding for each department and the number of employees in each department. The general population of the towns surveyed is displayed in the following graph:

Figure 4.5:

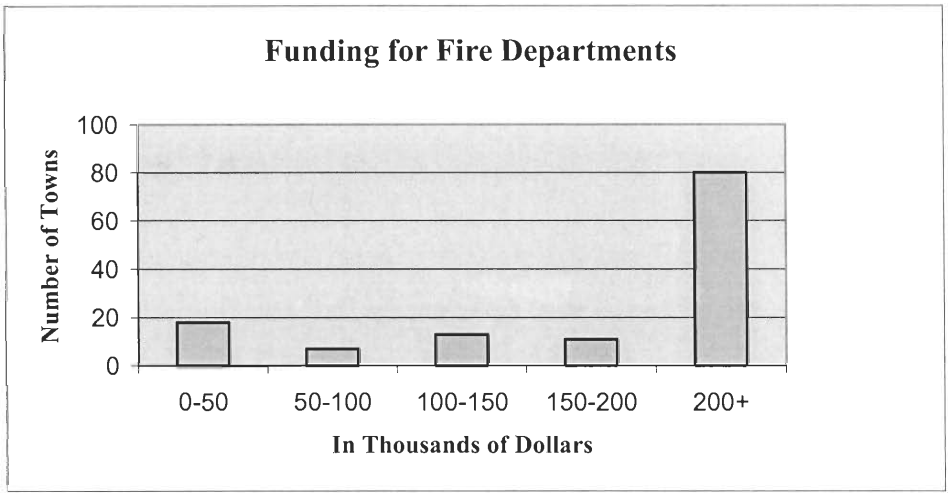


From the graph above it is evident that most of the surveys completed and returned were from smaller towns. This means that the information presented may not be accurate with larger communities.

The next question asked was, "How much money does your city or town allot for the fire department every year?" The information received from the responses to this

question would give an idea of how much money smaller community fire departments had to operate with. The following graph represents this information:

Figure 4.6:



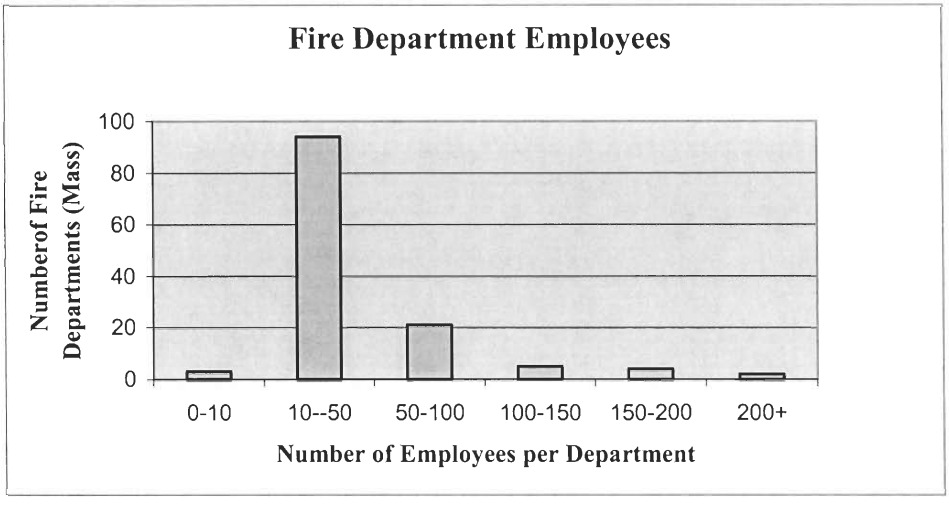
As the graph shows, many towns and cities in Massachusetts operate with a budget over $200,000. Many town and city administrators said that they have had to limit the funding to the fire department because of proposition 2 1/2. This is a law limiting taxing so that taxes can not be raised over 2.5% of overall property value[34]. The Brookline town administrator says, "Paying staff is the first issue, then equipment is the next factor." This is just another reason why many fire departments may not have had enough money for new equipment.

Many towns are limited in their budget for fire departments. A town administrator from Andover said, "A specific amount of funds is divided proportionally between municipalities." Some factors that limit fire department funds are the needs of other town funded operations, such as public schools and police. Several surveys indicated that the public school system received a higher priority for the municipal

budget. Some comments that support this are, "Public school funding is a bigger priority," and "School budget consumes 60% or more of town's revenue."

The final question asked on the administrator survey was, "How many employees are in your fire department?" From this question, it was desired to determine the size of the departments in question. The next graph shows the number of employees per station for various towns.

Figure 4.7:



Most fire departments that responded to the surveys have ten to fifty employees. Many of the smaller towns have ten to fifty employees per fire department with an operating budget of more than $200,000. This budget must meet the operating costs of the department for the entire year, so only a portion can be dedicated to purchasing new equipment. The town administrator from Everett said, "Salaries are approximately 95% of fire department's budget." This comment shows that there is not a lot of extra money for some departments to work with.

4.4 Equipment Manufacturer

The goal of creating the surveys for the manufactures was to gain a better understanding of the equipment that was researched. Five manufacturer surveys were received back out of ten. For the remaining three sections, due to the small sample size, it would be inaccurate to perform a statistical analysis on the data. More in depth polling of these groups must be conducted in order to obtain a reliable data set. The manufacturer's survey asked questions about their product like: how long it will last, if they think it needs further adjustments, and if they think it is an effective personal safety device.

These responses indicated a need for change of even the latest equipment. The manufacturers of the G.E.M. System said that their automated accountability system still needs some changes towards better instant notification of a PASS system in alarm mode. Manufacturers of thermal imagers indicated a need for better quality image performance and a smaller, lighter or even hands-free design. Clement, the manufacturer of the Bernard Easy Exit says that more emphasis should be place on preventing firefighters from becoming lost instead of trying to find better ways to locate them. With the exception of Clement, all of the manufacturers of personal fire protection devices that were surveyed agreed that there should be further study in the field of personal fire protection devices.

4.5 Fire Academy Instructor

Because only a limited number of surveys were sent to fire academy instructors, the responses were few. Only one instructor survey was received back. This survey did help to determine the training that firefighters receive before they become certified.

The firefighters attending the academy go through rigorous training on various devices. They are required to learn how to use lifelines and PASS devices and also become proficient with other equipment. They are tested on how well they can operate these devices and must pass these tests in order to become a certified firefighter. While attending the academy, the firefighters are tested weekly on these devices. After the firefighter receives certification they are not required to go back to the academy for retraining.

The information received from an academy instructor gave insight into the training that is required of a Massachusetts firefighter. Although they train at the academy, after a firefighter graduates they are not required to go back and retrain. Because of this, many older firefighters do not learn new techniques unless their individual department trains them.

4.6 Fire Investigator

It was sought to find information on technology used to locate lost firefighters from the point of view of a fire investigator, but only two responses were received from this group. Since the return was so small, it would be inaccurate to perform a data analysis on this data set. It was felt that this information was useful and decided to at

least mention the viewpoints expressed by these individuals. This may not represent the majority of fire investigators.

Both of the respondents had investigated a fire where a firefighter became lost at the scene. The two types of equipment used to locate the lost firefighters were radio and PASS devices. Both agreed that this technology was adequate in order to find the lost firefighters. When asked what changes they would make, one suggested GPS technology incorporated into firefighter tracking devices, and the other thought that easier to carry and operate equipment was a good change. Both have seen a firefighter become lost due to a lack of equipment.

On the section for general comments, an important one, "PASS devices are effective but firefighters fail to activate." This indicates a problem with the current technology, since the equipment is useless unless it is on and in working order.

This data group was comprised of only a few respondents and this should be accounted for when considering the recommendations of this section.

5. Conclusions and Recommendations

The following section contains the conclusions reached by the project group and recommendations that they feel should come out of this study. This was based on the information that can be found in this report. From the start, it has been the goal of this project to look at existing devices used to locate lost firefighters and investigate ways to improve them. This section will discuss the solutions to the problems that were identified in the unresolved issues section of this report.

The conclusions addressed here deal with the devices discussed throughout this report. From the information presented in the analysis section, the following conclusions about devices, training, and funding have been derived.

After considerable amounts of research in this area, it is the recommendation of this study that there is not a need to develop new technology with respect to locating lost firefighters. Of the firefighters and officers polled, the majority felt that their current equipment was effective. It was felt, however, that many departments were lacking some necessary equipment, which is already available on the market at the time of the study. The majority of firefighters thought that the current levels of training were adequate, and research shows that training occurs at least quarterly for the average department. Although some minor problems with current devices are listed in the following paragraphs, at this time it is concluded that the firefighting community is not calling for any new research. However, manufacturers should consider modifying current devices used for locating lost firefighters in order to increase safety levels.

The first problem addressed was that the PASS device does not always get turned on for various reasons. This is a risk to the firefighter, since the device will not perform

its intended function without activation. For this reason, PASS devices should have the capability of arming themselves automatically once they arrive on the scene. This added safety feature would remove human error and ensure that if a firefighter becomes lost, the firefighters' tracking device stays armed. To accomplish this, several options may be considered. A key could be attached to the apparatus and once the firefighter leaves the vehicle, the device would automatically arm. Another alternative would be to utilize the motion sensor already present in the device and have it automatically activate upon the first motion. By making the device activate automatically, the chances of the device being effective are greatly improved.

Another problem is the fact that the PASS alarm is audio based, and not a very accurate way to find a lost firefighter. It has been found that there is a need for a more effective way to alert rescuers to the whereabouts of the lost firefighter. One possibility would be to utilize the G.E.M. system discussed in the literary review of this report. However, this application was beyond the scope of this report, so only moderate consideration was given it this study. It is recommended that future work be dedicated to finding more effective alarming and locating methods.

This study also looked at the flaws of various simple devices, such as the Bernard Easy Exit System, Lifelines, and Radios. With respect to the Bernard Easy Exit System, It has been found that the system is ineffective in it's task. It has been found ineffective in helping to locate a lost firefighter, and interviews have supported the conclusion that its flaws outweigh its usefulness. This study shows that in Massachusetts, the average firefighter does not use lifelines, and does not have very much exposure to them. Therefore, there is not enough information to comment on the effectiveness of lifelines.

A more specialized study on lifelines would have to be conducted with subjects that use the device often. Radios have several problems and often are not sufficient for accurate fire ground communications. Firefighters participating in this study are unhappy with the quality of the radio equipment that they currently have. In the literary review of this document, a hands free radio system is referenced that could overcome some of these problems. In order to find the best way to solve this issue, future studies should concentrate on radio communication.

It has been found that most firefighters are happy with the quality of thermal imaging cameras. The only negative comment was the fact that the devices are so expensive, and as a result not affordable to many departments. At this time, this study sees no reason to change the thermal imaging camera or any of its technology.
State fire officials should regulate training on devices and training should be monitored. Firefighters should be required to train on these devices as often as feasible. It was found that firefighters who retrained often were more satisfied with the quality of training. Also, the only way to be sure all members are up to date on how to operate the devices is to retrain, and retrain often. Training on standard devices such as PASS, lifelines, and thermal imagers should be mandatory for all firefighters to ensure that they are aware of how to properly use these devices. Formal Training by an expert should occur at least once a year, the more often the better. Departments should also train more often on their own time, this study recommends once a month on these devices.

Training should also be monitored within the department. It is recommended that one officer from each department should be responsible for coordinating training throughout the department. The reason for this would be to assure that all firefighters

have received the same training and that the training is up-to-date. This coordinator should be certified by state fire officials and be required to retrain annually.

In conclusion, with a few modifications, devices used to locate lost firefighters can be greatly improved. By following the suggestions made in this study the chances of losing a firefighter can be reduced immensely. New technologies in firefighting personal safety devices should be developed along the guidelines that are specified in this report. By standardizing training, incorporating new technologies into firefighting, and making these devices more affordable, locating lost firefighters will become more efficient and reliable.

5.1 Possibilities for Future Studies

Throughout this study one hundred forty nine firefighters gave recommendations on how to improve current technology. These changes were beyond the scope of this study, but they deserve to be included in this report. For this reason, the following ideas should be considered for future work.

Many of the fire officers, fire fighters, and equipment manufacturers agreed that there is a need for further modifications of existing technologies in the field of personal fire safety devices. One way to improve fire ground safety is to improve the accountability tracking systems currently in use, more specifically the GEM system. This can be achieved through creating a receiver with a display that shows the status of every firefighter on scene and their location. The receiver should be able to store floor plans of buildings in the department's jurisdiction. The overhead display would show the position of all active firefighters relative to the floor plan stored in the receiver. It should be left

up to local authorities to decide which buildings should be required to submit floor plans. This new accountability system will aid in the rescue of lost firefighters because on scene coordinators will be able to see the relative location of rescue crews to the lost firefighter. Future work should be dedicated to see if such a system could be implemented.

Endnotes

1.North Atlantic Information Systems, "The Bernard Easy Exit," 5 December 1999, <http://www.bernardeasyexit.com/htm> (17 September 2000)

2. North Atlantic Information Systems, "The Bernard Easy Exit,"

3. Paul Hashagen, "Tools, Techniques & Innovations, New Device Leads Firefighters to Safety," September 1995, <http://www.bernardeasyexit.com/article.htm> (17 September 2000)

4. North Atlantic Information Systems, "The Bernard Easy Exit,"

5. Paul Hashagen, "Tools, Techniques & Innovations"

6. North Atlantic Information Systems, "The Bernard Easy Exit,"

7.Stephen Foley, "Occupational Health and Safety Standards Handbook" Quincy, MA: National Fire Protection Association, 1998

8.Mike Bentley, "Re: Firefighter Lifelines," 11 October 2000, Personal Email, (30 September 2000)

9. Mike Bentley, "Re: Firefighter Lifelines,"

10. Stephen Foley, "Occupational Health and Safety"

11. Ken Hoffman, "Navy License Can Help Nations Firefighters Save Lives," <http://www.navsea.mil/news/features/firefighter.html> (28 September 2000)

12. Ken Hoffman, "Navy License Can Help"

13. Byron Spice, "PG-Article," <http://www.mtac.pitt.edu/WWW/html/pg_article.html> (1 October 2000)

14. Byron Spice, "PG-Article,"

15. James P. Campman, "PASS Device," <http://www.gracesales.com/passalarms.html> (19 September 2000)

16. Wholesale Fire and Rescue, "Super PASS II," <http://www.wfrfire.com/website/breath/alarms/super.htm> (23 September 2000)

17. National Fire Protection Association, "Standard 1500" Quincy, MA: National Fire Protection Association, Chapter 5-8.1

18. National Fire Protection Association, "Standard 1001" Quincy, MA: National Fire Protection Association, Chapter 3-7.1

19. Fire and Rescue Apparatus & Products, "Dragonfly PASS," 1999 <http://www.fireandrescue.com/msa/dragonfly.htm> (20 September 2000)

20. James P. Campman, "PASS Device,"

21. Mitsubishi Electronics America Inc, "Thermal Imager MR700," 1999, <http://www.mitsubishi-imaging.com> (5 October 2000)

22. Mitsubishi Electronics America Inc, "Thermal Imager"

23.Sierra Pacific Innovations, "Thermal Infrared Specials," <http://www.x20.org/thermal/specials.htm> (22 September 2000)

24.Bullard Thermal Imagers, "Fire and Rescue Thermal Imager," <http://www.thermalimages.bullard.com> (4 October 2000)

25. Grace Industries, Inc., "G.E.M. System," <http://www.graceindustries.com> (4 February 2001)

26. Grace Industries, Inc., "G.E.M. System,"

27. Grace Industries, Inc., "G.E.M. System,"

28. Grace Industries, Inc., "G.E.M. System,"

29. Grace Industries, Inc., "G.E.M. System,"

30. Grace Industries, Inc., "G.E.M. System,"

31. Grace Industries, Inc., "G.E.M. System,"

32. Chief John O'Donahue, Cambridge Fire Department, Interviewed by Jason Kilty, Alycia Wood, and Dave Lashmit on 12/06/00 at the Massachusetts State Fire Academy in Stow, Ma.

33. Chief John O'Donahue, Cambridge Fire Department ,Interviewed by Jason Kilty, Alycia Wood, and Dave Lashmit on 12/06/00 at the Massachusetts State Fire Academy in Stow, Ma.

34. Katharine Bradbury, Christopher Mayer, Karl Case, "Property Tax Limits and Local Fiscal Behavior:," Federal Reserve Bank of Boston, Feb 5, 1997, pg 2

References

Bentley, Mike. "Re: Firefighter Lifelines." E-mail to the author. 11 October 2000.

Bradbury, Katharine, Case, Karl, Mayer, Christopher. "Property Tax Limits and Local Fiscal Behavior:," Federal Reserve Bank of Boston, Feb 5, 1997, pg 2

Bullard ThermalImager.com. "Fire & Rescue Thermal Imager." Online Posting. <http://www.thermalimages.bullard.com>.

Campman, James P. "PASS Devices." Online Posting. <http://www.Gracesales.com/passalarms.html>.

Fire and Rescue Apparatus & Products. "Dragonfly PASS." 1999. Online Posting. <http://www.fireandrescue.com/msa/dragonfly.htm>.

Foley, Stephen. Occupational Health and Safety Standards Handbook. Quincy, MA: National Fire Protection Association, 1998.

Grace Industries, Inc., "G.E.M. System," <http://www.graceindustries.com> (4 February 2001)

Hashagen, Paul. "Tools, Techniques & Innovations, New Device Leads Firefighters to Safety." Firehouse Magazine September 1995. <http://www.bernardeasyexit.com/article.htm>.

Hoffman, Ken. "Navy License Can Help Nation's Firefighters Save Lives." Online Posting. NAVSEA. <http://www.navsea.mil/news/features/firefighter.html>.

Mitsubishi Electronics America, Inc. "Thermal Imager MR700." 1999. Online Posting. Mitsubishi Imaging Products. <http://www.mitsubishi-imaging.com/>.

North Atlantic Information Systems. "The Bernard Easy Exit." 1998. Online Posting. Clement Firefighting Equipment Corp. December 6 1999. <http://www.bernardeasyexit.com/htm>.

O'Donahue, John, Cambridge Fire Department ,Interviewed by Jason Kilty, Alycia Wood, and Dave Lashmit on 12/06/00 at the Massachusetts State Fire Academy.

Spice, Byron. "PG-Article." Online Posting. MTAC. <http://www.mtac.pitt.edu/WWW/html/pg_article.html>.

Wholesale Fire & Rescue. "Super PASS II." Online Posting. <http://www.wfrfire.com/website/breath/alarms/super.htm>.

X20.org. "Thermal Infrared Specials." Online Posting. Seirra Pacific Innovations. <http://www.x20.org/thermal/spercials.htm>.

Appendix A

The following appendix contains the surveys that were sent out to the six groups.

Fire Officer Survey

City_____State_____

1. What equipment does your department use in order to locate lost firefighters?

(Check all that apply)

☐Bernard Easy Exit ☐Lifelines ☐Radios ☐PASS ☐Thermal Imaging Camera ☐Other

2. Do you feel that this equipment is effective in locating lost firefighters?

☐Yes ☐No

Explain Briefly

3. Do you feel that your department is lacking any necessary equipment to locate lost firefighters?

☐Yes ☐No

Explain Briefly

4. Are you responsible for training firefighters on how to properly use the previously mentioned equipment?

☐Yes ☐No

5. If yes, how often do your firefighters receive training on these devices?

6. Did you receive any training on how to teach others how to use these devices?

☐Yes ☐No

7. If yes, are you required to retrain and how often does retraining occur?

8. Do you feel that your department's current training techniques are adequate?

☐Yes ☐No

Explain Briefly

Additional Comments:

Firefighter Survey

City_____State_____

1. What equipment does your department use in order to locate lost firefighters? (Check all that apply)

☐Bernard Easy Exit ☐Lifelines ☐Radios ☐PASS ☐Thermal Imaging Camera ☐Other

2. Do you feel that this equipment is effective in locating lost firefighters?

☐Yes ☐No

Explain Briefly

3. Are you familiar with Britain's use of lifelines?

☐Yes ☐No

4. If yes, what is your opinion on these?

5. Do you believe that any changes should be made to the equipment that your department currently uses?

☐Yes ☐No

Explain Briefly

6. Do you feel that your department is lacking any necessary equipment to locate lost firefighters?

☐Yes ☐No

Explain Briefly

7. Do you receive training on these devices?

☐Yes ☐No

8. If yes, how often does your department receive training?

9. Do you feel that your department's current training techniques are adequate?

☐Yes ☐No

Explain Briefly

10. Do you feel that any changes need to be made to the behavioral tactics that your fire department uses, such as incident command or SOP? Please explain.

Additional Comments:

Town Administrator Survey

City_____State_____

1.What is the population of your city or town?
0 – 25,000 25,000 – 100,000 100,000 or more

2. How many different fire districts are in your city or town?
1 2 3 4 5 more than five

3. Do you have volunteer fire units? If yes how many?

4. How much money is allotted for a fire department in the city/town budget?
0-50,000 50,000-100,000 100,000-150,000 150,000-200,000
200,000 or more

5. What factors are considered when determining an amount of money for fire departments?

6. Are there any constraints to the funding for the fire department? If yes, can you please elaborate?

7. What is the average starting salary of a firefighter in your town or city?
0-10,000 10,000-20,000 20,000-30,000 30,000-40,000

8. How many people are currently employed in the town/city's fire department?
10-50 50-100 100-150 150-200 200-250 250 or more

Additional Comments:

Equipment Manufacturer Survey

Company_____Title_____

1. What devices for locating lost firefighters does your company manufacture?
   ☐Bernard Easy Exit System ☐Lifelines ☐Radio ☐PASS ☐Thermal Imager ☐Other

2. How many years has your company been producing the above questioned device(s)?

3. What is the life expectancy of the device(s)?

4. Do you perform any testing on the device(s) before it is marketed?
   ☐Yes ☐No

5. If yes, what kind of testing do you do? Give as many details as possible.

6. What is the selling price of the product in U.S. dollars?

7. Do you feel your device(s) gives a lost firefighter the best chance of being found?
   ☐Yes ☐No

8. What changes to the device or technology behind the device would you recommend? Give as many details as possible.

9. Do you feel that there is a need to continue development in the field of locating lost firefighters?
   ☐Yes ☐No

10. What size fire department do you do the most business with? (Average)

Additional Comments:

Academy Instructor Survey

State_____

1. How long have you been an instructor at a state fire academy?

2. Which of the following devices for locating lost firefighters are you familiar with?
   ☐Bernard Easy Exit System ☐Lifelines ☐Radio ☐PASS ☐Thermal Imager ☐Other

3. Which devices are all firefighters require to train on?
   ☐Bernard Easy Exit System ☐Lifelines ☐Radio ☐PASS ☐Thermal Imager ☐Other

4. How much training time is required on these devices? Be as specific as possible.

5. Are firefighters tested on how well they know these devices?
   ☐Yes ☐No

6. If yes, please explain the test.

7. What training are you required to complete in order to be an academy instructor?

8. Do you, as an instructor, have to be re-certified?
   ☐Yes ☐No

9. If yes, how often?

Additional Comments:

Fire Investigator Survey

City_____State_____

1. Which of the following devices are you familiar with? (Check all that apply)
   ☐Bernard Easy Exit System ☐Lifelines ☐Radio ☐PASS ☐Thermal Imager ☐Other

2. Have you ever investigated a fire where a firefighter became lost during the course of the fire?
   ☐Yes ☐No

3. If yes, which if any of the above mentioned devices where used by the lost firefighter? (Check all that apply)
   ☐Bernard Easy Exit System ☐Lifelines ☐Radio ☐PASS ☐Thermal Imager ☐Other

4. Do you feel overall, the available technology for locating lost firefighters is adequate? Briefly explain.

5. What changes if any, would you like to see made to the methods used to locate lost firefighters? Briefly explain.

6. Do you find that in some instances, a firefighter is lost due to a lack of equipment to prevent it?
   ☐Yes ☐No

7. Have you ever encountered a situation where a firefighter became lost despite having a device to prevent it?
   ☐Yes ☐No

8. Have you ever been a firefighter?
   ☐Yes ☐No

Additional Comments:

Appendix B

Firefighter Database

Town	Is your current equipment effective?	Do you think that changes need to be made?	Are you familiar with lifelines?	Are you lacking any necessary equipment?	Do you feel current training is adequate?	Important Additional Comments
Acushnet	No	Yes	No	Yes, lifelines	Yes	Despite training, fire personnel often enter structures w/o activating PASS
Adams	Yes	Yes	Yes, Most effective equipment we have	No	Yes	As new technologies and techniques emerge we need to become proficient
Andover	Yes	No	No	No	Yes	The best resource for rescue is more properly trained ff's on the scene
Ashburnham	no	yes	no	yes	no	GPS type systems to track firefighters and updated equipment.
Athol	Yes	Yes	No	Yes	No	Need more training and establish discipline on the fire ground
Avon	Yes	No	No	Yes	Yes	Could use more manpower
Barnstable	Yes	Yes	No	Yes, thermal imager	No	With new tech. such as GPS and grid patterns, locating a lost firefighter could be nearly eliminated
Bedford	Yes	Yes	Yes	Yes	Yes	Need more thermal imaging cameras, the lifelines seem to work well but have limitations
Belchertown	No	Yes	No	Yes	No	Always something changing to be trained on
Berkley	Yes	Yes	No	Yes	No	Need more training, also could use more lifelines
Billerica	Yes	No	No	No	Yes	
Bondsville	Yes	No	No	No	Yes	Equipment is best at the present time
Boston	Yes	No	No	No	Yes	Formal training once a year
Boxborough	Yes	Yes, upgrade PASS	Yes, Work well with RIT (Rapid Intervention	Yes	Yes	Are in the plans to purchase thermal imaging camera

			Teams)			
Burlington	Yes	Yes	No	Yes	No	PASS units should have strobes built in to help in smoke and darkness
Burlington	Yes		No	No	No	Need more manpower to develop a rapid intervention team
Burlington	Yes	Yes	No	Yes	No	Technology is available why hasn't it been developed for firefighters?
Cambridge	Yes	No	Yes, too complicated and labor intensive	No	Yes	Better technology will produce better results in the future
Chatham	Yes	No	No	No	No	Need more frequent and quality training on equip.
Chelmsford	Yes	No	No	No	Yes	
Clarksburg	Yes	No	Yes	Yes	Yes	Could use more equipment but money is tight
Cotuit	Yes	No	No	No	Yes	Train every year on equipment
Devens	yes	yes	no	no	yes	with proper procedures technology becomes less necissary.
Douglas	Yes	No	No	Yes	Yes	Need Rapid Intervention Equipment
Dracut	yes	yes	no	no	yes	training techniques are adequate
Falmouth	Yes	No	No	No	Yes	
Gardner	Yes	Yes	No	??	Yes	More education of firefighters on search methods
Hadley	Yes	No	Yes, department uses them	No	Yes	With accountability you cut down on search area for locating lost firefighters
Hatfield	Yes	Yes	No	Yes	Yes	Thermal imaging should be improved and more affordible
Hingham	Yes	Yes	No	No	No	Equipment and training should be geared towards preventing the ff's from getting lost
Hopkinton	Yes	Yes	No	No	Yes	Thermal Imaging should be intergrated into facepieces along with radio
Leominster	yes	yes	no	no	yes	Man power is needed to locate lost firefighters.
Lincoln	Yes	Yes	No	Yes	No	Usage of tag lines and

						thermal imaging cameras would be helpful
Lowell	Yes	No	No	No	No	Need more training because of lack of fires
Lunenberg	yes	yes	no	yes	no	They are good tools, but not foolproof
Mansfield	Yes	Yes	No	Yes, thermal imager	Yes	Need to make training more uniform
Marblehead	yes	no	yes	no	yes	more indepth training for all personell but mostly new ff
Marlborough	Yes	Yes	No	No	No	Accountability Monitors
Mashpee	Yes	No	No	Yes	No	Need training time that is uninterrupted by calls
Mattapoisett	No		No	Yes	Yes	Recently received equip. grant to update search & rescue equip.
Medford	Yes	No	No	No	Yes	Equipment is only effective if fire conditions allow it to be used
Nantucket	Yes	Yes	No	Yes	Yes	Get rid of prop. 2 1/2 so that they can have more money to buy latest equip.
Northborough	Yes	No	No	Yes	Yes	Looking into personal search ropes to increase safety of firefighters
Orange	Yes	Yes	Yes, works well	Yes	No	Many firefighters aren't willing to further their training, also training is from books, not hands on
Oxford	yes	yes	no	no	yes	light weight trunout clothing is a possible change
Palmer	Yes	No	No	No	Yes	Need to utilize equipment and tech. for military
Plainville	Yes	Yes	No	No	No	Need more manpower on initial response and up to date training
Princeton	No	Yes	No	Yes	No	Improve upon existing equip
Randolph	Yes	No	No	No	Yes	All the equipment balance each other
Salisbury	No	No	No	Yes		Equipment does not pinpoint the location of a downed firefighter
Sharon	Yes	No	No	No	Yes	Life lines are optional and some men carry

						them
Sterling	Yes	Yes	No	Yes	Yes	Equipment effectiveness is limited by training
Sterling	No	No	No	Yes	Yes	A tracking system would increase effectiveness
Stoughton	Yes	Yes	No	No	Yes	Dept. utilizes radios, PASS, and thermal imagers to locate lost firefighters
Tewksbury	Yes	Yes	No	Yes, thermal imager	Yes	Use RIT teams and every ff has a radio
Townsend	No	Yes	No	No	Yes	We are getting a thermal imaging camera and then everything will be better
Wakefield	Yes	Yes	No	Yes	No	Need a ff locator system similar to GPS
Walpole	Yes	No	No	No	No	Always have to update SOP's
Warren	yes	yes	no	no	no	human factor for free-lancing which always causes problesm
Wellfleet	Yes	No	No	Yes	No	With combination of PASS and thermal imager locating firefighters should be easier
Westfield	Yes	Yes	No	Yes	No	Need more training for worst case scenerio
Westminster	No	No	No	Yes	Yes	Need thermal imaging camera
Westport	Yes	No	No	No	Yes	
Winchester	yes	yes	no	yes	yes	Advanced fireground accountability system should be developed
Windsor	Yes	Yes	No	Yes	Yes, could be more frequent	Could update equip. Need thermal imager

Fire Officer Database

Town	Do you feel the current equipment is effective?	Are you lacking any necessary equipment?	Do you train firefighters?	How often is training given?	Do you feel the current training techniques are adequate?	Important Additional Comments
Abington	No	Yes	Yes	When new equipment is purchased	No	Accountability global positioning for fireground would be helpful
Acushnet	Yes	Yes	Yes	2 - 3 times per year	No	Call firefighters do not have time to train properly
Adams	Yes	No	Yes	Annually	No	Not as much time to train because all volunteers
Amherst	Yes, as long as PASS is integrated unit and activates automatically with SCBA activation	Yes	No		No	Need more training on wide are rope searches
Arlington	Yes	No	Yes	Twice Yearly	Yes	Fire dept. utilizes vacant buildings to train in
Ashburnham	yes	yes	no	??	yes	Need lifelines and thermal imaging cameras.
Athol	No	Yes	Yes	Quarterly	Yes	Fireground operations and accountability will prevent and help to find lost firefighters
Avon	Yes	No	Yes	Quarterly	Yes	
Barnstable	No	Yes, thermal imager	Yes	When new equipment is purchased, also more often	Yes	Have thermal imaging camera on order
Bedford	Yes	Yes	No	Annually	No	Need a system with 3-D graphics and chip Coaster system like in Mission Impossible II
Belchertown	No	Yes	Yes		No	All training needs to be current and on going, need to establish RIC teams
Berkley	Yes	No	Yes	Yearly	No	Hard to keep the training up to date with current technology
Billerica	Yes	No	Yes	As needed	Yes	
Bondsville	Yes	No	Yes	Every 2 weeks	Yes	
Boston	Yes	Yes	Yes	Formal training once a year	Yes	Only ladder companies and rescue companies carry TIC, need more
Boxborough	Yes	Yes	Yes	1 - 2 times per year	Yes	
Burlington	Yes	Yes	Yes	Irregularly	No	Need dedicated training officers also GPS device
Burlington	Yes	Yes	Yes	Periodically and when new	No	Need dedicated training officer, more handlights.

				equipment is issued		door wedges, and more lifelines
Burlington	Yes	No	Yes	Rarely	No	Need more manpower, training also GPS type tracking device for ff's in building
Burlington	Yes	Yes	No	Companies that sell equipment give training on it	No	Need to improve communications with radios, need more training
Carlisle	no	yes	yes	quarterly	yes	need better and more sophisticateded equipment
Chatham	Yes	Yes	No		No	Do not train enough and do not have lifelines
Chelmsford	No	No	Yes	2 to 3 times per year	Yes	Hopefully GPS will eventually play a part in future equipment
Clarksburg	No	Yes	Yes	bi-annually	No	Radios and PASS only have a limited battery life which is unacceptable in prolonged searches
Cotuit	Yes	Yes	Yes	At least once a year	Yes	There is no reason any dept. shouldn't have PASS, radios, and thermal imagers
Douglas	Yes	Yes	Yes	Monthly	Yes	Lacking ropes, harnesses, etc.
Easton	Unknown	Yes	Yes	Daily on radios and when needed on PASS and TI	Yes	The equipment without proper manpower to utilize it in a search is a big problem
Falmouth	Yes	No	Yes	Yearly	Yes	
Foxborough	Yes	No	Yes	By training coordinative schedule	Yes	ICS is used on all multi-company incidents
Gardner	Yes	No	Yes	On going	Yes	
Gloucester	Yes	No	Yes	As available and needed	No	Need better accountability system and location/tracking tech.
Great Barrington	Yes	No	Yes	Weekly	Yes	Lifelines can be a problem when they get caught on something or burned
Hadley	No	Yes	Yes	Yearly	No	Total on scene accountability is the responsibility of the senior FF or officer in charge
Halifax	Yes	Yes	Yes	Quarterly or more frequently	Yes	The advent of the MA firefighter safety equip. grant will greatly help increasing the amount of safety equip. available to firefighters
Hatfield	Yes	Yes	Yes	Weekly	Yes	Need thermal imaging camera but too expensive

Hingham	No	Yes	Yes	Not enough	Yes	Current equipment is not adequate
Hopkinton	Yes	Yes	Yes	Ongoing	No	Dedicate one person to training the entire department
Kingston	Yes	Yes	Yes	Annual	Yes	Need a GPS type locator that is portable
Leominster	yes	yes	yes	yearly	yes	Pass device with transmitter and GPS would be ideal.
Lincoln	Yes	Yes	Yes	Annually	No	Needs thermal imaging camera and also to train more often
Longmeadow	Yes	Yes	Yes	Not often enough	No	Big problem is how to remove ff from entrapment once they are located
Lowell	Yes	Yes	No	seldom	No	State should enforce standards for all responding firefighters, if not in compliance then lose state money
Mansfield	No	Yes	Yes	Training was part of recruit training only	No	Need to simulated lost firefighter incident in training
Marblehead	yes	yes	yes	regular training sessions	no	personell do not want to train fully, just see techniques
Marshfield	Yes	No	Yes	4 times a year	Yes	Use incident command and SOP/SOG's to control fireground operations
Mashpee	Yes	No	Yes	Annually	No	Firefighters are not required to retrain annually like policemen are
Medford	Yes	No	No		Yes	Training and equipment design should have a positive effect on finding firefighters
Melrose	Yes	Yes	Yes	Monthly	No	Need more safety equipment
Nantucket	Yes	Yes	Yes	every month or every other month	Yes	Factory Rep. also trains firefighters
North Adams	Yes	No	No		Yes	Always a need for more training
Northborough	Yes	Yes	Yes	Four to Six times a year	No	Need more men, time constraints on training. PASS and radios are difficult to hear with the commotion of a fire scene
Orange	Yes	Yes	Yes	Quarterly	Yes	Need a radio frequency dedicated to the fireground
Oxford	yes	yes	no	??	yes	Each tool is part of a system, none of them is the "save all"

Palmer	Yes	No	No	quarterly	Yes	Training and proper use of equipment are big parts in finding lost ff's
Plainville	Yes	Yes	No		No	Need more manpower and hands on training
Princeton	No	Yes, need state of art equip.	Yes	Bi-annually	No	Have to rely on equip. working at time of entrapment
Randolph	Yes	Yes	Yes	Twice per year	No	Hard to teach older members new techniques, Also cost and availability of tech. is problem (GIS-GPS)
Randolph	Yes	No	Yes	Ongoing	No	Should be taking better advantage of courses offered by MA fire academy
Raynham	Yes	No	Yes	Department Drills	Yes	
Reading	Yes	No	Yes	As needed	No	
Salisbury	No	Yes	Yes	Yearly	No	Needs a sy that gives a lat/long for a downed firefighter
Sandwich	Yes	Yes	Yes	Not enough due to budget limitations	no	Ambient sound and building structure play a big part in how the sound of a PASS is received
Sharon	Yes	No	Yes	Annually	Yes	PASS and TIC have only been used in practice, no actual experience
Shrewsbury	No	No	Yes	Every six months	Yes	Equipment is not very technologically advanced
Southborough	No	Yes	Yes	Once per year	No	Need a high-tech system to accurately locate ff's in a high smoke / heat environ.
Sterling	Yes	Yes	Yes	Quarterly	No	Cost of technology is too high for many small departments
Stoughton	Yes	Yes	Yes	Quarterly	Yes	Need handheld thermal imager and GPS
Swampscott	Yes	Yes	No		No	Need individual rescue ropes
Tewksbury	No	??	No		Yes	Use instructors from the MA fire academy to train
Townsend	No	Yes	Yes	annually	No	Equipment is out of date and lack necessary facilities for training
Walpole	No	Yes	Yes	Annually	No	Need PASS devices and more money to train with
Waltham	Yes	Yes	Yes	At least yearly	Yes	Need strobe lights and more portable radios
Warren	yes	no	yes	monthly	no	never enough training
Wayland	Yes	Yes	Yes	Yearly	No	Need personal radios, more

						funding is needed so that more training can occur
Webster	Yes	No	Yes	Every 2 weeks	Yes	
Wellfleet	Yes	Yes	Yes	Several times per year	Yes	Need and will be getting a thermal imaging camera
Wenham	Yes	No	Yes	Monthly	Yes	Have a 75% mandatory training attendance rule for employment
West Boylston	No	Yes	Yes	Monthly	No	Lifelines have just been implemented and are very valuable. Money constricts training and equipment. Also need more radios
Westfield	Yes	Yes	Yes	Infrequently	No	Need GPS system, not enough instruction from people who are experts in their field
Westhampton	Yes	Yes	Yes	Monthly	Yes	Limited funding and time to train because call fire department
Westminster	No	Yes	Yes	Once per year	Yes	Hard to find exact location of downed ff's with current equip.
Westport	Yes	No	Yes	Twice monthly	Yes	
Winchester	yes	no	no	??	yes	room for improvement in current training techniques
Windsor	Yes	Yes	Yes	Monthly	Yes	Only deal with single family homes

Town Administrator Database

Town	Population	How many fire districs?	How many volunteer units?	How much money is budgeted for the fire department?	How many people employed in town fire department	Additional Comments
Adams	0 - 25,000	2	2	0 - 50,000	10 - 50	Only forest warden is employed, the rest are volunteers
Agawam	25,000 - 100,000	2	15 call firefighters	200,000 +	50 - 100	Municipal budget requests from other agencies
Andover	25,000 - 100,000	1	0	200,000 +	50 - 100	A specific amount of funds is divided proportionally between municipalities
Aquinnah (Formerly Gay Head)	0 - 25,000	1	1	0 - 50,000	10 - 50	Town meeting approves funding
Arlington	25,000 - 100,000	1	0	200,000 +	100 - 150	Population and available funding affect budget
Ashburnham	0 - 25,000	1	1	100,000 - 150,000	10 - 50	Limitations from proposition 2.5 and growing school expenses and town
Ashfield	0 - 25,000	1	1 (All volunteer)	0 - 50,000	10 - 50	Proposition 2 1/2 limits funding
Attleboro	25,000 - 100,000	1	0		50 - 100	Statutory limit on amount of propery tax that can be levied without citizen vote
Avon	0 - 25,000	1	0	200,000 +	10 - 50	Town meeting votes on funding
Becket	0 - 25,000	1	1	0 - 50,000		All volunteers, budget is approved at town meeting
Bedford	0 - 25,000	1	6	$200,000+	10 - 50	prop 2 1/2 limits ability to raise taxes
Belchertown	0 - 25,000	1	1	100,000 - 150,000	32	Always a challenge to maintain necessary funding
Berkley	0 - 25,000	1	0	0 - 50,000	4 fulltime, 39 call	Community is considering overriding prop 2 1/2
Beverly	25,000 - 100,000	3	0	about 4,000,000	???	Must balance needs and costs
Billerica	25,000 - 100,000	5	0	200,000 +	50 - 100	Funding is based on needs of each town dept.
Bolton	0 - 25,000	1	1	0 - 50,000	10 - 50	Town would like a volunteer FD. Proposition 2.5
Boxborough	0 - 25,000	1	0	$465,632	10 - 50	Budget preparation and what town meeting will approve are constraints
Brewster	0 - 25,000	1	50 call firefighters	200,000 +	8 full time	Proposition 2 1/2 limits funding
Brimfield	0 - 25,000	1	29 men	150,000 - 200,000	10 - 50	
Brookfield	0 - 25,000	1	1	150,000 - 200,000	10 - 50	mostly volunteer, paid lump sum

Brookline	25,000 - 100,000	More than 5	0	200,000 +	150 - 200	Paying staff is first issue, then equipment is next factor
Buckland	0 - 25,000	2	2	0	10 - 50	The town government does not appropriate any money for fire
Cambridge	25.000 - 100,000	More than 5	1	200,000 +	250 +	Station Renovation takes up part of budget
Canton	0 - 25,000	1	0	2.9 million	10 - 50	Proposition 2 1/2
Carlisle	0 - 25,000	1	0	200,000 +	10 - 50	All call fire department
Chatham	0 - 25,000	1	0	200,000 +	10 - 50	Growth in budget as it effects the tax base is the constraint
Chelmsford	25,000 - 100,000	5 Stations	0	200,000 +	50 - 100	Money is limited by property taxes
Chelsea	25,000 - 100,000	1	0	200,000 +	50 - 100	Budget must be closely monitored by money appropriated and available money
Concord	0 - 25,000	2 stations	0	200,000+	10 - 50	Balancing municipal budget with limited dollars
Douglas	0 - 25,000	1	4	50,000 - 100,000	10 - 50	Can afford what opperating budget allows
Dracut	25,000 - 100,000	1	none	$200,000+	10 -50	prop 2 1/2 limits budget
Dudley	0 - 25,000	1	30	200,000+	10 - 50	Amount depends on local and state funding.
East Bridgewater	0 - 25,000	1	0	200,000 +	10 - 50	Budget growth is limited to offset inflation
East Brookfield	0 - 25,000	1	1	50,000 - 100,000	10 - 50	Budget has been limited due to rise in school costs.
Eastham	0 - 25,000	1	0	200,000 +	10 - 50	Proposition 2 1/2 and town fiscal constraints
Easthampton	0 - 25,000	1	0	200,000 +	10 - 50	Proposition 2 1/2
Egremont	0 - 25,000	1	2	0 - 50,000		All volunteers, receive more funding if equipment is needed
Everett	25,000 - 100,000	1	0	200,000 +	108	Salaries are approximately 95% of fire department's budget
Falmouth	25,000 - 100,000	5	Very limited	4 million +	50 - 100	Labor costs, Staffing and seasonal demands have an effect on funding
Fitchburg	25,000 - 100,000	3	0	$7,947,284	50 - 100	City can only raise property taxes 2 1/2% of the assessed valuation of the property
Foxborough	0 - 25,000	1	25 men	200,000 +	10 - 50	Prop. 2 1/2 limits budget
Framingham	25,000 - 100,000	5	0	200,000 +	100 - 150	The town has state mandated fiscal constraints tied to the property tax
Franklin	25,000 - 100,000	2	15 on call	200,000 +	50 - 100	Municiple finance is always a juggling of needs and assumption of risks
Gardner	0 - 25,000	2	0	200,000+	10 - 50	City has only so much to

						spend so everything has limitations.
Gill	0 - 25,000	1	1	0 - 50,000	10 - 50	Need more equipment. One chief and the rest are call firefighters. Town votes on budget
Gloucester	25,000 - 100,000	2	0	200,000 +	50 - 100	Requests are prioritized by Mayor and City Council
Grafton	0 - 25,000	3 districts	82	150,000 - 200,000	50 -100	
Granville	0 - 25,000	1	1	$12,000	All volunteer	Population 1500
Greenfield	18,000	1	0	200,000 +	32	Prop. 2 1/2 limits ability of town to raise money
Hadley	0 - 25,000	1	All volunteer	50,000 - 100,000	10 - 50	Tax levy limits and available funding
Halifax	0 - 25,000	1	30 - 35 call firefighters	$390,000	10 - 50	Prop. 2 1/2 and needs of other departments affects budget
Hardwick	3000	1	1	$39,000	10 - 50	More money goes to improvements in schools instead of f.d.
Harwich	0 - 25,000	1	0	200,000 +	10 - 50	Prop. 2 1/2 and willingness/ability of tax payers to pay the bill
Haverhill	25,000 - 100,000	1	0	200,000 +	100 - 150	More attention needs to be centered on funding for training and fire prevention
Hopkinton	0 - 25,000	1	13 people	??	10 - 50	Constraint is how much can be taxed and approved at town meetings.
Hudson	0 - 25,000	1	0	200,000+	10 - 50	Public school funding is a bigger priority.
Ipswich	0 - 25,000	1	0	200,000 +	10 - 50	Proposition 2 1/2 levy limit
Kingston	0 - 25,000	1	0	200,000 +	10 - 50	
Lawrence	25,000 - 100,000	1	0	200,000 +	100 - 150	City budget is 160 million and city only raises 40 million in taxes
Leicester	0 - 25,000	3	Some	150,000 - 200,000	10 - 50	Selectmen, Finance Committee and Town Meeting approve funding
Leicester	0 - 25,000	3	3	150,000 - 200,000	50 - 100	Capital equipment when the economy is down
Leominster	25,000 - 100,000	1	0	200,000+	50 -100	Money depends on available funds
Longmeadow	0 - 25,000	1	0	200,000 +	10 - 50	Needs vs. Budget are weighed
Lowell	100,000 +	2	0	200,000 +	200 - 250	Actual and live firefighting training is less frequent and poorly administrated
Lynnfield	0 - 25,000	2	0	200,000 +	46 (6 full time 40 call)	Fire department usually gets what it needs
Manchester	0 - 25,000	1	0	200,000 +	10 - 50	Fire Departments do not receive the amount of grants

						as the police but their costs are higher
Marblehead	0 - 25,000	2	none	$200,000 or more	10 - 50	funding constraint is diregctly related to availability of money at budget time.
Marshfield	25,000 - 100,000	3	0	3.2 million	50 - 100	
Mattapoisett	6,500	1	All call, 1 full time chief	$194,265	38 - 40	All funds are subject to Town Meeting vote
Maynard	0 - 25,000	1	0	200,000 +	10 - 50	To expend beyond the limits of prop. 2 1/2 requires a majority vote
Medfield	0 - 25,000	1	0	200,000 +	3 ft, 29 on call	Funds are limited by available tax money
Mendon	0 - 25,000	1	0	100,000 - 150,000	10 - 50	Fire departments request vs. available funds.
Middleton	0 - 25,000	1	0	$750,000	10 - 50	Proposition 2 1/2 limits funding
Millville	3100	1	15 Call Firefighters	+/- 200,000	10 - 50	Town Budget is $3,000,000
Nantucket	0 - 25,000	3	Some	$1,539,721.40	10 - 50	Need more men and not enough money because of prop. 2 1/2
Needham	25,000 - 100,000	1	0	200,000 +	50 - 100	Injuries to older firefighters a growing concern as the workforce grows older
New Salem	0 - 25,000	1	All call	0 - 50,000	10 - 50	Town only has 900 citizens
Northborough	0 - 25,000	1	0	200,000+	10 - 50	Proposition 2.5 tax cap rate.
Northbridge	0 - 25,000	1	0	200,000 +	10 - 50	Faced w/ dividing funds between personnel and expenses. $25,000 per year goes to safety equip.
Norton	0 - 25,000	1	0	200,000 +	10 - 50	Some monies are restricted to emer. med services
Orange	0 - 25,000	2	0	200,000 +	34	Proposition 2 1/2 limits funding
Otis	0 - 25,000	1	1	0 - 50,000	All volunteer	Finance comm., selectmen, and town voters must approve budget
Oxford	0 - 25,000	2	1	150,000 - 200,000	10 - 50	Budget depends on several factors.
Paxton	0 - 25,000	1	all	100,000 - 150,000	10 - 50	Ability of taxpayers to fund
Pelham	0 - 25,000	1	1	0 - 50,000	10 - 50	Normal fiscal restraints
Pembroke	0 - 25,000	4	1	200,000 +	10 - 50	Propostion 2 1/2 and the amount of men and equipment needed
Plainville	0 - 25,000	1	0	200,000 +	19 (11 full time + 8 call)	Propostion 2 1/2
Plymouth	25,000 - 100,000	1	0	200,000 +	100 - 150	Budget approved by town meeting
Plympton	0 - 25,000	1	All call	50,000 - 100,000	10 - 50	School budget consumes

						60% or more of town's revenue
Princeton	0 - 25,000	1	0	100,000 - 150,000	10 - 50	Payroll, equip needed, and programs
Reading	0 - 25,000	1	0	200,000 +	10 - 50	Proposition 2 1/2 constraints
Revere	25,000 - 100,000	4	0	200,000 +	100 - 150	Proposition 2 1/2 limits funding
Rockland	0 - 25,000	1	0	200,000 +	10 -50	
Saugus	25,000 - 100,000	1	0	200,000 +	10 - 50	Projected development and population factor into funding
Seekonk	0 - 25,000	3	18 personell	200,000 +	10 - 50	School gets 65% of money, the rest goes to town hall, fire, police, and others
Sharon	0 - 25,000	1	0	200,000 +	22	Budget depends on Prop 2 1/2 and other municipal budgets
Sheffield	0 - 25,000	1	1	0 - 50,000	10 - 50	
Shrewsbury	25,000 - 100,000	3 stations	1 (20 - 25)	$1,855,679	10 - 50	only 2.5% of tax money to FD
South Hadley	0 - 25,000	2	2 call	100,000 - 150,000	10 - 50	2 full time 32 call firefighters
Southborough	0 - 25,000	1	0	200,000 +	10 - 50	Proposition 2 1/2 limits, also needs town meeting vote
Spencer	0 - 25,000	1	0	100,000 - 150,000	10 - 50	
Sudbury	0 - 25,000	3	0	200,000+	10 - 50	Proposition 2.5 tax cap rate.
Sunderland	0 - 25,000	1	1	50,000 - 100,000	10 - 50	Only one full time firefighter
Swampscott	0 - 25,000	1	0	200,000 +	10 - 50	Chief prepares budget and finance committee assesses
Topsfield	0 - 25,000	1	Just call	200,000 +	10 - 50	78% of the town budget goes to schools, the rest has to be divided
Truro	0 - 25,000	1	1	100,000 - 150,000		
Truro	0 - 25,000	1	1	100,000 - 150,000	10 - 50	Funds are voted on by town meeting
Wakefield	0 - 25,000	1	0	200,000 +	10 - 50	Fiscal constraints imposed by proposition 2 1/2
Walpole	0 - 25,000	1	0	200,000 +	10 - 50	Competing needs of all other gov. functions restricts funding
Waltham	25,000 - 100,000	1	3	200,000 +	150 - 200	Funding for the fire department is a high priority
Ware	0 - 25,000	1	1	200,000 +	10 - 50	If revenues decrease all major departments take a cut
Warren	0 - 25,000	1	All call	150,000 - 200,000	10 - 50	Need to fund other departments and control the tax rate
Wayland	0 - 25,000	2	0	200,000	10 - 50	Must follow state law for budgeting
Webster	0 - 25,000	1	0	200,000 +	10 - 50	Prop. 2 1/2 and town budget (Call Dept.)

Wellfleet	0 - 25,000	1	0	200,000 +	10 - 50	Town meeting decides funding
Wendell	0 - 25,000	1	1 call unit	0 - 50,000	10 - 50 (No full time firefighters)	
Wenham	0 - 25,000	1	0	200,000 +	10 - 50	Competition for funding between schools and other town depts.
West Bridgewater	0 - 25,000	1	20 + call firefighters	200,000 +	10 - 50	Town meeting approval required for budget
West Newbury	0 - 25,000	1	1	100,000 - 150,000	10 - 50	Safety, Timing, and availability of funds are constraints
Westfield	25,000 - 100,000	1	0	200,000 +	50 - 100	Vying for tax dollars against other municipal depts.
Westford	0 - 25,000	1	Combination full time/call	200,000 +	10 - 50	Propostion 2 1/2 limits funding
Westminster	0 - 25,000	1	0	200,000 +	10 - 50	Propostition 2 1/2 limits funding
Westwood	0 - 25,000	1	0	1,857,711	10 - 50	Equip. to find lost firefighters was added to budget after Worc. fire
Whately	0 - 25,000	1	1(All volunteers)	0 - 50,000	10 - 50	All budgets are limited to the growth in town revenues.
Wilmington	0 - 25,000	1	0	200,000 +	10 - 50	Available resources constrains funding
Winchester	0 - 25,000	2	none	$200,000+	10 -50	Taxes restricted by legislation
Winthrop	0 - 25,000	2	0	200,000 +	10 - 50	Prop. 2 1/2 constains funds, also union contracts have an effect on funding
Yarmouth	0 - 25,000	1	3	3,430,470	50 - 100	Voter approval and prop. 2 1/2
	Stockbridge	1	1	50,000 - 100,000	10 - 50	Chief submits budget to selectmen, then goes to town mtg.

Equipment Manufacturer Database

Company	What device(s) does your company produce?	Life expectancy of device.	Price?	What changes do you reccomend?	Need to continue development	Additional comments.
Bullard	Thermal Imaging Camera	10 yrs	$15,000.00 to 20,000.00	Hand free design and better image performance	yes	none
Clement Firefighting Equipment	Bernard Easy Exit	8 - 10 yrs.	$17.50, about $560 to outfit an engine	Not many	Yes	Need to focus more on prevention
Grace Industries	Automated PASS	5 - 10 yrs	$29,000.00 for dept w/50 personell	none	yes	Gives instant notification of a downed firefighter by displaying name and riding position.
Grace Industries	Automated Accountability System (Transmitting PASS alarm)	5 - 7 yrs	$200.00	Changes for instant notification	yes	none
Marconi Applied Technologies	Thermal Imageing Camera	5 yrs min	$9995.00	Making it smaller and lighter	yes	none

Fire Academy Instructor Database

What devices do you require training on?	Are firefighters tested on how well they know these devices?	How often are they tested?	Do you have to be recertified?
Lifelines, PASS	yes	weekly	no

Fire Investigator Database

City	Have you investigated a fire where ff was lost?	Which devices used by that ff?	Do you feel technology is adequate?	What changes should be made?	Have you seen ff lost due to lack of equipment?	Additional comments.
Plainfield, CT	yes	radio and pass	yes	gps type technology	yes	PASS devices are effective but ff fail to activate.
Plainfield, Ct	yes	pass	yes	easier to carry and opperate	yes	none