# DEVELOPING A THERMAL IMAGING TRAINING PROGRAM FOR THE FIRE SERVICE

STRATEGIC MANAGEMENT OF CHANGE

By: John N. Carnegis
Rhode Island State Fire Academy
North Providence, Rhode Island

An applied research project submitted to the National Fire Academy
as part of the Executive Fire Officer Program
August 1999

## ABSTRACT

The problem facing the Rhode Island State Fire Academy was that numerous area fire and rescue departments were considering the purchase or had purchased thermal imaging cameras without consideration into the training aspect. In addition, the Rhode Island State Fire Academy did not have a training program to offer to the fire service regarding thermal imaging. The academy was then challenged to keep pace with this change in technology and develop an appropriate training program.

The purpose of this applied research project was to provide a draft training program and a checklist for proper usage of thermal imaging cameras for the Rhode Island State Fire Academy. In addition, this training program would be suitable for export to local fire departments. The action research method was used in the research project to answer the following questions:

1. What are the national training standards for using thermal imaging cameras?
2. What was the historical background, attributes, advantages, and limitations associated with thermal imaging that can effect operation and training?
3. How were fire departments using thermal imagers in their emergency application and response?
4. What training activities were fire departments and state training institutions utilizing to implement training programs for thermal imagers into the fire service?

The purpose of this applied research project was to identify how the fire and rescue service was using thermal imaging technology and from this information develop an appropriate training program for thermal imaging cameras. All authors cited within this research recommended that fire departments embrace the application of thermal imaging technology. Numerous authorities

provided detailed accounts of system advantages associated with the application of thermal imaging technology by the fire and rescue service. Advantages associated included, improvement in fire suppression activities, hazardous material analysis, and emergency medical operations, as well as an improvement in overall fireground safety.

The procedure utilized to answer the four research questions included the utilization of two survey instruments. The first survey was mailed to the 80 fire departments that comprised the fire service in the State of Rhode Island. The 75% (60) of the questionnaires were completed and returned. This first survey indicated that 33.3% (20) of departments in Rhode Island had thermal imaging equipment in place, which was an 11% increase above 1998 survey results. In addition, 20% (12) were currently planning to implement thermal imaging technology in the near future, this represented an increase of 33.3% above 1998 survey results.

The second survey involved the polling of state and federal training institutions. A total of 55 surveys were distributed to these agencies. The survey return rate of completed questionnaires was 92.7% (51). The results of this survey project indicated that only two (4%) of state based training agencies had specific training programs on thermal imaging cameras. In addition, only the U.S. Navy and Coast Guard had training in thermal imaging utilization on the federal side of the training equation. However, this training was conducted at specialized training facilities and not applied to all fire suppression personnel.

This research paper has provided evidence to support a recommendation that the Rhode Island State Fire Academy make an effort to start the course development process necessary to develop a training package on thermal imaging cameras. A proposal for the developmental process was also provided within this research endeavor. In addition, reference sources and training options were provided to the committee.

# TABLE OF CONTENTS


| | PAGE |
|---|---|
| Abstract…… | 2 |
| Table of Contents…… | 4 |
| List of Tables…….. | 5 |
| Introduction……. | 6 |
| Background and Significance……. | 7 |
| Rhode Island State Fire Academy……..…… | 7 |
| Thermal Imaging…… | 13 |
| Literature Review…… | 14 |
| Procedures……... | 32 |
| Limitations……... | 35 |
| Definitions……... | 36 |
| Results…… | 38 |
| Discussion…….. | 55 |
| Recommendations……. | 57 |
| References……. | 86 |


## APPENDICES


| | |
|---|---|
| Appendix A: Cover Letter…….. | 60 |
| Appendix B: Training Program Survey 1999……..…….. | 61 |
| Appendix C: State and Federal Training Institutions Thermal Image Training Program Results…… | 65 |
| Appendix D: Thermal Imaging Survey Results 1998…… | 69 |
| Appendix E: Thermal Imaging Survey Update 1999…… | 71 |
| Appendix F: Proposed Thermal Imaging Training Program…… | 73 |

# Tables

Table 1 Hand-held and Helmet Mounted Comparison…… 26

Table 2 Manufactures Information……. 59

# INTRODUCTION

A major problem facing the fire and rescue service in the State of Rhode Island was that many area fire departments were utilizing thermal imaging technology without any training standards or training programs in place. The 1990's brought about a media and public demand for a new fire service tool called, thermal imaging cameras. This public demand already compounded the economic strain placed upon numerous area fire and rescue departments. These expensive units were financed through a variety of means. The various manners used in obtaining thermal imaging cameras included the traditional budgetary allocation as well as several innovative approaches including donations, fundraisers, and grants. However, the initial effort was focused upon only in obtaining thermal imaging cameras. Subsequently, area fire departments made little effort on the associated changes in departmental policy, procedure, or the necessary training associated with the implementation of new thermal imaging technology.

Although perceived as "new" technology; thermal imaging cameras (TIC), were increasing in popularity and availability to numerous Rhode Island fire and rescue services. However, as an emergent technology, it was also apparent that majorities of fire departments across the United States and in the State of Rhode Island were not using this technology. Consequently, nor were the fire and rescue services familiar with the training requirements necessary for safe implementation.

The purpose of this applied research project was to identify how the fire and rescue service was using thermal imaging technology and from this develop appropriate training for thermal imager technology. Obstacles facing this consideration was that the majority of the fire service, nationally and locally were not using thermal imaging devices in their operations. In addition,

very few state based training institutions had developed or modified their training program to reflect the changes associated with thermal imaging technology.

The purpose of this applied research project was to provide a draft training program and a checklist for the proper usage of thermal imaging cameras for the Rhode Island State Fire Academy. In addition, this training program would be suitable for export to local fire departments. The action research method was selected to answer the following questions:

1. What are the national training standards for using thermal imaging cameras?
2. What was the historical background, attributes, advantages, and limitations associated with thermal imaging that can effect operation and training?
3. How were fire departments using thermal imagers in their emergency application and response?
4. What training activities were fire departments and state training institutions utilizing to implement training programs for thermal imagers into the fire service?

## BACKGROUND AND SIGNIFICANCE

### Rhode Island State Fire Academy

Rhode Island is America's smallest state in area; only 1,214 square miles, and is second in population density according to the United States census of 1990 (Rhode Island Department of Economic Development, 1995, citing 1990, U.S. Census Data). In addition, the State's population of 1,003,464 residents has increased by approximately 53,000 residents as compared to the 1980 census represents a 5.5% increase (Rhode Island Department of Economic Development, 1995). Rhode Island has five counties, but no form of county government in place.

The state is composed of 39 cities and towns that provide all services associated with municipalities.

In December of 1982, the Rhode Island State Division of Fire Safety, Fire Marshal's Office received a grant from the federal government. The grant was through the National Emergency Training Center for $14,579 to develop fire training and education programs (Firefighter Training and Education, 1995). This was a two-phase program by the National Emergency Training Center's Academy Planning and Assistance Program (APAP). Phase or Part one entailed an assessment of the adequacy of firefighting training in Rhode Island. This initial research was conducted by the Division of Fire Safety and the Governor's Justice Commission. The research program was completed in October 1981. Part one of the report determined that there was no statewide standardization of fire service training programs and local fire departments varied in their approaches and emphasis (Firefighter Training and Education, 1995).

A Fire Education and Training Task Force of 21 members began meeting in 1983. The composition of this committee included members of the fire marshal's office, fire chiefs, state education office, legislative members, insurance industry representatives, state building code office, and the public. After receiving assistance from other States' fire training institutions, a final report was developed containing recommendations for increasing the knowledge and skills of Rhode Island firefighters by improving their opportunity for education and training. The final report was broken into six sections containing recommendations comprising a five-year plan for the time-period of 1985-1989 (Firefighting Training and Education, 1985).

The summarized recommendations are broken down as the following: section one describes the existing fire service training and education available in 1985. The recommendation in section one, calls attention to the lack of standardized statewide training. Thereby, fire service training

responsibilities fall upon the local fire departments with the result of little consistency or uniformity (Firefighter Training and Education, 1985).

Section two discusses the first goal of the plan, which is to obtain consensus support for the recommendations in the developed plan. The recommendation contained in section two further stated that opposition could be fatal, especially in sections requiring legislative support and changes (Firefighter Training and Education, 1985).

Section three addressed the second goal of this package. The establishment of the Rhode Island State Fire Education and Training Coordinating Board and a Fire Education and Training Unit within the Division of Fire Safety/ Fire Marshal's Office (Firefighter Training and Education, 1985). The plan also provided the appropriate legislation necessary to accomplish this end. The composition of the State Fire Education and Training Coordinating Board included representatives from the following organizations, each with a single representative. This board's make up was as follows;

1. Chief representative from a predominately paid, fully permanent fire department.
2. Chief representative from a combination paid /volunteer fire department.
3. Chief representative from a volunteer fire department.
4. Delegate from the Rhode Island State Fire Instructor's Association.
5. Representation from the Rhode Island Department of Environmental Management.
6. Representation from the Rhode Island State Bureau of Vocational and Education.
7. Delegate representing the Rhode Island League of Cities and Towns.
8. An industry representative from the American Insurance Association.
9. Representative from a college / university offering fire service education courses.
10. Rhode Island Fire Safety Association representative.

11. Rhode Island Communication Officer's Association representative.

12. Rhode Island State Firemen's League representative.

13. Three representatives from the Rhode Island Association of Firefighters.

14. Two members from regional firemen's league.

The state fire marshal and the chief of training would serve in the ex-officio capacity. Appointments would be made through the legislative process (Firefighter Training and Education, 1985).

Section four encompassed the third goal of the plan. It called for the establishment of a standardized recruit training program based upon National Fire Protection Association Standards (NFPA) and modified to meet the needs of Rhode Island's firefighters (Firefighter Training and Education, 1985).

Section five, which addressed the fourth goal of the plan, which calls for various in-service programs. Many of these programs would be based on NFPA standards (Firefighter Training and Education, 1985).

Section six calls for the certification process for firefighters and fire officers. This fifth goal entailed a certification process was to be designed by the Educational Standards Board. The Board would construct the appropriate programs and exams necessary for certification. An examination process for certification would be developed based upon NFPA standards that would form the criteria for all professional standards examinations (Firefighter Training and Education, 1985).

Section seven addressed the importance of proper instructors to deliver the training. It was stated that, " no matter how good curricula might be, if instructors are not of a high quality the training efforts will not be successful." (p.1). It was recommended; that an instructor meets

NFPA standard 1041 for Fire Service Instructor and act as part-time consultants, this was the sixth program goal (Firefighter Training and Education, 1985).

Section eight, which formed the basis of goal seven, included the development of public fire education programs. This goal emphasized the importance of prevention (Firefighter Training and Education, 1985).

The final section, section nine provided the eighth goal of the plan. This goal included the development of marketing and education programs for private sector firms. This approach was to be two-fold in nature, providing a preventative service and source of income. This revenue generating potential was utilized by several area fire academies (Firefighter Training and Education, 1985).

The Rhode Island State Fire Training Coordination and Training Board was established by legislation in 1984. Shortly thereafter, the first students of the Rhode Isalnd State Fire Academy graduated in 1984. In conjunction, a Fire Service Instructor program was conducted and thereby certifying the first fire academy pool of instructors. Chief Ronald Jones was appointed as the Rhode Island State Fire Academy's first director (T. Cocco, personal communication, June 26, 1999). The Academy offered mainly recruit training programs, NFPA 1001, Firefighter Level One, on a regional basis for the next three years. Several specific training programs were provided such as; first responder emergency medical services, hazardous materials awareness and operations, National Fire Academy outreach programs, and fire service instructor training programs.

External influences in the late 1980's caused a severe impact on both the Rhode Island Fire Academy and State Fire Marshal's Office. Influencing factors included the Rhode Island Banking crisis, recession or economic downturn in the state, and employee layoffs coupled with

early retirements effected both organizations significantly (Ted Cocco, personal communication, June 23,1999). The administrative structure of these entities was also shuffled between governmental agencies during this period causing additional problems (Kenneth Erickson, personal communication, June 23, 1999). During this operational period, the fire academy activities were reduced. At times, the state seemed to have no fire academy (Kenneth Erickson, personal communication, June 23,1999).

In 1995, the activities of the Rhode Island Fire Academy appeared to make resurgence. This was due to the appointment of a new State Fire Marshal Irving Jesse Owens, and the Rhode Island Chief's Associated lobbying efforts (Donald Campbell, personal communication June 24, 1999). In addition, the fire academy received the services of Chief David Sylvaria; from the Rhode Island Chief's Association volunteered to function as a coordinator for training. This action brought about some resumption of limited training which was initiated by the academy shortly thereafter (Fred Serbst, personal communication, June 24, 1999). Legislation was introduced and passed to reduce the large fire academy board membership from 21 members into manageable 11 members (Dave Sylvaria, personnel communication July 1, 1999).

An anticipated change within the Academy structure in July 1999 was expected. This was based upon the appointment of a full-time director for the fire academy (Michael DiMascolo, personal communication, June 9, 1999). This change was coupled with the appointment of a full-time academy secretary in June (Michael DiMascolo, personal communication, June 9, 1999). The Rhode Island Fire Academy Board will continue to function in an advisory capability to the Director of the Fire Academy (Ted Cocco, personal communication, June 30, 1999).

The Rhode Island Fire Academy services 82 fire departments in the State. These communities represented the 39 cities and towns that comprised the State of Rhode Island, including one

federal installation and two quasi-public agencies (Rhode Island Fire Marshal's Division of Fire Safety Report, 1998).

The main objective of this applied research project was to provide insight into the training aspect of thermal imaging cameras. Areas examined included the operational aspects of thermal imagers on the fireground by fire departments, advantages, disadvantages, and limitations. A review of training activities undertaken by local area fire departments and state fire academies regarding the implementation of this new technology and tool. A review would be conducted into additional areas that would be impacted as a result of this adoption of thermal imaging technology. Focus points to be examined included policies, procedures and work rules that changed to facilitate safe imager operation. The results of this study will aid the Rhode Island State Fire Academy in the development of a training program on thermal imager operation. This training package in turn would be provided to local fire and rescue departments for their implementation. This review will aid others in the fire service in thermal imaging training as well as students enrolled in the National Fire Academy's Executive Fire Officer Program.

## Thermal Imaging Cameras

There have been numerous technological changes that have effected the fire service over the years. However, the inability to improve fireground visibility has hindered the basic operations of search and rescue (Woodworth, 1996, July). Thermal imaging is not new to the fire service, but it has taken time for the technology to receive widespread acceptance by the fire service (Fire Rescue, 1998, April). Thermal imaging holds more promise for improving fire protection and will greatly change the way we conduct our business (Fire Rescue, 1998, May).

Thermal imaging technology allows the firefighter to "see" through the smoke. The

translation or conversion of heat energy to a readable light image accomplishes image creations that can improve the life safety aspect for the responder and occupant through improvements in visibility by the user. The thermal imaging camera (TIC) measures and displays a true heat picture. In turn, the thermal imaging camera creates a black and white television view that is viewable through the smoke and darkness. Hot items appear white and colder articles darker, along with various shade of gray (Fire Rescue, 1998, April). Since the operator is viewing through a lens or view piece, the shape of the room, objects in the room, and victims retain their shape.

This project specifically relates to the National Fire Academy's Executive Fire Officer Program entitled, Strategic Management of Change. The research project used the Change Management Model of the student manual. This paper was undertaken to satisfy the requirements of the National Fire Academy's Executive Fire Officer Program. This project and its results will be used by the Rhode Island State Fire Academy and area fire departments to conduct training on thermal imaging units.

## LITERATURE REVIEW

A literature review was performed to identify existing research on the subject of training programs for thermal imaging cameras for fire and rescue service. The literature review conducted concentrated upon four areas of focus for examination. Items examined included the following; the search for national standards for thermal imaging, the historical background of thermal imaging, operational attributes, advantages, and limitations, and safety concerns regarding the application of thermal imager technology, how fire and rescue services were using thermal imagers, and training programs available on the state training level. These essential

issues would be compiled to form a draft training program assessment and a checklist for the proper and safe usage of thermal imaging cameras for the Rhode Island Fire Academy and local jurisdictions. The process of review and examination included a search for authoritative sources that are experts in the field of thermal imaging for the fire and rescue service aided in this literature review. This literature review entailed a search of training manuals, fire service journals, magazines, and publications. Additional information was obtained through the collection of manufacturer's pamphlets and unit specific operational manuals.

The review started with contacting an authoritative source of information and standards regarding the fire service operations, namely the National Fire Protection Association (NFPA), Quincy, Massachusetts. First contact was made in August 1998, requesting standards for thermal imaging cameras during the literature review for a previous executive fire officer program project. In a follow up conversation on December 9,1998, customer service stated that currently no standards exists for this technology. The customer service then transferred the request to the standards administration division of the NFPA. The standard administration office advised me to send a committee proposal form that would suggest that the NFPA develop a committee for the purpose of standard development for thermal imaging (Linda Cohen, personal conversation, December 10,1998). In June 1999, subsequent contact was made with the NFPA to ascertain the status of any standard or proposed standard regarding thermal imaging cameras, including the training for these cameras. Again, customer service stated that no standards were available at this time for thermal imagers or the training required for their operation. A check of NFPA 1001, Standard for Professional Firefighter Qualification 1997; due for revision in 2002, found no training competencies listed for thermal imager utilization (Frank Florence, personal communication, June 25, 1999). Repeating the same message of 1998, that no standards

currently exist, it was recommended to the author to file a proposal request to the NFPA. The exact proposal could be forwarded to the technology division for the fire service or the professional standards section (Don LeBlanc, personal communication, June 25,1999). This influenced this research providing a limitation. This meant that there was not any objective based national standard that could be applied for thermal image comparison purposes or training standards for the operation of thermal imagers. In addition, there were no national standards for the performance aspects for thermal imagers.

The next authoritative source contacted was the Fire Protection Publications operation of Oklahoma State University, Stillwater, Oklahoma, the home of a leading training consortium of fire service professionals involved in training. Since 1934, the International Association of Fire Service Training Association (IFSTA) formed an educational alliance to develop training materials for the fire service. A review of their publication, *Essentials of Firefighting, Fourth Edition*, found no training objectives listed for thermal imaging cameras. Again, this created an additional research limitation. This meant that there were no specific training standards or measurable objectives available for training of the firefighter in thermal imager application.

In 1973, *America Burning* identified our nation's fire problem. This report presented 90 recommendations for local, State, and Federal efforts to reduce further the loss of life and property due to fire. A key item addressed was research and development of improved technology and equipment in fire suppression (America Burning, 1973). Even into the '80s, the fire service did not have the ability to see effectively in a burning structure although we had the technology to put a man on the moon (Woodworth, citing America Burning, 1996, July). *America Burning Revisited* (1990) again examined the fire hazard in the United States. A critical continual problem identified was the lack of information for choosing and evaluating equipment

and apparatus (America Burning Revisited, 1990, p.63). The report recommended a consumer guide publication to assist in evaluation. This influenced this research by providing a path to follow in order to assist others in the fire service by creating a guide for others to review.

The military roots of thermal imaging were demonstrated during the Persian Gulf War. Although first used in the 1960's during the Vietnam Conflict, thermal imaging was not recognized until the Gulf War to the public. The original military purpose was to provide night-vision to pilots and ground forces. Many people then soon gained widespread recognition of the night-vision capabilities of the modern military fighting force after the media reporting of the conflict. Thermal imaging for fire protection purposes gained importance during and after the Falkland War. Following the United Kingdoms' effort, the United States Navy and Coast Guard began an aggressive program to put on board its vessels thermal imaging cameras. The combined threats of hidden fires, lack of visibility, and the devastating effects of fire on ships at sea poised an unreasonable risk that needed to be addressed by the military (Gallagher, 1991). Utilization of thermal imaging technology would speed detection and aid in suppression (Steve Lee, personal communication, June 7, 1999).

Additional analysis of the historical background of thermal imaging was provided in the writings of Newman and Irving (1973). These authors reported on early civilian application of thermal imaging technology or military night-vision capability by the fire service. These points affected this research by providing documentation on early thermal imaging research and application efforts of the fire service.

The implementation of thermal imaging technology has not been limited to the United States alone. The European Community, especially the United Kingdom has been aggressively

deploying units for their fire service. As reported by Lyons and Parmenter in *Fire Engineers Journal* of September 1995:

> Against a background of increasing demanding health and safety legislation, including European Community Directives, a more litigious environment and a general reduction in annual budgets, the Fire and Rescue Services will be required to radically assess their fireground operations to ensure the maximum safety of firefighters and greater efficiency in the deployment of resources and equipment…. Perhaps one major radical initiative would be the deployment of "Through Smoke Vision" as part of standard equipment…. (Lyons and Parmenter, 1995, p.7).

The article made a comparison to the self contained breathing apparatus (SCBA) to thermal imaging. The comparison stated that without an SCBA, a firefighter is unable to breathe and without thermal imaging, the firefighter cannot see (Lyons and Parmenter, 1995).

The research into the historical background influenced the research by providing documentation into the how early thermal imaging application was utilized and by what agencies. The research project was further influenced by the scope and international application of thermal imaging technology outside of the fire service in the United States.

The literature review then examined the working attributes of thermal imagers. The purpose of this was to understand the attributes, advantages, and limitations that were associated with thermal imaging that would affect upon training and operation. There was a single factor identified by Woodworth (1996, July) that had remained a constant in firefighting. A lack of visibility produced by the fire in the form of smoke hinders search and rescue, slows handline placement, fire detection, and obscures structural defects (Woodworth, 1996, July). The products of combustion further poised a risk to firefighters who can become lost and disorientated in the

structure thus affecting their ability to exit during an emergency (Woodworth, 1996, July). The impact of Woodworth's writings identified the key threat poised to firefighters was the inability to see through smoke during fireground operations.

The main by product of the combustion process known as smoke. Smoke consists of two elements; gases produced by the breakdown of the fuel by fire, and carbon particles. The carbon particles, known as soot obscures light, impeding the firefighter's ability to see in a burning structure. The amount of smoke depends upon the products being burnt, amount of oxygen present, size of the fire, and structure involved (Woodworth, 1996, July). The light waves that are blocked by the smoke are shorter in wavelength and cannot penetrate the smoke. This thereby limited the firefighter's vision capability in a burning structure (Wagner and West, 1998). The writings of Woodworth, Wagner and West identified the obscuring agent smoke as effecting fire suppression and rescue efforts of the fire department.

Although invisible to the human eye, infrared energy or heat would be felt by the firefighter through the light blocking smoke (Newman and Irving, 1973). Thermal imaging cameras read infrared radiation or heat waves invisible to the human eye (Wagner and West, 1998). Human bodies, structural members, and physical objects vary in heat levels produced and absorbed. The various sensors in the thermal imager units are able and designed to detect this difference in heat levels in a fraction of degree (Wagner and West, 1998). Firefighters using thermal imager cameras would be able to see through the smoke and would be furnished with a representation of the heat (Woodworth, 1996, August). These authors provided the literature review with an understanding of heat energy and combustion properties in thermal imaging.

Thermal imagers display their readings in several shades of gray to the firefighter applying thermal cameras (Wagner and West, 1998). In basic terms, what thermal imagining performs is a

thermal heat view of the world. Viewing through a thermal imager would provide the operator with a black and white television representation of the fire through the light obscuring smoke (Fire Rescue, 1998, April). The process utilized by the thermal imager to interpret heat energy was identified as thermal contrast effect (Woodworth, 1997, February). Temperature difference or heat energy forms the image displayed. All thermal imaging cameras display objects as follows; objects devoid of heat appear black, cooler in temperature and bright white for warmer or hotter objects (Wagner and West, 1998). This difference in heat energy was displayed on the viewer for the operator. Therefore, the firefighter can see the room as if the smoke were not there at all (Wagner and West, 1998). A key is that everything that is viewed by the operator retained their shape by the lens (Fire Rescue Magazine, 1998, April). Consequently, rooms and human forms all retain their shape for easier viewing (Wagner and West, 1998).

As stated previously, smoke hinders fireground visibility for the firefighter. Woodworth (1996, July) found that until the advent of thermal imaging technology, the fire service had relied upon traditional methods to improve visibility. These methods included lights, which had little effect, and ventilation to remove smoke for visibility purposes in structural fires. The literature review conducted clarified the properties of heat energy and components of smoke by reviewing the combined writing of Woodworth and Newman.

The literature review examined the attributes of thermal imaging that would effect operation. Woodworth listed three kinds of infrared energy sources that are the keys to understanding the working principles of thermal imaging (Woodworth, 1996, November). The three kinds of sources are active emitters, passive emitters, and direct source emitters (Woodworth, 1996, November).

Active emitters emit a constant amount of infrared red energy with little variation. An example of an active emitter is the human body. Interference from several factors that could effect readings of infrared energy was identified. These factors included multiple layers of construction material, multiple layers of clothing, wet clothing and bulky clothing which in turn would effect readings of infrared energy (Dunbar, 1998; Woodworth, 1996, November).

Passive emitters are inanimate objects that have a wide variation in temperature. These types of emitters do not generate heat on their own and must be heated by other source, an example of a passive emitter include steel (Dunbar, 1998). Steel unheated would appear black on the view screen next to a human. Once heated, steel would generate a whiter image, indicating absorption of infrared energy (Woodworth, 1996, November). The mass and density of the passive emitter would effect detection (Woodworth, 1996, August). Woodworth identified a safety advantage to thermal imager use as the detection of a flashover threat through the observation of the heating of room contents (Woodworth 1996, August).

The final source of infrared energy identified was the direct source emitters. Examples include the sun, fire, and chemical chain reactions (Woodworth, 1996, November). This energy source would effect some readings by a thermal imaging camera by causing a “white-out” condition when pointed at a direct emitter. A “white-out” condition indicates a large amount of heat or infrared image was present, causing the imager to go white across the view screen (Woodworth, 1996, November).

Some materials were analyzed as incapable of infrared detection. Materials such as water, plastic, and glass poise a barrier. These items had to be heated for readings to take place through the imager (McLauglin, 1992). McLaughlin listed additional barriers to thermal imager usage. Imagers cannot see through walls or multiple layers of material (McLauglin, 1992).

The combined writings of Woodworth and McLaughlin effected the research by providing insight into the sources of infrared energy and the impact upon thermal imager application.

The literature review identified three technology types currently available for fire/rescue thermal imaging. The first early thermal imagers known as cooled IR detectors were large, bulky and expensive (Woodworth, 1996, July). These early units were handheld, prone to "white- out," and saw little use in the fire service (Woodworth, 1996, November).

The second type of technology described by Nygren's article, *Thermal Imaging for the Fire Service* (1997) was Pyro Electric Vidicon. This unit used tube construction for thermal imaging (Woodworth, 1996, July). This unit was similar to earlier types of imagers but smaller, newer in technology and less prone to "white- out". If "white-out" occurred it could be cleared in seconds or accomplished by aiming away from the direct emitter (Nygren, 1997).

Micro-engineering had yielded a third type of thermal imaging device identified as focal array chip technology (Woodworth 1996, July). This provided the fire and rescue service with a helmet mounted thermal imager that is smaller in size, lighter in weight, and allowing for hands free operation (Dunbar, 1998). This unit put to use solid state construction for thermal imaging (Nygren, 1997).

The literature review of the technology types provided the author with additional operational concerns regarding thermal imager operations.

The literature review continued to research the limitations and advantages associated with thermal imager operation. The first limitations focused upon were the training aspects of thermal imager application. Woodworth (1997, February) provided the research with essential limitations in thermal imager operation. In the six part series of articles, Woodworth continued to provide the research with additional limitations; linking training and thermal imager operation

(Woodworth, 1997, March, August). Nygren's articles provided this author with additional training concerns regarding thermal imager operations (Nygren, 1997).

Next, the literature review examined the advantages and limitations of thermal imaging cameras found on the fire and emergency scene. *Fire Engineering Journal* (1995) reported several advantages in using thermal imaging cameras on the fireground. The benefits derived from thermal imager operations were illustrated in detail from after incident reports gathered from three incidents. In addition, *Fire Engineering Journal* (1995) through the writings of Lyons and Parmenter, also noted significant boundaries or limitations associated with thermal imager technology.

All of the major manufacturers, which were reviewed, state clearly the advantages of their respective systems. This point was evident in reviewing the literature and various videotapes provided by the following manufacturers: Cairns, International Safety Instruments, ISG, Bullard, and Mine Safety. This documentation provided the research process with technologies available, applications, and actual news reports of saves contributed to the use of thermal cameras.

Cairns (1998) in their product specifications also stated a limitation in the utilization of their IRIS system. Just like Woodworth (1997, March) who also reported limitations in using any thermal imaging tools. Cairns (1998) company called for the continuation of applying the basics of firefighting in using thermal imaging for safety purposes.

Render (1997), provided a word of caution in this technology, it does not replace prevention. These points would be influential in the research project, as potential disadvantages or system limits.

*An Examination of the use Thermal Imaging Cameras in the Fire and Rescue Services* (Patterson, 1997), an EFO paper submitted by Assistant Fire Chief Thomas Patterson, Houston

Fire Department, surveyed 40 departments utilizing thermal imaging cameras. The survey was replicated locally to check upon the similarities of results. Patterson noted, through the survey, several advantages, disadvantages, and training considerations associated with thermal imager application. The results of Patterson's 1997 national survey would be compared and contrasted to locally obtained statistical information.

Maine's Fire Training and Education publication entitled, *Thermal Imaging for the Fire Service* (1997), by Allen Nygren, reviews several advantages of thermal imaging camera found in fireground operations. In addition, Maine's thermal imager training program listed several disadvantages and limitations of implementing this thermal imaging technology. This comprehensive training publication itemizes cautions to be emphasized during the initial phase in period or training program before the placement of thermal imagers on the fireground or emergency scene. This publication also allowed numerous fire departments to share in advantages, applications, and training associated with thermal imaging cameras.

In his first writings, Woodworth (1995) described insight into Atlanta, Georgia Fire Department's testing of Cairns IRIS thermal imager camera. This provided a detailed account into several early applications and advantages found with the application of thermal imaging. These experiences documented the findings in the testing and actual incident experience phase of thermal imaging technology in the City of Atlanta's Fire Department. Several of the early applications went beyond traditional search and rescue situations. Applications included water flow detection, hazardous materials analysis, and mutual aid applications. Woodworth also provided insight into the training components of thermal imaging cameras. This influenced the research in providing a suggested method of instruction for the proposed lesson plan on thermal imaging.

*Fire Rescue Magazine* (1998, April) enumerated six advantages using thermal imaging for the fire and rescue service. This article contained a useful chart comparing a handheld (PEV Technology) or helmet-mount (FPAC). This chart influenced the research of thermal imaging cameras by providing a simple comparative analysis of both of the commonly utilized thermal imaging technologies. The chart; labeled as Table 1, page 26, was replicated in this research paper and would also be applied in the training program. In addition, this article provided this research with the first written suggestion for the operation of thermal imaging technology for fireground application. Within this text, a recommendation was made for a combination approach in thermal imager application on the fireground. The recommendation stated that a helmet mounted system for initial search and rescue and a handheld for size up and detection. *Fire Rescue Magazine* (1998, April) also provided a way to demonstrate the capabilities of thermal imaging in a training session. The methods identified by this magazine would influence the research effort in providing insight into the psychomotor phase of instruction. Many of the methods identified would be incorporated into the draft lesson plan for thermal imaging.

Cogan (1992) provided information on thermal imager application by the Fire Department of New York (FDNY). His writings included additional application advantages found with imager usage by the fire department. Cogan goes on to provide information regarding proper viewing of the imager. Specifically, when to interpret the image as a hot location requiring overhaul operation. Cogan further provided additional essential training consideration in thermal imager training, the valuable of repetition in thermal imaging training. Again, this provided the literature review with additional cited experiences of imager applications on the fireground. Furthermore, it provided the research process with training factors to examine and apply in the proposed thermal imaging training.

**Table One**

| **Handheld Thermal Imager** | | **Versus** | **Helmet-Mounted Thermal Imager** | |
|---|---|---|---|---|
| **Pro** | **Con** | | **Pro** | **Con** |
| Do not have to adjust eyepiece. | Some units don't focus within 12 ft. Potential to drop or strike an object. | | System allows for hands free operation. | What you see in the eyepiece may not be in front of the wearer. Image can be a few feet or inches off. |
| No helmet to adjust. | Inability to use both hands. | | Certain units offer video and thermal images. | The wearer must remember to move their head up & down, left & right to expand the field of view. |
| No wires to snag. | | | Unit can be connected to a data link for live broadcast. | They are heavy to wear. |
| Cost approx. 25% less than helmet mounted. | View may be better with helmet mounts due to inferior optics in some handhelds. | | With the imager attached to the helmet, it goes in whether it's needed or not. Someone must be designated to wear it or it will not be there when you need it. | Helmet must be adjusted during the transfer process. |
| Easily transferable from one firefighter to another. | Optics easily damaged by heat in some older models. | | Helmet view may be superior to handheld units. | Battery pack must also be transferred to new user. |
| Batteries easily replaced longer duration. | Other than easily damaged vidicon tubes on older analog systems, heldhelds are tough. | | | Quick disconnect on battery wire and eyepiece easily damaged. |
| Can secure around user's neck, allowing hands free operations. | | | | Increase need for spare batteries. |
| What you see in the viewfinder is what is actually in front of you because the viewfinder and imager are in line. | | | | Battery pack to helmet cable equipped with a breakaway feature difficult to connect in smoke. |
| They can be held above the head or through a hole to get an image. | | | | |

Replicated from *Fire Rescue Magazine* (1998, May, p.44).

*Fire Rescue Magazine* (1998, May) continued the review of thermal imaging cameras for the fire service. Their article provided a list of nine precautions that should be undertaken with thermal imaging usage. The presentation further goes on to enumerates eleven fire service tasks that the application advantages were found in the usage of thermal imaging technology.

Several tactical applications of thermal imaging on the fireground were identified in Maine's Fire and Education's training program authored by Nygren. The literature review and research of this package was instrumental in providing some statistical conclusions achieved in thermal imager applications. In addition, several tactical advantages were mentioned regarding the utilizing thermal imagers on the fireground (Nygren, 1997). Maine's publication and training program provided this research with several tactical advantages found in the utilization of thermal imagers on the fireground. This information was complimented with several interesting statistics regarding imager usage and implication of thermal imagers on the fire service.

Research was continued examining the area of tactical applications and considerations of thermal imager application on the fireground. In John Norman's textbook, *Fire Officer's Handbook of Tactics* (1991), no material was presented to aid in potential tactical applications of thermal imager technology on the fireground, either for strategic or tactical applications. This lack of information presented the literature review with a limitation.

Tactical considerations of thermal imager application on the fireground were provided in an EFO paper titled, *Standard Operating Guidelines for Combating Single Family Dwelling Fires* (Hart, 1998). Hart enumerated guidelines to follow that outlines specific responsibilities and equipment to be used at single-family dwelling fires. The purposes of the guidelines were to improve the safety of responders and the occupants. The writings also provided this research with information yielded from several training and field exercises concerning thermal imagers.

The writings of Wagner and West (1998) reviewed several manufactured types of thermal imaging units. Their research produced a comparison chart of the respective units, handheld versus helmet-mounted. Wagner and West (1998) further in their article go on to interview two fire department training officers, each of whom uses thermal imaging. However, one department uses a handheld unit, and the other uses a helmet-mount system. The interview process asks both objective and subjective questions to each of the officers. Some of Wagner and West's interview questions were incorporated for replication by this author during the survey aspect in this project. In addition, during the interview both training officers added information regarding training aspects of thermal imager application. These interviews provided this research with documented opinions of the two technology options available to the fire service. Further more, additional documentation of the advantages found with thermal imaging application on the fireground was provided in the interview. The impact of these authors yielded the research process with several items to be examined during the training consideration of thermal imaging as well as additional system advantages noted.

Stevens (1991) reported his observations on the advantages of having thermal imaging capabilities. His writings also provided documentation regarding actual incidents using thermal imaging camera. The additional capabilities of thermal imaging were given beyond the traditional fireground application. Stevens influenced this research by providing documented instances how thermal imaging technology changed the fireground operation

Woodworth (1997, February) gives several additional features that a thermal imaging camera should possess to enhance safety and proper utilization. He mentions the importance of using technology in the fire service to improve firefighter safety and job performance. The author also provided an essential limitation that would influence this research.

Stevens (1999) reported the impact of thermal imagers on larger municipal fire departments. He brought up some additional findings on imager usage on the fireground in terms of locating victims in a burning building. Stevens' impact upon the research was a recommendation that was stated in his latest article, which called for radical changes in the traditional thermal imaging concept. The radical change called for the placing of an imager on each apparatus as essential equipment, as opposed to the one imager per department mentality (Stevens, 1999). Stevens also stated his belief that," Thermal imaging holds more promise for improved fire protection services than anything other than mandatory fire sprinklers and monitored notification systems. The ability to see through smoke and darkness and spot heat through wall will greatly change the way we conduct our business on the scene" (Stevens, 1998, p 68).

The research examined the final area of consideration, training. A search for specifically designed training activities for thermal imaging cameras was attempted. Research undertaken to identify authorities that would provide essential elements that had to be incorporated within a thermal imager training program. As a result of the literature review, a limitation was revealed. The research provided only two articles specifically on thermal imager training programs. As stated earlier the National Fire Protection Association (NFPA) and International Fire Service Training Association (IFSTA) are without any standards for thermal imager training.

In researching state based fire academy programs additional limitations were identified during the literature review activities. Maine's Fire Training and Education package was the only state based training program at the present time and has been previously cited in this research. The Connecticut Fire Academy has a program developed and is currently being piloted within their jurisdiction (Adam Piskura, personal communication, June 23, 1999).

Training for all military based fire service personnel is provided at the Department of Defense (DoD) Fire Training Center, based at Goodfellow, Air Force Base, Texas. This facility revealed a limitation in basic recruit training of personnel in thermal imaging that would influence the training aspect of this research.

In comparison, the Chief of Naval Operations established criteria to address firefighting requirements of the U.S. Navy. This sense of urgency was based upon the tragedies encountered during fires aboard the naval vessels, Forrestal, Stark, Enterprise, and Roberts. The Navy determined through post-fire analysis indicated that a leading factor involved in these disasters was the lack of training (NETC, 1999). The Navy then established a set of uniformed standards and performance based objectives that would influence the training program development portion of this paper. In addition, the U.S. Navy's use of live fire simulations in thermal imaging training influenced the course of training program development. This was evident through the Navy's emphasis on realistic applications and realism in practical training sessions.

The impact of thermal imager application in the area of training was provided in the writing of Siuru (1996). This article, which was very similar to the other articles referenced, provided many of the same system advantages associated with thermal imager applications. However, a unique aspect was contributed by the author that focused upon the impact of thermal imager application during training exercises. This unique training aspect of thermal imager application had an impact upon the research process of this paper and influenced fire training program development.

Dozier (1999) provided insight into the Abilene Texas fire departments experience with thermal imaging. In this writing, the author provided this research with methods to evaluate and

train firefighters on thermal imaging. The evaluation program included the opportunity for various vendors to field demonstrate their products.

The importance of training on the firefighter's ability to interpret the thermal imager was stated by Woodworth (1997, February). Some essential concepts of understanding were provided in this piece of literature. In further writings, Woodworth (1997, March) stressed the order of training regarding thermal imagers. The importance of the adequacy of training was stressed within his writings regarding thermal imagers. Woodworth (1997, August) emphasized a goal that stated the importance of realistic and ongoing training in thermal imager utilization for successful operation. In addition, he presented the current training situation far from this stated goal. Throughout the writings of this author, tactical operational considerations and proper searching techniques were furnished. The impact of these elements contained within the writings of Woodworth would greatly affect the training component of this research.

In addition, several of these authors stated throughout their respective writings that the impact of thermal imaging technology would continue to grow.

Lyons stated, " We are confident that thermal imaging is indeed progressing from the nice to have category and will become essential part of the fire service front line equipment in the coming years" (Lyons, 1995, p 7).

"Infrared imagining's time may have come for the fire service" (Woodworth, 1995, p 81).

Cogan, Dozier, Dunbar, Gallagher, Hart, Irving, Lyons, McLauglin, Irving, Parmenter, Patterson, Irving, Stevens, Siuru, Wagner, West, Woodworth, the writings from *Fire Rescue Magazine*, and training material from Maine Fire Training and Education, and the Connecticut Fire Academy influenced this research by examining the role of thermal imaging technology on the fire service. All the authors and organizations provided information regarding operations,

system advantages, and technological aspects of thermal imaging cameras. They all provided solid, rational arguments in favor of implementing this technology on the fireground. In addition, documentation of instances of how new technology can influence firefighter safety and impact fireground operations in a positive manner. In addition, several essential points were emphasized such as proper training that was realistic and ongoing. Training was considered vital to ensure the proper application of thermal imaging technology with its associated advantages and in providing for the safety of thermal image camera users on the fireground.

## PROCEDURES

The research procedures in preparing this paper started with a literature review at the Learning Resource Center at the National Fire Academy in April 1999 and in July 1999. Additional literature reviews were conducted at the North Providence Union Free Library in North Providence, Rhode Island, the Providence Public Library in Providence, Rhode Island, the Providence College Library in Providence, Rhode Island, University of Rhode Island Library, Kingston, Rhode Island, and the author's personal library between May 1999 and August 1999. The purpose was to obtain material relative to thermal imaging training programs for the fire and rescue service.

The literature review focused on four areas for review. The first area researched upon was the historical origins of thermal imaging. This was initiated to understand the background of this technology and learn about early applications of this unit. The next area examined was the attributes associated with the technology of thermal imaging cameras. This was done to gain a perspective of the workings and systems associated with this tool. A review of material was conducted thirdly, to examine the reporting of system advantages and limitations of fire

departments using this technology. The forth area examined was to review how thermal imagers were utilized on the fireground. This was to formulate a training assessment based upon the functional aspect of thermal imagers. The final area examined was how fire departments and State based training institutions were implementing training programs for thermal imaging. This was performed to compare and contrast training initiatives already in place for thermal imagers.

Interviews were conducted with Theodore Cocco, Rhode Island Fire Education and Training Board delegate, President of the Rhode Island Instructors Association, on the following dates June 23, 1999, June 26, 1999, and June 30, 1999; Kenneth Erickson, Chairman, Rhode Island Fire Education and Training Board, on June 23, 1999; Donald Campbell, Chief of Hope-Jackson Fire Department and past President of Rhode Island Fire Chief's Association, on June 24, 1999; Fred Serbst, Training Officer, Bristol Fire/ Rescue, on June 24, 1999; David Sylvaria, Chief of Bristol Fire / Rescue and past Rhode Island Fire Academy Director, on July 1, 1999; Michael DiMascolo, Retired Chief of Department Providence Fire Department and interim Fire Academy Director, on June 9, 1999; Linda Cohen, NFPA standards division, on December 9, 1998;Frank Florence, NFPA, June 25, 1999; Donald LeBlanc, NFPA, on June 25, 1999; Thomas O'Connell, Battalion Chief, Sunrise, Florida, on April 17, 1999; Richard Hally, Connecticut Fire Academy, on June 23, 1999; Steve Lee, Department of Defense, U.S. Navy Office of Safety and Survival, on June 4, 1999: Charles Werner, Battalion Chief, Charlottesville,Virginia Fire Department, on May 25, 1999; John Manera, Master Sargent, United States Air Force, Fire Protection Training Manager, on June 14, 1999; Adam Piskura, Director of Training, Connecticut Fire Academy, on June 23,1999; Bob Athanas, FDNY, instructor Safe IR Inc. on June 24, 1999, and David Peveler, Lieutenant Commander U.S. Navy, Director Damage Control Division, Naval Education and Training Center, Newport, RI on July 15, 1999

Two survey instruments were employed during this research project. The first was entitled "Thermal Imaging for the Fire Service Update 1999", was mailed out and delivered to all 80 fire departments listed by the Rhode Island State Fire Marshal's Office. The results of which were labeled Appendix E on page 71. This represented a survey of the entire 39 cities and towns comprising the State of Rhode Island, including two federal installations. This survey replicated one conducted earlier to determine thermal imager utilization in the State of Rhode Island in 1998 for an Executive Development paper entitled, *Thermal Imaging Evaluation for the Fire Service* (Carnegis, 1998). The summarized results of this original 1998 survey can be found on page 68, Appendix D. This replicated survey was modified from the initial survey to ascertain only if planned thermal imagers were in place and evaluate training programs. This survey used the cover letter of Appendix A and Appendix B; part one, using only questions one and two. Sixty surveys (75% percent) were completed and returned for data analysis.

A second survey was conducted in this course of research. The survey was divided into three part sections. Fire departments considering or had thermal imagers answered the first section of the survey. The second section of the survey focused upon advantages and limitations found in thermal imager utilization. The last section of the survey focused upon the training aspect and considerations for thermal imager application. A survey effort was made to all stated-based training and federal training institutions listed by the National Fire Academy State Outreach pamphlet 2000 (USFA,1999). In addition, the military based component of fire protection training was considered in this survey. Titled," Survey of State Based Training Institutions Training Programs in Thermal Imaging Cameras", was undertaken to determine training programs specific to thermal imaging (Appendix B). The survey was distributed to 55 agencies in this effort. In addition, five leading manufacturers, based upon local sales, were contacted to

determine their involvement in the training of thermal imagers. The survey of State and Federal training institutions yielded 46 responses to the inquirer of information (92% percent). The results of the survey were listed as Appendix C, on page 65 titled, State and Federal Training Institution Thermal Imager Training Programs.

The data results of the survey were entered into a database (Microsoft Excel for Windows 98). The results were tabulated and were analyzed to obtain information and used to assist in answering the four research questions examined within this applied research paper.

## Limitations

Several limitations were encountered in this research endeavor by the author. The research was limited by the lack of information and documentation about thermal imaging training. There were very few articles and no instructional textbooks found that specifically addressed the role of thermal imagers in the fire / rescue scene. Furthermore, there were no national standards or National Fire Protection Association publications regarding minimum standards for thermal imager construction or competency standards in place. A search at the Learning Resource Center at the National Fire Academy located only four research paper on the topic of thermal imaging.

The survey instrument was also flawed in its construction. The survey was limited in scope and failed to consider and examine the training activities of fire departments outside of Rhode Island that utilized thermal imaging cameras. The survey concentrated only upon state based training agencies and associations to gather information regarding training programs on thermal imaging. In failing to examine, communities that had thermal imagers in place flawed this survey. Many of these communities had developed their own specific training programs to implement this change associated with thermal imager application by the fire and rescue service.

**Definitions**

**Active Emitters -** infrared energy emitted with little variation of energy. An example is the human body and nuclear decay of some materials. There exist little fluctuations in temperature associated with active emitters.

**Direct Source Emitters** - infrared energy sources that produce great amounts of heat. Examples are fires, chemical reactions, rapid oxidation, torches, and the sun. There exist a wide range of fluctuations in temperature associated with direct source emitters.

**Field of View-** is the area of the thermal imaging camera through which the firefighter looks. The size or area viewed varies with imager purchased. Similar to viewing an area through binoculars, there exist a potential for missing areas, or "tunnel vision" to occur if operator fails to scan area completely.

**Focal Plan Array Chip (FPAC) –** this type of thermal imager provides a virtual reality image as opposed to a pictorial representation. This technology possess the ability to view direct sources without "whiting out". FPAC uses micro-engineered chips in this type of construction. This unit can be helmet-mounted thereby allowing for hands free operation.

**Infrared Energy-** is a region of the electromagnetic spectrum. The human eye cannot view this energy type. Humans, only through the sense of touch or feeling, can only detect this energy source, sense the presence of heat

**Minimum Resolvable Temperature Difference (MRTD) -** describes the capability of the thermal imaging camera to detect differences in temperature. The MRTD is the sensitivity of the unit, or how little a temperature differences the unit can detect. Some units can detect as little as half a degree difference in temperature

**Passive Emitters -** are objects or materials that have infrared emissions with significant variability. An example is steel at room temperature, steel appears cold or darker than a person in the same area. If steel is heated, it appears white, indicating an increase in temperature. These objects do not emit heat on their own and therefore must be heated by other sources.

**Pyro Electric Vidicon (PEV)-** a thermal image camera type, usually handheld. This type of unit can be affected by pointing at direct source emitters causing the "white-out" phenomenon. PEV uses "tube" construction. Newer versions are less prone to "white-out".

**Thermal Contrast -** the difference in the temperatures of the object being viewed. This contrasting makes it possible for thermal imaging camera to create a viewable image. The contrast is displayed as follows: Black indicates cooler or absences of heat in areas, white indicates heated objects, and shades of gray are detected in between the range.

**Thermal Inversion-** are changes noted with images viewed due to changes in ambient temperature. Firefighters viewed by a thermal imaging camera outside a structure would appear white or hotter then the surrounding area. When viewed inside the burning structure this image displayed would change or invert. The firefighters would appear darker, indicating the temperature of the surroundings have changed.

**Thermal Imaging Camera (TIC)-** a tool capable of converting infrared heat energy to a viewable real time image. Converts infrared energy to a viewable image.

**Thermal Resistance-** the maximum temperature the thermal imaging camera can be subjected to without damage. Duration usually stated in terms of minutes.

**Virtual Reality**- the temperature differences of detected energy concerted into a visible image by the thermal imager.

**White-Out or Whiting out Effect-** refers to what happens to the thermal imaging camera when it is pointed at a very hot object (direct source emitter). This causes the sensor to be overloaded and generates a completely white screen on the view screen. The unit must be cleared to resume operation

## RESULTS

### 1. What are the national training standards for using thermal imaging cameras?

The literature research located no applicable national training standards for using thermal imaging cameras by the fire and rescue service. In addition, the National Fire Protection Association is without guidelines or standards that addressed the construction of thermal imagers or training of these units. This lack of training standards or measurable student objects extended to the International Fire Service Training Association, for this organization is also without any training standards for thermal imaging cameras. Research of the various manufacturers of thermal imaging cameras discovered that they had no training standards in place for the operation of their units. Discovering this absence of standards, a search for authoritative sources on thermal imaging technology was undertaken by this author.

### 2. What was the historical background, the attributes, advantages, and limitations associated with thermal imaging that can effect operation and training?

Historical analysis indicated some significant background information on thermal imagers. This provided information beyond the traditional civilian application of military night-vision

capabilities. In the writings of Newman and Irving (1973), it was identified that one of the first fire departments to use thermal cameras was the Reading Fire Department in Pennsylvania. In 1965, the HRB-Singer Corporation under contract with the Office of Civil Defense; under the auspices of the Secretary of the Army, developed 20 handheld units for civilian application. These devices were able to detect infrared energy not by providing a visual representation, but through an audible signal. The Reading Fire Department found that these early designed thermal cameras were helpful in their suppression operation. However, believing that there was no market potential or demand for this product, the Singer Corporation stopped production in 1966.

Thermal imaging cameras have been described as the most exciting new technologies to emerge for the fire service as stated by Wagner and West (1998, p.32). Wagner and West also reported on the early application of thermal imaging by the U.S. Forest Service in the 1970's. Helicopters that were unable to see through the smoke and vegetation to map out temperature differences used thermal imaging. This data was converted onto maps to aid in suppression activities. The writings also provided additional documentation on the military roots of thermal imaging. In addition, Wagner and West further documented the effects of two significant military events that hastened implementation of thermal imagining. The first was the Falkland War that was the driving force for placement on naval vessels. The most recent event was the impact of Desert Storm's night- vision capabilities. This was evident in a large part due to media frenzy on the daily action reporting of this night-vision capability

Wagner and West also provided an understanding into the workings or operational aspects of thermal imaging technology. In their writings, the authors described the thermal imagers' attribute of reading heat through the means of infrared energy detection. The sensitivity of

detection by some thermal imaging cameras in the noting differences of heat can be in the fractions of a degree Fahrenheit.

A leader in the reporting of thermal imaging cameras would be Steven Woodworth. Woodworth leads the field with seven published articles on the subject of thermal imaging technology innumerous trade publication. Steven Woodworth, a firefighter with the City of Atlanta, Georgia, instructor Georgia Fire Academy, and instructor for Safe IR, Incorporated provided additional information on thermal imaging attributes. Woodworth (1996, July) in his writings states that thermal imaging is the fastest fire service tool. Historical the fire service had relied on the traditional skills of ventilation and lighting to "see" through the obscuring smoke present at structure fires (Woodworth, 1996, July). Woodworth (1996, July) reported on the one constant in the fire service as being smoke. The effect of smoke was far reaching, its impact extended into operations on the fireground by obscuring vision. This would poise a life, safety threat to firefighters (Woodworth, 1996, July). This new fire service tool was not to be used as a replacement for these traditional skills, but as an aid in the search and rescue effort through increased visibility.

Several authors provided this research with information regarding the operational attributes associated with thermal imager technology. Thermal imaging cameras translate infrared energy into a viewable image (Wagner and West, 1998). This converted image of translated infrared image than can be read by the firefighter (Woodworth, 1996, July). Woodworth provided information regarding the principles and physics regarding the transmission of infrared energy. Woodworth compared infrared energy to light energy, but only infrared was capable of penetrating smoke (Woodworth, 1996, July). Although invisible to the human eye, thermal imaging cameras read infrared energy (Wagner and West, 1998).

The concept of thermal contrast was presented in the writings of Woodworth as well as Wagner and West. Thermal contrast, which is the differences in the temperatures of objects in an area, provided the basis of thermal imaging (Wagner and West, 1998). Thermal imagers are able to detect these differences in heat absorption in fractions of a degree and convert them into a viewable black and white image (Woodworth, 1997, February, August). Fire suppression and rescue personnel that used thermal cameras would then able to see through the smoke (Woodworth, 1996, August).

Lyons and Parmenter article in *Fire Engineering Journal* (1995) provided the author with detailed advantages and limitations found with thermal imager utilization. The report provided was based upon the after action reports of the Cleveland County Fire Brigade, United Kingdom.

This international information listed five advantages found after a post incident analysis or conclusion as reported in *Fire Engineering Journal* (1995);

1. Thermal imaging restored vision to almost normal.
2. It was invaluable in locating the fire.
3. Enable a faster more effective fire attack.
4. Improved firefighter safety.
5. Enables the officer in charge to accurately assess the situation (p.8).

Although Lyons and Parmenter found in thermal imager applications that there were essential limitations associated with imager application. Limitations included the lack of awareness regarding the benefits of this technology, financial limitations, and traditional resistance to change by the fire and rescue service. As expressed in the writings of Lyons and Parmenter, was a quote by Deputy County Fire Officer Peter Shead, Lead Officer, “ The most efficient and safe

use will be dependent on the development of procedures for the use of TIC inside structures." (p.7)

Authors noted some limitations. In his writings of February 1997,Woodworth compared thermal imagers similar to other tools in the fire service. Fire service personnel must be trained frequently and effectively if devices are to be used safely and properly (Woodworth, 1997, February). The firefighter must be capable interpreting the image displayed. The author stated that a person would be easily recognized after the firefighter understands how to interpret the image. However, some imagers are not easily recognizable, such as a flashover (Woodworth, `997, February). If unable to recognize this rapidly occurring phenomenon, safety would be risked and tactics jeopardized (Woodworth, 1997, March).

Steven Woodworth links thermal imaging training as a limitation. Thermal imaging camera's popularity are gaining at a tremendous rate, yet unfortunately training for thermal imagers are not growing at the same rate (Woodworth, 1997, March). Thermal imagers are often placed into service after one training session, sometimes only classroom training was provided (Woodworth, 1997, March). Thermal imagers can only be successful if ongoing and realistic training was provided (Woodworth, 1997, March). The survey instrument given during this research paper found that several local fire departments had received training in a similar manner. Quoting Lieutenant Mike Cogan, Fire Department City of New York, Rescue Three; "If Joe Montana threw the football only once a year, he wouldn't make it to the Super Bowl." (Woodworth, 1997, March). Nygren (1997) also provided some important limitations. Training with the unit was identified as a key in safety. "Never forget your training." (Nygren, 1997). Firefighters could enter the structure too deeply too fast. Thermal imaging devices must be used with the thought

that the unit might fail. Traditional firefighting operations must not be forgotten by thermal image carrying rescue personnel (Nygren, 1997).

The author stated several disadvantages included failure to recognize building collapse indicators, failure to recognize victims, failure to note flashover conditions, and moving too quickly (Nygren, 1997). Firefighters and occupants, who are wet from hoselines, could be masked during the search. Certain material, such as glass, water, or mirrors will cause imaging problems. The effects of "Tunnel Vision" can place the operator in peril or danger, holes can be misjudged to be farther away, or masked. In addition, the author goes on to state that the operator can often overlook the structural integrity of the building by depending upon TIC alone. Nygren's concern echoed those given by Woodworth regarding the essential of training, principles of operations, and using the basics.

The importance of utilizing TIC along with the traditional tools of search and rescue was emphasized in Nygren's writings (Nygren, 1997). As stated by the author as imperative and vital safety link in TIC usage, rested upon team training on thermal imaging (Nygren, 1997). This would allow for communication of encountered hazards (Nygren, 1997).

In addition, *Fire Rescue Magazine* (1998, May), provided this research with a listing of nine precautions or limitations that should be undertaken with TIC application

Nine precautions for imager use described by *Fire Rescue Magazine* (1998, May,) are as follows:

1. Exercise extreme caution when using delicate and expensive thermal imaging cameras.
2. When the camera is off, do not point it at the sun or any other heat source.
3. Do not look directly at the fire with older imagers because it damages imaging tube.

4. Always check the imager battery level before walking away with it, and replace batteries with every use.
5. Operators should carry a rag to wipe the imager's tube or eyepiece because of the build up of the products of combustion, namely, steam, fog, or high carbon smoke.
6. With vehicle mounted systems leave the unit on white-hot and scan during response.
7. Be aware that with some helmet-mounted systems, the lens is offset from the natural line of sight, making things seem two feet to three feet to the left of the image. This makes it difficult to judge distance, stairs, doorknobs, and other obstacles.
8. Know that on occasion, the entire viewer will "white-out" because everything is hot. Practice staying oriented when traveling through a structure.
9. Peel off thermally transparent plastic covers to protect heat seeking optics from smoke and tar in fire conditions, and protect the optics from scratching when cleaning. (p.77)

In the survey instrument utilized in this research, the Central Falls Fire Department, Rhode Island reported some of the same problems listed as precautions by this article. This department has been using the Cairns Iris system the longest in Rhode Island and reported that the lens had become foul in smoke created from burning plastics. This was resolved by cleaning with a rag.

*An Examination of the use of Thermal Imaging Cameras in the Fire and Rescue Services* (Patterson, 1997), Patterson surveyed 40 departments utilizing thermal imagers. The survey indicated several advantages and disadvantages associated with thermal imaging cameras.

The advantages noted in Patterson's survey were as follows:

1. Thermal imaging cameras allows the performance of search and rescue with more reliability in half the, less manpower commitment.

2. The camera provides firefighters with the advantage of added safety on the fireground because it reduces the time involved in search and rescue.
3. The existence of hot spots under debris is known immediately during overhaul operations.
4. The thermal imaging camera allows rapid intervention teams to quickly locate missing or injured firefighters.
5. Hazardous materials teams may use thermal imaging cameras to locate a chemical leak that is invisible to the eye.
6. Property loss is reduced as a result of locating the fire much quicker utilizing thermal imaging devices.
7. The existence of overheated electrical devices is located with much more certainty.
8. The device allows firefighters to see in an environment that in some cases is totally dark.
9. In certain situations, the device will allow a fire crew to skip the overhaul operations all together (Patterson, 1997, p. 16).

Some disadvantages were noted in the survey done by Patterson. Disadvantages noted within the paper were:

1. Intensive individual training is required before the device can be safely and effectively used on the fireground.
2. The helmet-mount unit is heavy and may strain the wearer's neck.
3. Due to resistance to change, some veterans refuse to wear the device.
4. The units are very expensive.
5. The lens will fog over when re-entering a structure in extreme cold (10 degrees or colder).
6. Because the devices are so expensive, many departments are unable to purchase the quantities that will allow a positive impact on the fireground.

7. Inadequately trained individuals have unrealistic expectations in difficult situations, which could lead to unnecessary risk taking (Patterson, 1997, p.17).

Patterson also cited from Cairns (1998) product specifications. Citation provided an ominous warning or limitation in thermal imaging usage. According to Cairns, the only problem with this or other vision enhancement systems is the risk of failure and the virtual blindness experienced by the user. Once the user becomes accustomed to working the system, he can become dependent on it for navigation. Failure in these circumstances could cause disorientation and confusion, which could be fatal or harmful to the user (p.7).

Cogan (1992) provided insight into the FDNY experience in the advantages of thermal imaging utilization. Many of the advantages were similar to other fire departments. Repeated advantages included faster fire identification, improved visibility, locating hidden fires, detecting water flow in sprinklers and electrical problem identification. Cogan provided insight in the value of training, without it, a limitation occurs. Thermal imaging camera must be used many times at simulated drills and fires in order for the operator to become completely familiar with the information it provides (Cogan, 1992).

In an EFO paper by Hart (1998), the use of thermal imaging technology was incorporated in the development of a standard operating guideline for combating single-family dwelling fires for the Olathe Fire Department. The results of several training fires provided additional comments regarding the usage of thermal cameras. As reported several comments gathered included faster searching, improved visibility, and feeling safer. In addition, some limitations were also provided after these training fires. Personnel stated difficulty carrying the TIC with the tools of the trade e.g., irons, hose handling and now the camera. Others reported difficulty “seeing” the victim if located close to the fire (Hart, 1998).

3. **How were fire departments using thermal imagers in their emergency application and response?**

Numerous authors and fire departments had reported many success stories with the application of thermal imaging cameras. The results presented tell of incidents some unique to the application and some commonplace with thermal imagers. Many of these same applications were reported by several of the authors used in this research project

Woodworth (1995) reported on early thermal imager applications done by the Atlanta, Georgia Fire Department. A majority of Atlanta's experience with thermal imager was focused on two-story framed dwelling fires were it was used for search and rescue. It was found that search and rescue times were approximately cut in half (Woodworth, 1995). In addition, the imager was deployed at a detergent company silo fire to determine water flow from a sprinkler. The imager revealed a valve was closed thus preventing water flow (Woodworth, 1995).

Maine's Fire Training and Education training publication, *Thermal Imaging for the Fire Service,* (1997) provided several advantages of thermal imaging in specific areas of fireground operations. Many of these reported advantages were also communicated through similar experiences reported in Woodworth's writings (Woodworth, 1995, June). The primary advantage identified was the activity of search and rescue primary with TIC application.

Some unique applications found included the following. The detection of water flow to the sprinkler heads in a system determines if the system is reaching the seat of the fire. Thermal imaging assists the officer in size up; noting the location of the fire, fire spread, or hidden fires could be determined through the use of TIC. Overheated electrical fixtures including lights,

ballasts, overheated motors could be detected. Heated containers and vessels could be detectable by thermal imaging cameras in hazardous materials assessment. Information gathered would then assist in ventilation, salvage and overhaul, hazardous materials operations, and fire suppression operations. Fire suppression would be assisted by TIC in determining the shortest route to the fire, and structural hazards. Exiting from the structure would be possible because hose-lines would be cooler, thereby easily detectable for the TIC (Nygren, 1997). The survey instrument utilized during this research paper found that several local fire departments had similar results associated with their imager application.

*Fire Rescue Magazine* continued its effort identifying a list of eleven fire service tasks that thermal imager application would provide significant advantages when utilized properly (1998, May). Several of the applications found a local connection. These results were expressed in the survey instrument used in this paper. The listing in this article was then crossed checked with survey results received.

1. Response: Command vehicles would be able to see through smoke and properly positioned. Rhode Island Airport Corporation noted this in the survey response.
2. Size-up: Size up of the structure by TIC utilization to indicate fire floor, involvement, and extension.
3. Attack: The article suggests the officer is equipped with a helmet-mounted system for the attack crew. The crew compartment carried a handheld unit for rescue crew or second attacks line.
4. Search and Rescue: The article states that thermal imaging would greatly speed up the search in fire buildings. This was noted by many of the respondents to the survey.

5. Command Eye in the Sky: The article stated imager at large incidents could display multiple sides of a building and monitor attack and rescue operations.
6. Rapid Intervention Teams: These units should be equipped with an imager when possible, A RIT should be led by the deputy incident commander who has viewed thermal images of the incident up to that point according to this article. The Pawtucket Fire Department, RI cited this as an application currently in use in their department
7. Hazardous Materials: A benefit that was stated by this publication was the ability of TIC to determine heat intensity and levels of fluid within vessels. The Central Falls Fire Department in their response to the survey echoed this ability in working with the Drug Enforcement Agency (DEA) in clandestine drug lab raids.
8. Water Rescue: The article reported the use of TIC to find individuals in swift water rescue situations. This was conditional on the person being alive and on the surface of the water.
9. Wildfires: This use echoes the U.S. Forest Service early use of thermal imaging as reported in the literature review of this paper. The Hope-Jackson Fire Department in Rhode Island also noted a similar application.
10. Overhaul: Viewing all fires completely to ensure the fire is out was an advantage stated by the author. The author then went on to remind the reader that the third largest fires in the United States, Oakland California Fire in 1991 was a rekindle, which cost 24 lives and destroyed 5,000 structures.
11. Mutual Aid: This series recommends informing non imager departments about imagers and the technological advantage they provide. In the survey instrument used in this

report, seven, (7) of the departments reported they considered purchasing thermal imagers, but did not since one existed in a neighboring community (pp. 68-75).

*Fire Rescue Magazine* (1998, April) provided six applications thermal imaging for the fire service. The applications listed are:

1. Search and rescue.
2. Night wildland fires.
3. The ability to accurately check smell of smoke in the area calls.
4. Hazardous material use.
5. Fire extension checks.
6. Improved vision that results in reduced firefighter and civilian injuries and deaths (p.40).

Stevens (1991) reported on emergency applications or fireground applications of thermal imaging cameras. An incident at a 5,000 square foot building was searched under two minutes using a thermal camera in zero visibility conditions. The entry crew reported to the incident commander (IC) that three people were trapped on the second floor. Using a TIC, the crew was able to show the incident commander what was recorded on videotape during their search. This, thereby, allowing the IC to develop strategy that resulted in the rescue. As noted in the writings of Stevens was described an emergency medical incident were thermal imaging could be used to survey an auto accident scene checking for victims that could have been thrown from the wreck (p.73)

**4. What training activities were fire departments and state training institutions utilizing to implement training programs for thermal imagers into the fire service?**

The final research question was focused upon the training aspect for thermal imaging cameras. In particular, specialized training programs that dealt with imager application.

Woodworth (1995) provided insight into the training experience of the Atlanta, Georgia Fire Department in thermal imaging. Atlanta was chosen by Cairns to field test their Iris camera because of the wide variety of actual fire conditions faced by the fire department (Woodworth, 1995). In addition, the activity level of this fire department would also allow for extended usage of the units and test the durability of the units (Woodworth, 1995). All personnel received initial training at the department's training center. Training entailed classroom instruction regarding the operation, donning and doffing the unit, daily maintenance and care (Woodworth, 1995). Instruction was next provided at the department's burn building involving two separate types of fires. The first live burn situation was a fire allowed to progress to the free burning state with personnel observing in full turn-out gear. The purpose of the demonstration was to observe associated structural changes encountered during the burning process. The next evolution involved an actual search of the structure using the Cairns Iris (Woodworth, 1995). After training was received by all platoons assigned to field test the thermal imager, after this was completed then the unit was deployed (Woodworth, 1995).

Joseph Kosiarski, Cairns product manager, provided additional insight regarding this crucial training and field testing stage, "Training uses are generally more rigorous than actual firefighting, since the equipment may be in operation six to eight hours a day and on a regular basis" (Woodworth, 1995, p.82). This training period allowed for the development of tactics and

procedures for the thermal imager in order to achieve maximum effectiveness (Woodworth, 1995, p. 82).

Training of all military and some civilian fire suppression forces of the Department of Defense personnel occurs at Goodfellow, Air Force Base in Texas. A limitation was noted that thermal imager application was not taught at this facility.

The United States Navy through the Chief of Naval Operations, mandated training of all deployed forces in fire suppression. This in large part is based upon the past historical experience of Navy vessels and the effects of fire on these ships. The Navy has in place several fire simulator units at shore based facilities designed specifically to train crew members in live fire suppression and damage control techniques (NETC, 1999). One such facility is located in Newport, Rhode Island at the Naval Education Training Center (NETC). Approximately 6,000 students per year are trained in live firefighting techniques at the facility, including members of the U.S. Navy, U.S. Coast Guard, and foreign navy personnel (NETC, 1999). At this facility, instruction is provided in the classroom and in the 19F3A Trainer on the application of the thermal imaging cameras used by the fleet. This facility offers various realistic levels of firefighting training based upon ranking and level of responsibility, in addition to basic awareness training (NETC, 1999)

The results from surveyed State based training institutions provided some surprising results. Only two state training institutions had incorporated or developed training programs for thermal imaging cameras. The State of Connecticut has a program that is currently being piloted for eventual distribution (Adam Piskura, personal communication, June 23, 1999). Maine's Fire Training and Education package was the only state based training program at the present time for thermal imaging cameras. In its newsletter, *Thermal Imaging for the Fire Service* (1997,

September) Maine's Fire Training and Education stated goal is to provide 300 thermal imagers in the state within three years. Consequently, it has designed a training program, training materials, newsletter and a fund raising program to assist fire and rescue departments to prepare for thermal imaging technology (Nygren, 1997).

The results of surveyed manufacturers revealed that the five leading manufacturers of thermal imagers all provided classroom instruction on thermal imaging cameras. The instruction was delivered in a variety of means including; employees, sales representatives or the distributors in the area for the respective products. Live application was left up to the local fire and rescue department that purchased the unit.

Several of the manufactures contract with companies or training individuals to provide the training aspect. One such company is Safe IR, a non-profit company especially for thermal imager training. The company provides classroom and live fire instruction for the agency that purchased the camera. Training is provided over two days. The first day is classroom instruction regarding operation, theories, tactics, safety considerations and maintenance of the thermal imager. The second day is the live fire application of the thermal imager. This company uses all certified instructors. In addition, has been contracted by Cairns and Bullard to provide training on their respective thermal imagers (Bob Athanas, personal communication, June 24, 1999). The expense is approximately $2,000.00 per session (Bob Athanas, personal communication, June 24, 1999).

The survey indicated that this type of training provide by Safe IR; a combination of classroom and live fire training, seems to had been replicated by all Rhode Island fire and rescue departments that were in possession of thermal cameras. However, the standardization of

training, lesson plans, and guidelines were lacking. The issue to continuing education and annual refreshers was together overlooked by many of the survey respondents.

A unique role for thermal imager was note by Siuru in his writings. Siuri (1996) stated that in a training situation, a thermal imager would provide the instructor with the ability to observe students in the smoke-house or live-fire situation. If the unit was so equipped, a video link would allow for capture and later analyzed and reviewed (Siuru, 1996).

Wagner and West (1998) provided in their respective writings notations regarding training. Wagner and West cited Doug Patey, training officer for the Kennebunk, Maine Fire Department, reported that there was a decent amount of classroom education to learn the technology and also some field training with live fire conditions and search and rescue conditions. It takes some time to understand the issues involved and getting use to the image (p.36). This department used a helmet-mounted system .The training officer went on further to state that you have to learn to interpret the image and react to it accordingly (Wagner and West, 1998).

Wagner and West (1998) also interview the training officer for Bath Maine Fire Department, Captain Desmond, whose department uses a handheld unit. This department utilized training plans similar to those already presented that included classroom, simulation, and live fire training. Through their interviews, Wagner and West writings indicated that essentially regardless of the unit type; handheld or helmet-mounted, training was presented in the same fashion (Wagner and West 1998).

The Abilene Texas fire department established a committee of 10 members representing a cross section of the department to evaluate thermal imagers (Dozier, 1999). Evaluation was conducted over a two-day period. The session began with a two-hour classroom presentation on the basics and properties of imaging technology. After the class, each of the six vendors had one

hour to demonstrate their imager to the committee. Then each member had a standard evaluation sheet to evaluate the imager. The second day was field testing of the actual units through various fire scenarios, lastly approximately three hours (Dozier, 1999). The committee then began the process of selection.

## DISCUSSION

The literature review conducted in this applied research paper was in agreement with the survey tools utilized within this project. The survey instrument titled, *Thermal Imaging Survey Rhode Island 1998,* utilized in a previous EFO paper by the author indicated that only 26.8% (18) departments had thermal imagers in place (Carnegis, 1998). The results of this original survey are contained within this report and were labeled as Appendix D on page 69. This survey produced the additional results, 13.4% (9) were currently planning to implement thermal imaging technology in the near future (Carnegis, 1998).

Portions of this original survey were replicated in a survey titled *Thermal Imaging Survey Update 1999*. This survey was to verify if the additional acquisition of thermal imagers had taken place by area fire departments. Sixty fire departments (75%) returned this new survey titled, *Thermal Imaging Survey Update1999.* The 1999 survey results; Appendix E on page 71, indicated that two fire departments had obtained and placed into service thermal imagers, an increase of 11.1%. Additionally, three more fire departments were in the process of planned acquisition of thermal cameras, again an increase of 33.3% compared to 1998 survey results.

Cogan (1992) associated several advantages of thermal imaging cameras including located duct fires, overheated motors, broken pipes, improve visibility, hidden fires, an defective lighting. Patterson's (1997) survey associated within his EFO presentation identified several advantages found in thermal imager application. All these stated applications were collaborated

by respondents in the survey conducted of actual cases where thermal imaging was applied by area fire departments. Numerous respondents to both survey's used thermal imaging in situations similar to those five enumerated by *Fire Rescue Magazine* (1998, April). This provided emergency applications that can be interpreted as a universal system advantage associated with thermal imager utilization by the fire and rescue service.

*Fire Rescue Magazine* (1998, May), provided eleven on scene applications of thermal imaging cameras by the fire and rescue service. Again, many of those surveyed indicated that several local departments were using thermal imagers in areas suggested by the author. In addition, this literature provided as a comparison of the two technology types currently available to the fire service, which would assist in purchasing and be incorporated into training on thermal imaging. This chart was reproduced and is labeled as Table 1 on page 26.

The Rhode Island State Fire Academy and the fire service in general, must recognize the benefits of changes in technology. These changes can improve the overall operational efficiency of the fire department and improve fireground safety. The organization should view change as a force to be dealt with, not hidden by the excuses of funding or lack of awareness. Remaining current, organizations must expect the resistance, anticipate, and forecast the implications change. Organizations must recognize this need for innovation in technology called thermal imaging, and apply its advantages. In order to achieve full system advantages, proper training on thermal imaging must be provided and continually updated in order to reflect changes realized.

## RECOMMENDATIONS

The importance of thermal imaging would be communicated to all area fire and rescue departments to bring forth universal acceptance of this technological change and associated training required. A committee, similar in make-up as utilized by Dozier in Texas, would be established to develop and evaluate training programs for thermal imaging cameras. This committee would be made up of a representative of the basic firefighter program, a representative from educational standards area, two representatives of fire departments utilizing thermal cameras; one handheld and one helmet-mounted system, and a program chair.

This initial action entailed the establishment of the thermal imaging training committee within the fire academy structure. The first action of the committee would be to review aspects of this proposed training program for the thermal imagers (Appendix F, page 73). The overall goal would be to train emergency personnel properly before imager placement on an apparatus. The proposed program would be comprised of a lecture portion and a hands-on practical exercise. The practical component would encompass many of the techniques described in the writings of Cogan, McLaughlin, and Woodworth. As previously discussed by Woodworth, thermal imaging cameras are a tool, and the successful operation of thermal imaging is dependent upon the training of the operator.

Additional research would be conducted to determine the training aspect of thermal imaging cameras and technology in the fire service. Research would involve further contact with Maine's Fire Training and Education division and the Connecticut Fire Academy to obtain their training program for detailed committee review and subsequent analysis. Furthermore, consideration would be made into sending committee members through these state's training programs in order to gain more experience. Training packages would be obtained from the various manufacturers.

Table 2 on page 59 provides a listing of various manufacturers of thermal imagers. Training programs obtained from these state fire academies and manufacturers would assist in the development of the training resources needed for thermal imaging training. This committee would then develop a draft training program on thermal imaging cameras based upon this proposed plan and research material received.

If sufficient funding permitted, the Rhode Island State Fire Academy could contract with Safe IR Company to provide a training program for select instructors, similar to a train the trainer program. A potential group of instructors would be sought through the instructional certification committee of the Rhode Island State Fire Academy. The thermal imaging implementation committee would provide the instructional certification committee with suggested attributes and abilities of potential instructors to aid in instructor selection process by the Board and academy director.

After potential instructors were selected, a target audience would be assembled representing one group of experienced operators of thermal imaging and one group of inexperienced operators. Several test programs would be conducted. In each, comment analysis would be conducted both during delivery and at the post critique session of this training program. These initial training sessions would be two-fold in nature. The first aspect would be to review the training program in as far as student results achieved. The second purpose would be to train a group of specialty fire instructors in thermal imaging instruction.

After a period review and adequate training had demonstrated the adequacy of the program, the program of instruction would be made available to fire departments across the state. A checklist of suggest competencies for TIC would be included within the lesson plan so local training officers could evaluate their training programs.

The committee should lobby both the NFPA for the establishment of appropriate standards for this tool similar to the standards for SCBA, PASS and turn-out protection and IFSTA to develop associated training standards.

After this program and its adjunct instructors trained, a refresher training program would be developed and provided to update students and instructors in developmental changes in thermal imaging technology.

**Table Two**

| ***Manufacturer's Information As 29 July 1999*** | | | |
|---|---|---|---|
| **Manufacturer** | **Model(s)** | **Phone** | Misc. |
| Cairns & Brother Inc. | Viper | 800-230-1600 | Handheld |
| Cairns & Brother Inc. | Iris | 800-422-4767 | Helmet system |
| Mine Safety Appliances | Argus | 800-672-2222 | Handheld |
| ISG | ------ | 877-733-3473 | Handheld<br>Helmet- mounted system |
| International Safety Instruments | Vision 3 | 888-474-7233 | Handheld ( Vision 3) |
| E.D. Bullard | Bullard | 800-827-0423 | Handheld |
| Flir | Flir | 877-322-7282 | Helmet-mounted |
| Texas Inst. | Palm IR | 888-474-7233 | Handheld |
| Scott | Eagle | 704-282-8400 | Handheld |
| Texas Instruments | Night Sight | 972-243-3307 | Truck Mounted<br>Crash Fire Rescue Vehicle Mount System. |

**Appendix A**

Chief of Department / Training Director / Thermal Imaging Camera Manufacturer
0000 Street
City/Town, State 00000-0000

Chief of Department/ Training Director/ Thermal Imager Manufacturer:

I am conducting a survey regarding the training component of *Thermal Imaging Cameras in the Fire Service.* This survey is directed at fire departments that are in the process of obtaining or have units in service, fire training institutions, and thermal imaging camera manufacturers. I have requested information on how your department, institution, or manufacturer provides training for thermal imaging cameras. Your answers will assist the Rhode Island State Fire Academy and local fire departments on making informed decisions on the training component of thermal imaging.

Please take a few minutes to fill out the enclosed questionnaire and return it in the self-addressed reply envelop at your earliest convenience. If you are interested in receiving a copy of the National Fire Academy's Executive Fire Officer Project, please indicate this on the last page of the questionnaire with a mailing address

Thank you In Advance,

John N. Carnegis

Rhode Island State Fire Academy
6 MacLaine Drive
North Providence, RI 02904-5210

**APPENDIX B**

**NATIONAL FIRE ACADEMY**
**EXECUTIVE FIRE OFFICER PROGRAM**
**APPLIED RESEARCH PROJECT**

**Course:** **Strategic Management of Change**

**Subject Matter:** **Thermal Imaging Training for the Fire Service 1999**

**Survey Questions:** **Fire Chiefs/ Training Officers / Training Agencies**

**The purpose of this survey is to obtain data, opinions, and perspectives on the subject of training for thermal imaging units for the fire service. These surveys are to be collected from; fire departments, training institutions, and manufacturers that either have thermal imagers, manufacturers of thermal imagers, or train firefighters. The results of this survey will be included in an applied research project for the National Fire Academy's Executive Fire Officer Program. Please answer the following questions in the following parts:**

| | | |
|---|---|---|
| Part One: | All fire departments and Training Institutions. | Survey page 1. |
| Part Two: | Fire Departments and Training Institutions with Thermal imagers (In-service or order). | Survey page 2. |
| Part Three : | Thermal Imaging Camera Manufacturers | Survey page 3. |

**Part One: All Fire Departments and Training Institutions:**

Fire Department Responding: _____

Training Agency: _____

Type of Fire Department or Training Institution

Department Size: _____ members

Paid _____ Call/Volunteer____ Combination _____

1. Does your department currently own a Thermal Imager Camera? Yes____ No ____
2. If not, does your department plan to purchase one? Yes____ No ____

**<u>Part Two:</u> Only Fire Departments with Thermal Units (In-service or on order)**

1. What led you to consider the purchase of a TIC?

_____

_____

_____

2. What training factors were considered in purchasing the Thermal imaging unit ?

_____

3. How long has the unit been in service? _____

4. What type of training have you received on thermal imager use?

   Classroom:_____ Live Fire Training:_____ Both: _____ Other:_____

5. Who provided the initial training on thermal imaging?

   Manufacturer_____ Outside Contractor_____

   Training Academy_____ Own Agency _____

6. Was this training Adequate? If not explain.

_____

_____

_____

7. Were there any cost factors encountered with this training evolution?_____

   No: _____ Yes:_____ If yes, the amount expended $_____

8. In what roles does your agency use the Thermal Imager Cameras?

_____

_____

9. In addition, do you have any reports on how additional training could have improved the operational aspect of the thermal imager?

_____

_____

10. Is annual refresher training provided?

Yes: _____ No: _____

12. How often is thermal imaging used in training exercises?

_____

13. How does your department use the thermal imager ?

_____

_____

14. What are the any advantages, or limitations found in your department's experience with thermal imaging?

_____

_____

**<u>Part Three</u> Thermal Imaging Camera Manufactures:**

1. Does your company provide training? Yes ___ No ___

2. If training is provided by the manufacturer, please explain instruction type given in terms of lecture, live fire, or other.

_____

_____

_____

3. Who provided this instructional activity?

Direct by Manufacturer: _____ Local Sales Representative:_____

Contracted third party: _____ Other: _____

4. Is there an associated cost involved to the purchaser ?

_____

_____

If copy of final report is requested,

Please list a mailing address: _____

_____

**Thank you for your assistance**.

**APPENDIX C**

**State and Federal Training Institution**
**Thermal Imager Training Programs**
**June 1999**

| Training Institution | Phone Number | Thermal Imager Training | Type(s) * | Contact Person |
|---|---|---|---|---|
| Alabama State Fire College | 205-391-3776 | No | x | x |
| Alaska Fire Service Training | 905-269-5789 | No | x | x |
| Arizona Fire Service Training | 602-255-4964 | No | 1 | x. |
| Arkansas Fire Academy | 501-824-4045 | No | Planned | x |
| California Fire Training Division | 408-646-4240 | No | x | Local |
| Colorado Division of Fire Safety | 303-239-4484 | No | x | x |
| Connecticut Fire Training & Education | 860-627-6363<br>fax<br>860-654-1889 | Yes | 2 (pilot) | Adam Piskura **$500.00 sponsor fee to regional academy sites |
| Delaware State Fire School | 302-739-4773 | No | x | x |
| Florida State Fire College | 352-732-1330 | No | x | x |
| Georgia Fire Academy | 912-993-4670 | No | 1 Planned | x |
| Hawaii State Fire Council | 808-831-7748 | No | x | x |
| Idaho Fire Service Training | 208-334-3216 | No | x | x |
| Illinois Fire Service Institute | 217333-3800 | No | x | Hosted Only |
| Indiana State Fire Marshal | 317-232-2169 | No | 1 | x |
| Iowa Fire Service Institute | 515-294-6817 | No | x | x |

| Training Institution | Phone Number | Thermal Imager Training | Type(s) * | Contact Person |
|---|---|---|---|---|
| Kansas Fire Service Training | 785-864-4467 | No | x | x |
| Kentucky Fire/Rescue Training | 606-246-3142 ext. 1106 | No | x | x |
| Louisiana Firemen Training Program | 225-766-0600 | No | x | x |
| Maine Fire Training & Education | 207-767-9556 | Yes | 3 | Lt. Dunbar |
| Maryland Fire Training & Institution | 301-220-7240 | No | x | x |
| Massachusetts Firefighting Academy | 978-567-3200 | No | x | x |
| Michigan Firefighter's Training Council | 517-322-5461 | No | x | x |
| Minnesota Fire Service Director | 651-649-5454 | No | x | x |
| Mississippi Fire Academy | 601-932-2444 | No | x | x |
| Missouri Fire & Rescue Training Institution | 573-882-4735 | No Response | | |
| Montana Fire Services Training School | 406-761-7885 | No | x | x |
| Nebraska Fire Marshall-Training Div. | No Response | | | |
| Nevada Fire Training | 775-687-5011 | No | x | x |
| New Hampshire Fire Training Comm. | 603-271-2661 | No | x | x |
| New Jersey Bureau of Fire Safety | 609-633-6321 | No formal Training Programs County based | 1 | x |
| New Mexico State Fire Marshall's Office | 505-835-7521 | No | x | x |
| New York State Fire Administrator | 607-535-7136 | No | x | x |

| Training Institution | Phone Number | Thermal Imager Training | Type(s) * | Contact Person |
|---|---|---|---|---|
| North Carolina Fire & Rescue Services Division | 803-896-9850 | No | x | x |
| North Dakota Firemen's Association | 701-222-2709 | No | x | x |
| Ohio Fire Academy | 614-752-7207 | No | x | x |
| Oklahoma Fire Service Training | 405-744-5727 | No | 1 | x |
| Oregon Bureau of Fire Training | 503-378-2100 | No | x | x |
| Pennsylvania State Fire Academy | 717-248-1115 | No | 3 Planned Development Stage. | Incorporated into Rapid Intervention Program Only. |
| Rhode Island Division of Fire Safety | 401-294-0861 | No | 1 | x |
| South Carolina Fire Academy | 803-896-9850 | No | 1 | x |
| South Dakota Fire Service Training | 605-773-3876 | No | x | x |
| Tennessee State Fire School | 615-898-8010 | No Response | | |
| Texas Fire Protection Training Division | 409-845-7641 | No | x | US&R. only Members |
| Utah State Fire Service Training | 888-548-7816 | No | x | x |
| Vermont Fire Service | 802-483-9407 | No | x | x |
| Virginia Department of Fire Programs | 804-371-0220 | No | x | x |
| Washington Fire Service Training | 425-453-3000 | No | x | x |
| West Virginia Fire Service Extension* | 304-293-2106 | No | x | x |
| Wisconsin Fire Education & Training | 608-266-1671 | No response | | |

| Training Institution | Phone Number | Thermal Imager Training | Type(s) * | Contact Person |
|---|---|---|---|---|
| Wyoming Fire Prevention and Electrical Safety | 307-856-6776 | No | x | x |
| Federal Agencies | | | | |
| Department Of Defense: U.S. Air Force | | No | x | x |
| Department Of Defense: U.S. Army | | No | x | x |
| Department Of Defense: U.S. Marines | | No | x | x |
| Department Of Defense: U.S. Navy | | Yes | 2 | x |
| Department Of Transportation: U.S. Coast Guard | | Yes | 2 | x |

**Type(s) Legend:**

1. TIC Training Manufacturer provided.
2. TIC Training Specially Designed ; Classroom and Live Fire/Simulation
3. TIC Training Incorporated into other programs

**No response**: Nebraska, Wisconsin , Tennessee, Missouri, (4)

**Appendix D**

Thermal Imaging Survey
Rhode Island December 1998

| Department | TIC | Planned |
|---|---|---|
| Barrington | 1 | 0 |
| Bristol | 0 | 0 |
| Burrilville-Harrisville | 0 | 0 |
| Burrilville-Nasonville | 0 | 0 |
| Burrilville-Oakland Mapleville | 0 | 0 |
| Burrilville-Pascoag | 0 | 0 |
| Central Falls | 1 | 0 |
| Coventry-Anthony | 0 | 1 |
| Coventry-Central | 0 | 0 |
| Coventry-Harris | 0 | 0 |
| Coventry-Hopkins Hill | 1 | 0 |
| Coventry-Tiogue | 0 | 0 |
| Coventry-Washington | 0 | 0 |
| Coventry-Western | 0 | 0 |
| Cranston | 0 | 0 |
| Cumberland-Fire District | 1 | 0 |
| Cumberland-Cumberland Hill | 1 | 0 |
| Cumberland-North Cumberland | 0 | 0 |
| Cumberland-Valley Falls | 0 | 0 |
| East Greenwich | 0 | 1 |
| East Providence | 0 | 0 |
| Foster-South Foster | 0 | 0 |
| Foster-Center | 0 | 0 |
| Glocester-Chepachet | 0 | 0 |
| Glocester-Harmony | 0 | 0 |
| Glocester-West | 0 | 0 |
| Hopkinton-HVFD | 0 | 0 |
| Hopkinton-Ahaway | 0 | 1 |
| Jamestown | 0 | 0 |
| Johnston | 1 | 0 |
| Kingston | 0 | 1 |
| Lincoln-Albion | 0 | 0 |
| Lincoln-Limerock | 0 | 0 |
| Lincoln-Lonsdale | 0 | 0 |
| Lincoln-Manville | 0 | 0 |
| Lincoln-Saylesville | 0 | 0 |
| Little Compton | 0 | 0 |

| | | |
|---|---|---|
| Middletown | 0 | 1 |
| Narragansett | 0 | 0 |
| Newport | 1 | 0 |
| New Shoreham | 1 | 0 |
| North Kingstown | 0 | 0 |
| North Providence | 0 | 1 |
| North Smithfield | 0 | 0 |
| North Smithfield-Primrose | 1 | 0 |
| Pawtucket | 1 | 0 |
| Portsmouth | 1 | 0 |
| Providence | 1 | 0 |
| Richmond | 0 | 0 |
| Scituate-North | 1 | 0 |
| Scituate-Hope Jackson | 1 | 0 |
| Scituate-Poterville | 0 | 0 |
| Scituate-Chopmist Hill | 0 | 0 |
| Smithfield | 0 | 1 |
| South Kingstown | 0 | 1 |
| Tiverton | 0 | 1 |
| Warren | 1 | 0 |
| Warwick | 0 | 0 |
| Westerly-Bradford | 0 | 0 |
| Westerly-Dunn's | 0 | 0 |
| Westerly-Watch Hill | 0 | 0 |
| Westerly-Misquamicut | 0 | 0 |
| West Warwick | 0 | 0 |
| Woonsocket | 0 | 0 |
| RI Air Guard | 0 | 0 |
| RI Airport Corp. | 1 | 0 |
| US Navy Newport | 1 | 0 |
| | | |
| **Total (67)** | **18** | **9** |

Replicated in part from *Thermal Imaging Evaluation for the Fire Service* (Carnegis, 1998,p.58)

**APPENDIX E**

# Thermal Imaging Survey Update
# Rhode Island June 1999

| Department | TIC | Planned |
|---|---|---|
| Barrington | 1 | 0 |
| Bristol | 0 | 0 |
| Burrilville-Harrisville | 0 | 0 |
| Burrilville-Nasonville | 0 | 0 |
| Burrilville-Oakland Mapleville | 0 | 0 |
| Burrilville-Pascoag | 0 | 0 |
| Central Falls | 1 | 0 |
| Coventry-Anthony | 0 | 1 |
| Coventry-Central | 0 | 0 |
| Coventry-Harris | 0 | 0 |
| Coventry-Hopkins Hill | 1 | 0 |
| Coventry-Tiogue | 0 | 0 |
| Coventry-Washington | 0 | 0 |
| Coventry-Western | 0 | 0 |
| Cranston | 0 | 0 |
| Cumberland-Fire District | 1 | 0 |
| Cumberland-Cumberland Hill | 1 | 0 |
| Cumberland-North Cumberland | 0 | 0 |
| Cumberland-Valley Falls | 0 | 0 |
| East Greenwich | 0 | 1 |
| East Providence | 0 | 0 |
| Foster-South Foster | 0 | 0 |
| Foster-Center | 0 | 0 |
| Glocester-Chepachet | 0 | 0 |
| Glocester-Harmony | 0 | 0 |
| Glocester-West | 0 | 0 |
| Hopkinton-HVFD | 0 | 0 |
| Hopkinton-Ahaway | 0 | 1 |
| Jamestown | 0 | 0 |
| Johnston | 1 | 0 |
| Kingston | 1 | 0 |
| Lincoln-Albion | 0 | 0 |
| Lincoln-Limerock | 0 | 0 |
| Lincoln-Lonsdale | 0 | 0 |
| Lincoln-Manville | 0 | 0 |
| Lincoln-Saylesville | 0 | 0 |
| Little Compton | 0 | 0 |

| | | |
|---|---|---|
| Middletown | 0 | 1 |
| Narragansett | 0 | 0 |
| Newport | 1 | 1 |
| New Shoreham | 1 | 0 |
| North Kingstown | 0 | 0 |
| North Providence | 0 | 1 |
| North Smithfield | 0 | 0 |
| North Smithfield-Primrose | 1 | 0 |
| Pawtucket | 1 | 0 |
| Portsmouth | 1 | 0 |
| Providence | 1 | 0 |
| Richmond | 0 | 0 |
| Scituate-North | 1 | 1 |
| Scituate-Hope Jackson | 1 | 0 |
| Scituate-Poterville | 0 | 1 |
| Scituate-Chopmist Hill | 0 | 1 |
| Smithfield | 0 | 1 |
| South Kingstown | 1 | 1 |
| Tiverton | 0 | 1 |
| Warren | 1 | 0 |
| Warwick | 0 | 0 |
| West Warwick | 0 | 0 |
| Woonsocket | 0 | 0 |
| **Total (60)** | **20** | **12** |

Survey of June 1999

**APPENDIX F**

| Rhode Island State Fire Academy<br>Thermal Imaging Cameras<br>**Part One** Classroom Session **Timeline:** Three hours Page 1 of 11 | Support<br>**Reveal** means multiple points in the slide. |
|---|---|
| Thermal Imaging Cameras<br><br>Attendance:<br>Introduction of students<br>Introduction of presenter(s)<br>Course rules and regulations: exits, breaks, and restrooms. Safety policy.<br><br>**Introduction to the course:**<br><br>Purpose*: To properly and safely train firefighters in thermal imaging technology.*<br><br>Course Schedule<br><br>Day 1 Classroom Session 3 hours.<br>1. Introduction.<br>2. Historical background of thermal imaging.<br>3. Theory / Operations.<br>4. Applications.<br>5. Tactical Considerations.<br><br>Day 2 Practical Session 6-8 hours.<br><br>1. Manufacturers/Vendors Demonstration.<br>2. Basic Hands On Applications.<br>3. Advanced Practical.<br>4. Special Applications.<br>5. Summary. | Overhead projector with Power Point® capabilities<br>20 Chairs/desks<br>Writing Board.<br><br>**Slide 1** Title Slide<br>Handout Safety Guide.<br><br>**Slide 2** Goal.<br><br>**Slide 3** Schedule.<br><br>**Handout (1)** re:<br>Proper P.P.E.<br>SCBA/PASS.<br>Accountability.<br>Evacuations Signal.<br>Site Orientation.<br>Performance Standards.<br>Evaluation Sheets. |
| Estimated completion time:_____ | DRAFT ONLY |

| Rhode Island State Fire Academy<br>Thermal Imaging Cameras<br>**Part One** Classroom Session **Timeline:** Three hours Page 2 of 11 | Support |
|---|---|
| **Module One Introduction to Thermal Imaging.**<br><br>Advantages of thermal imaging. "Ask open ended questions?"<br>**Advantages:**<br><br>1. Allows operator to see through the smoke.<br>2. Dramatically speeds the search and rescue operation, up to 50% per Maine FE&T.<br>3. Increases victim chances of survival.<br>4. Assists in fireground size-up.<br>5. Allows firefighters to locate hidden fires, minimizes associated damage.<br>6. Reduces "anxiety" that challenges firefighters on the fireground.<br>7. Overcomes the blindness of smoke.<br>8. ……..And MORE!<br><br>**" Additional tactical applications and advantages will be taught throughout this class"** | **Slide 1.1**<br>Section Title.<br><br>**Slide 1.2**<br>Advantages<br>(reveal each). |
| **The Rhode Island Statistics**<br><br>1998 18 departments I-service TIC.<br>1999 20 departments (11.1% increase).<br><br>1998 9 departments planning to obtain.<br>1999 12 departments planning to acquire thermal imagers (33,3% increase). | **Slide 1.3**<br>RI Statistics. |
| **Manufacturers / Units on the Market**<br>Distribute handout and identify vendors that will be presenting within this program. | **Handout(2)**<br>Manufactures<br>APR pg.59 Table 2 |
| **Technology Types**<br>Review of handout and reveal slide. | **Slide 1.4**<br>Handheld /vs./<br>Helmet mounted<br>(reveal).<br>**Handout**<br>**Technology Types**<br>APR pg.26 Table 1. |
| Estimated completion time:_____ | DRAFT ONLY |

| Rhode Island State Fire Academy<br>Thermal Imaging Cameras<br>**Part One** Classroom Session **Timeline:** Three hours Page 3 of 11 | Support |
|---|---|
| State: **The RIFA does not recommend one type of technology or one brand over another, the purpose of this training is only to provide safe training for all thermal imaging cameras.**<br><br>One suggested application was presented in *Fire Rescue Magazine*, May 1998.<br>(read the slide)<br><br>**Obstacles**: (per a 1998 EFO Survey)<br>1. Costs - Solution alternative fund raising.<br>Examples: Johnston, Warren, Cumberland, Central Falls,<br><br>2. Grants – Scituate (2 departments), Hopkins Hills<br><br>3. Traditional Budgets.<br><br>**BREAK**<br><br>**Module Two History and Background of Thermal Imaging.**<br><br>Details of below can be obtained through the RIFA thermal Imaging files:<br><br>Ask:<br>How many remember Desert Storm?<br>How many remember the Vietnam War?<br>Do you recall the Falkland War?<br>Does anyone remember the Navy disasters aboard the Forrestal, Enterprise, Roberts, or Stark?<br>Or Has anyone had a fire where finding the fire or victims proved to be challenging?<br><br>Key points /or/ Lessons Learned<br><br>1. The lack of visibility hindered detecting of fire area.<br>2. The lack of training<br>3. Lack of visibility because of smoke<br>Military technology now enters civilian application | **Slide 1.5**<br>Statement.<br><br>**Slide 1.6**<br>Quote.<br>(read)<br><br>**Slide 1.7**<br>Obstacles<br>(reveal)<br>costs, fundraising.<br><br>**Slide 2.1** Title.<br><br>**Slide 2.2**<br>Details regarding each cases<br>(reveal).<br><br>**Slide 2.3**<br>Key points of each<br>(reveal). |
| Estimated completion time:_____ | DRAFT ONLY |

| Rhode Island State Fire Academy<br>Thermal Imaging Cameras<br>**Part One** Classroom Session **Timeline:** Three hours Page 4 of 11 | Support |
|---|---|
| **Ask,** " What does thermal imaging do?"<br>Provides the firefighter with the ability to "see" through smoke | **Slide 2.4**<br>TIC. |
| **Smoke**<br>**Ask,** "What makes up smoke?"<br>"Does light penetrate smoke?"<br><br>Note: See IFSTA , *Essentials of Firefighting 4th edition*. For detailed information<br>*Fire Engineering Magazine*, Woodworth Part1, Part 2<br>**Smoke**:<br>1. Particles<br>2. Carbon<br>3. Heat<br>4. Toxic gases | **Slide 2.5**<br>Smoke<br>(reveal). |
| Influencing factors: air present, material being burned, ventilation, quantity, and temperature.<br><br>Light does not effective penetrate smoke. | **Slide 2.6**<br>Smoke continued<br>(reveal). |
| Ask, " How does smoke effect the firefighter on the fireground"<br>• Hinders visibility.<br>• Slows search and rescue.<br>• Slows handline advancement.<br>• Obscures exits… can cause ff. To be disorientated, and lost.<br>• Hides structural deficiencies. | **Slide 2.7**<br>Question?<br>(reveal) |
| Why thermal imaging?<br>Ability to see… increase popularity…public demand.<br><br>**BREAK** | **Slide 2.8**<br>Why? |
| Estimated completion time:_____ | DRAFT ONLY |

| Rhode Island State Fire Academy<br>Thermal Imaging Cameras<br>**Part One** Classroom Session **Timeline:** Three hours Page 5 of 11 | Support |
|---|---|
| **Module Three Theory and Operation** | **Slide 3.1** Title. |
| Light waves as scattered by smoke, unable to penetrate the smoke | **Slide 3.2 Light.** |
| **Heat**<br>Heat as a form of energy.<br><br>Heat waves, penetrate smoke and travel as an electromagnetic wave.<br><br>Infrared energy blind to the human eye, although we are able to sense/ feel heat. | **Slide 3.3** Heat.<br>(reveal) |
| **Heat Transfer** (reference IFSTA, *Essentials of Firefighting 4th edition*.)<br><br>Review Heat transfer Mechanisms:<br>1. Convection (slide 3.5).<br>2. Conduction (slide 3.6)<br>3. Radiation (slide 3.7) | **Slide 3.4-3.7**<br>Heat transfer.<br>(reveal) |
| **Demo** with a candle and wire, heat wire notice the associated change | **Demonstration** |
| Heat travels from areas of heat to areas of cold, note that objects absorb heat at different rates. Heat flow depends on the material, size, and amount of heat present. | **Slide3.8**<br>Heat flow chart. |
| Thermal Imaging translates heat image into visual image. The difference in temperature is what forms a picture. | **Slide 3.9** TIC. |
| Reference to a black and white TV display. Hot –whit, cold-black, with shades of gray | **Slide 10a** Image. |
| **Caution:** A flashover condition, with the associated increase in temperature caused by the increasing fire condition, will minimize or block this temperature difference. Or if detected and recognized early will be able to predict one before occurring | **Slide 3.10**<br>CAUTION 1. |
| Estimated completion time:_____ | DRAFT ONLY |

| Rhode Island State Fire Academy<br>Thermal Imaging Cameras<br>**Part One** Classroom Session **Timeline:** Three hours Page 6 of 11 | Support |
|---|---|
| State the First Warning<br>**Thermal imaging is not a tool designed to replace good fireground tactics.**<br>Steven Woodworth, Atlanta Georgia, FD / Instructor Safe IR.<br><br>Essential tools included ventilation, SCBA, Crawling, search-lines, buddy system, and safe operating practices. | **Slide 3.11**<br>Warning<br>Not a replacement for the basics. |
| Infrared Energy,<br>**Ask,** "What is It?"<br><br>Blind to the human eye, energy visible or detectable to the TIC.<br>Travels in wave-lengths (refer to the slide).<br><br>**IR SPECTRUM**<br><br>Near infrared energy: .9-1.5 microns too sensitive to detect.<br>Midwave Infrared: 2.5 to 7 microns, sunlight, a limitation for TIC.<br>Long wave: 8-14 microns useful for fire service detection, TIC work within this Range. | **Slide 3.12**<br>IR Spectrum (reveal). |
| **MRTD**<br><br>Minimum Resolved Temperature difference; refers to the sensitivity of the TIC, some units are able to detect as low as .5 degree F. temperature difference<br><br>**Demo:** with a cup of coffee, place on the table, see if an outline forms when the cup was removed.<br><br>Example provided by Woodworth, *Fire Engineering*, August 1996.<br><br>**BREAK** | **Slide 3.13**<br>MRTD.<br><br>**Demonstration.** |
| Estimated completion time:_____ | DRAFT ONLY |

| Rhode Island State Fire Academy<br>Thermal Imaging Cameras<br>**Part One** Classroom Session **Timeline:** Three hours Page 7 of 11 | Support |
|---|---|
| **Operations Part II**<br><br>**Emitters**<br><br>**Purpose:**<br>• To be able to distinguish among the types of emitters and how each will affect the operation of TIC.<br>• Understanding and knowledge of these sources will aid in image interpretation.<br><br>**Types:**<br><br>1. **Active**: little variation in IR energy. e.g. the human body, however, clothing, and wet turnout gear can mask image provided.<br>2. **Passive**: vary greatly in IR emissions. e.g. steel cold /vs./ hot, change will occur when heat is applied. Effecting elements include: renovation, multiple layers, concrete (hard to see) gypsum (good penetration), on imaging capabilities.<br>3. **Direct Source**: great amount of heat. e.g. sun, flame/fire, torch.<br><br>Technology Currently Available<br><br>1. Pyro Electric Vidicon (PEV): effects of white-out (explain this effect) and tube construction.(slide 3.19).<br>2. Focal Plan Array Chip (FPAC): no white-out, costs more.<br><br>**General rule of thumb: never point the TIC at a direct source emitter**.<br><br>**White- out** Defined (reveal Slide)<br><br>**Thermal Contrast**<br><br>An essential concept in TIC, the difference in the temperatures of the objects being viewed. | **Slide 3.14** Emitters. (reveal).<br><br>**Slide 3.15** Emitters. Types (reveal).<br><br>**Slide 3.16** Active.<br><br>**Slide 3.17** Passive.<br><br>**Slide 3.18** Direct.<br><br>**Slide 3.19-3.20** Technology Types. (Reveal)<br><br>**Slide 3.21 a** Rule of Thumb.<br><br>**Slide 3.21** white-out condition.<br><br>**Slide 3.22** Thermal Contrast (reveal). |
| Estimated completion time:_____ | DRAFT ONLY |

| Rhode Island State Fire Academy<br>Thermal Imaging Cameras<br>**Part One** Classroom Session **Timeline:** Three hours Page 8 of 11 | Support |
|---|---|
| **Thermal Contrast** (Continued)<br><br>The difference in absorption creates contrast or an image.<br>• Heat flows form warm areas to cold areas.<br>• Black indicates lack of heat.<br>• White indicates the presence of heat.<br>• The more heat an object has… the hotter the object is. | **Slide 3.22**<br>Thermal Contrast.<br>(reveal) |
| **Thermal Inversion**<br><br>• The effect when images change color due to changes in ambient temperature e.g. when firefighters are viewed outside by a TIC they would appear white However; when they entered the structure the image would invert, now appeared cooler in temperature, in comparison to their surroundings.<br>It also can appear when moving from one room to another (fire room to exposures, changes in temperature). | **Slide 3.23**<br>Thermal Inversion<br>(reveal) |
| **Field of View / Distance**<br><br>The viewing portion of the TIC. Varies with Mfg.<br><br>Distance: how far can the TIC view from (range)<br><br>**Importance: the firefighter must scan the entire room, or risk missing a victim**.<br>***Viewing is like scanning an area with binoculars.***<br><br>**Options to consider** ( Recommended by Woodworth)<br>• Warning icons for high temperatures low-battery, internal temperature.<br>• Spare battery<br>• Video link **( all to be discussed at practical)**<br><br>**BREAK** | **Slide 3.24**<br>Field of View/<br>Distance.<br><br>**Slide 3.25**<br>**Caution**<br><br>**Slide 3.25a** View<br><br>**Slide 3.26**<br>**Options** (reveal). |
| Estimated completion time:_____ | DRAFT ONLY |

| Rhode Island State Fire Academy<br>Thermal Imaging Cameras<br>**Part One** Classroom Session **Timeline:** Three hours Page 9 of 11 | Support |
|---|---|
| **Module Four Applications**<br><br>Thermal imaging just like any tool, similar to our four gas monitors or the C.G.I.<br>• Thermal imaging personnel must train and retrain frequently if the device is to be used properly and safely. To know the ins and outs of the situations exposed to on the fire ground.<br>• Firefighters must be able to interpret "new" images seen.<br>• Some images are self-explanatory.<br>• Other viewed images are not easily recognizable, or identifiable.<br>• Some images change rapidly such as flashover, or even thermal inversion effects.<br>• Ask, "Any others? "<br><br>**Applications**<br><br>Ask members of the class and compare to listing by *Fire Rescue Magazine*, May 1998 reveal local application<br>• Central Falls DEA application.<br>• Hope Jackson search and rescue and hidden fires.<br>• Cumberland electrical fires, hidden fires, overheated motors.<br><br>**Ask / Solicit** from audience<br>Fire Spread, size-up, limited with office structures or masonry retail plazas, however through pre-planning can identify these structures. (too much glass and concrete)<br><br>Useful in wood-frame buildings our residential apartments, condominiums.<br><br>**BREAK**<br><br>Other Applications with Thermal Imagers: beyond search and rescue<br><br>1. Water flow from sprinkler pipes; relate Atlanta's experience<br>2. Size Up Consideration; balloon construction, fire area determination, assessing ventilation and hose-line placement, locating fires in large areas obscured by smoke.<br>3. Locating hot spots. Assist Command in attack, overhaul, additional line placement, and ventilation effectiveness.<br>4. Chemical reactions in drums, truck, and tanks. (Cite Atlanta, Central Falls).<br>5. Structural Integrity: if large volume of heat present with truss construction | **Slide 4.1** Title<br><br>**Slide 4.2** Notes (reveal)<br><br>**Slide 4.3** Applications (reveal)<br><br>**Slide 4.4** Applications.<br><br>**Slide 4.5** Additional usage. (reveal) |
| Estimated completion time:_____ | DRAFT ONLY |

| Rhode Island State Fire Academy<br>Thermal Imaging Cameras<br>**Part One** Classroom Session **Timeline:** Three hours Page 10 of 11 | |
|---|---|
| **Module Five Tactical** | **Slide 5.1** Title. |
| Let us go back to flashover, firefighters using imager will lose vision, due to the lack of thermal contrast.<br>**Solution One** The firefighter should then direct the imager at the ground scanning low, if any contrast exists it will be low. This makes it poss. To ID exits or the vital hoselines.<br>**Solution Two** The operator should continuously scan the ceiling for heat build up. In addition, t operator should ID a place on the wall as a reference point; possible above a door or window to monitor how the heat is banking down. | **Slide 5.2**<br>Tactics Flashover (reveal)<br>Solution 1<br>Solution 2 |
| **Note** Thermal imagers are very reliable today. However, they are mechanical devices that can be subject to fail. Technology has challenged us today but also can help use with thermal cameras if we just use the basics. | **Slide 5.3** Warning. |
| Let us remember the basics. Always carry a flashlight, maintain contact with your buddy,<br><br>Maintain contact with a wall, follow left or right, use a rope or handline and use communication with your team and command. | **Slide 5.4** Basics. (reveal) |
| **Search Techniques**<br>Woodworth, Maine FT&E and Connecticut recommend this method | **Slide 5.5**<br>TIC Techniques. |
| First locate the fire: one person can scan the area ID the fire or spread.<br>Enter the area use a six sided approach, Scan Left-right at floor level for victims, looking for structural integrity, and fire conditions, half way up left-right, then top left-right. | **Slide 5.6**<br>Scanning techniques.<br>Handout (4) Techniques |
| **Warning: 1** Looking into glass, water, concrete, and mirrors will distort the image… remember the basics | |
| **Warning: 2 I**magers cannot see under beds, in closets under blankets or under heavy wet blankets…. Remember the basics. | **Slide 5.7** Warning.<br>Reveal 1 and 2 |
| **BREAK** | |
| Estimated completion time:_____ | DRAFT ONLY |

| Rhode Island State Fire Academy<br>Thermal Imaging Cameras<br>**Part One** Classroom Session **Timeline:** Three hours Page 11 of 11 | |
|---|---|
| **Key Points of Operation**: Steps to Prevent failure<br>1. Change SCBA Bottle change battery<br>2. Assume a 20 operational time period for use<br>3. Carry a towel to wipe imager screen<br>4. Scan the entire room remember the vision limitation<br>5. DO THE BASICS | **Slide 5.7**<br>Key Points.<br>(reveal). |
| **Operator Should**: Steps to Prevent Failure<br>1. Keep track of crewmembers and numbers, if conditions deteriorate, operator can lead to safety.<br>2. Placing a flash light or scene light near exit will generate heat, identifying the exit.<br>3. Communicate with your team they cannot see what you can.<br>4. Provide directions and clear instructions to teammates.<br>5. If fire does not cause a change in image viewed, water is not cooling the fire.<br>6. Use an "anchorman", prevents team from moving too quickly into the structure, and allows imager member time to interpret the vision. He slows the team down for safety.<br>7. Anchor man looks for signs of flashover, evaluates fire conditions | **Slide 5.8**<br>Operator Responsibilities.<br>(reveal)<br><br>**Slide 5.9** Anchor Man.(reveal) |
| **Team:**<br>1. Use a tool to probe ahead as the basics remind us.<br>2. Training continually is a must | **Slide 5.10**<br>Team. |
| **State** "Quote the Slide"<br><br>**Questions**<br><br>Introduction and review practical session<br><br>**END Classroom** | **Slide 5.11**<br>Joe Montana.<br>F.E. Cogan<br><br>**Slide XX**<br>END. |
| Session One END Classroom Total Time _____ | |

# PRACTICAL SESSION

| Rhode Island State Fire Academy<br>Thermal Imaging Cameras<br>**Part Two** PRACTICAL SESSION **Timeline:** 6-8 hours Page 1 of 1 | 1 handheld with video link, tv, vcr. Check for props in guide |
|---|---|
| Attendance and Safety Check of all participates.<br><br>Review of Safety, Emergency Evacuation, and accountability policy.<br>**Break into groups: 1 instructor to 5 students into groups**<br><br>**Session 1 Manufactures / Vendors**<br><br>Allow equal time for each manufacturer to discuss their product and methods.<br>No more than 10 students in a session.<br><br>**Session 2 Basic Suppression Skills** **Small fires single areas.**<br><br>**General Order of Operation.**<br>One Burn Master with Safety Officer<br>1 Entry team<br>1 Back up team<br><br>**Session 3 Advanced Level Fires** **Multiple level, stack fires, Water flow, Victim Recovery**<br><br>**Session 4 Special Applications**<br><br>HtH® in Drum chemical reaction, Wet Firefighter, Glass demonstration Nitrogen Gas leaking.<br><br>**Final Critique**<br>Conclusion :<br>1. Thermal imaging allows for exterior size up, which promotes improved utilization of existing and limited resources.<br>2. A wide-range of tactical applications have been provided.<br>3. Remember it is only a tool. Practice to make perfect.<br>4. Maine reports firefighters had a 28% faster victim recovery time, Atlanta reports a 50% reduction in search<br>**Thanks to Bob Athanas, Safe IR ; U.S. Navy Office of Safety and Survival, Maine Fire Training and Education, and Conn. Fire Academy for their assistance.** | TIME<br><br>3 hours.<br><br>View participates with Handheld unit, record using a video link for review<br><br>**Demonstration**<br>Using electric heater in burn building.<br><br>Follow:<br>Live Burn policy<br>Session 2-4<br><br>**Slide P1**<br>Conclusion<br>(reveal).<br><br>**Slide P2 Thanks Slide.** |

Practical Session Time Line: xx

_____

**Rhode Island State Fire Academy**

Thermal Imaging Proficiency Sheet

Self- Assessment:

Answer the flowing questions:

1. What steps should a firefighter take before entering a structure with a thermal imager?
2. What objects can and cannot be viewed by the thermal imager?
3. What objects block an imager?
4. What steps should be taken to prevent failure?
5. What tool(s) should the firefighter have their possession?
6. What additional applications can thermal imagers be deployed at successfully ?
7. What does it mean when thermal inversion is no longer present?

**If you cannot answer any of questions**

Call the RI Fire Academy to set up a safety program for thermal imaging cameras

# NOW

**YOUR FIREFIGHTERS SAFETY MAY DEPEND ON THIS TRAINING**

# REFERENCES

Cairns IRIS Product Specification (1998). Helmet mounted thermal imaging system (3rd rev.). [Brochure]. Clifton, NJ: Author.

Can you see through the smoke? Part 1. (1998, April). Fire Rescue Magazine,16, pp.38-45. Author.

Carnegis, J.N. (1998). Thermal imaging evaluation for the fire service. (NFA research paper 29223). Emmitsburg, MD; National Fire Academy.

Cogan, M.R. (1992, February). Thermal imaging cameras. Firehouse, 17, p. 38.

Donzier, K.(1999, July). Thermal Imaging Technology: What's right for your department. Fire Engineering,152, pp. 95-97

Dunbar, M.O.(1998, September). Thermal Imaging Newsletter, pp 5-7. Bangor ME: Maine Fire Training and Education.

Federal Emergency Management Agency. (1990). *America Burning Revisited* (USFA Publication No. 1990-724-156/20430, p.63 ) Washington, DC: U.S. Government Printing Office.

Firefighter Training and Education. (1985). Recommendation of the fire education and training task force prepared for the governor and the general assembly. Grant EME-G-0017. Providence, Rhode Island :Author

Gallagher, J. (1991). Seeing in the dark. WYNF, 52, pp.22-23.

Hart,T.S.(1998) Standard operating guideline for combating single family dwelling fires. (NFA Research paper 28659 pp.13-16). Emmitsburg, MD: National Fire Academy.

Image is everything: Part 2. (1998, May). Fire Rescue Magazine, 16, pp.68-79. Author.

Lyons,J., & Parmenter, G. ( 1995, September). Thermal imaging: a changing approach. Fire Engineers Journal,55, p. 7-8.

McLaughlin, J. (1992, February). Thermal cameras Q&A. Firehouse, 50, p.37.

National Commission on Fire Prevention and Control. (1973). *America Burning* (Publication No.1973-0-495-792). Washington, DC: U.S. Government Printing Office.

Naval Education Training Center (NETC). (1999) Damage Control Division. (Web page URL www.cnet.navy.mil/newport/dcd/index.htm. (unpublished).

Newman, J. M. & Irving G.F. (1973). Modern technology in the fire service. Berkeley, CA: Institute for Local Self Government.

Norman, J. (1991) Fire Officer's Handbook of Tactics, Fire Engineering, NJ: PennWell Publishing. p. 367.

Nygren, A.S. (1997). Thermal Imaging for the fire service. Bangor ME: Maine Fire Training and Education.

Patterson, T.F. (1997). An examination of the use of thermal imaging cameras in the fire and rescue services. (NFA Research paper 27654, pp.10-22). Emmitsburg, MD: National Fire Academy.

Render, G. (1997, March). Thermal imaging cameras. Hot Flashes, 5, p.1.

Rhode Island Department of Economic Development. (1995). North Providence. Providence, Rhode Island: Author.

Rhode Island State Fire Marshal's Division of Fire safety Report. (1998). Annual report. North Kingstown, Rhode Island: Author.

Siuru, W. (1996, March). Piercing the smoke. Emergency, pp.61-65

Stevens, L.H. (1991, November). Thermal imaging cameras offer improved visibility at emergency scenes. Fire Chief, 10, p.74.

Stevens, L.H. (1996,October/November). A question of vision. Firefighters News, 30, p.6.

Stevens, L.H. (1998, May). Image is everything Part 2. Fire-Rescue Magazine, pp-68-79

Stevens, L.H. (1999, February). See your way clear. Fire-Rescue Magazine, p.8.

U.S. Fire Administration (USFA). (1999). State Outreach Program 2000. [Brochure} Emmitsburg, Maryland: Author

Wagner, M.J. and West, P.C. (1998, February/March). Technology from the war zone, thermal imaging, saving lives in the hot zone. National Fire and Rescue, 22, pp.32-38.

Woodworth, S.P. (1995, June). Field test report: infrared imaging for the fire service. Firehouse,20, pp. 81-82.

Woodworth, S.P. (1996, July). Thermal imaging for the fire service, Part 1: The basics of thermal imaging. Fire Engineering, 149, pp.22-26.

Woodworth, S.P. (1996, August). Thermal imaging for the fire service, Part 2: The electromagnetic spectrum. Fire Engineering, 149, pp. 24-26.

Woodworth, S.P. (1996, November). Thermal imaging for the fire service, Part 3: Thermal characteristics. Fire Engineering, 149, pp. 22-26.

Woodworth, S.P. (1997, February). Thermal imaging for the fire service, Part 4: Thermal imaging devices. Fire Engineering, 150, pp. 16-18.

Woodworth, S.P. (1997, March). Thermal imaging for the fire service, Part 5: Tactics for fire attack. Fire Engineering, 150, pp. 16-21.

Woodworth, S.P. (1997, August). Thermal Imaging for the fire service, Part 6:The search. Fire Engineering ,150, pp.24-27.