MAXIMISING
THERMAL IMAGING
USE IN THE
EMERGENCY SERVICES

This research is dedicated to my father Graham, to his memory, and to the memory of his twin sister Merle
who was a victim of a house fire, and to the firefighters who have made the ultimate sacrifice in the line of duty.

1. This report is intended for responders, instructors and members of emergency services organisations in Victoria, Australia. It is also intended as a resource for the Emergency Services Foundation, Victoria, who sponsored the research included within this report.

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2.01 Abbreviations

TIC	Thermal Imaging Camera (s)
TI	Thermal Imaging
MFB	Metropolitan Fire Brigade, Melbourne
CFA	Country Fire Authority, Victoria
ESF	Emergency Services Foundation
LAFD	Los Angeles City Fire Department, California
LACoFD	Los Angeles County Fire Department, California
FDNY	Fire Department New York City, New York
CFD	Chicago Fire Department, Illinois
BCoFD	Baltimore County Fire Department, Maryland
MFRI	Maryland Fire Rescue Institute, Maryland
FairfaxCoFD	Fairfax County Fire & Rescue Department, Virginia
NIOSH	National Institute for Occupational Safety and Health (USA)
LODD	Line of Duty Deaths
NIST	National Institute of Standards and Technology (USA)
NFPA	National Fire Protection Association (USA)
Engine	Front line pumping appliance
Truck	Front line appliance with a large hydraulic ladder, sometimes articulated.
SES	State Emergency Service
SME	Subject Matter Expert
RAAF	Royal Australian Air Force
SOP	Standard Operating Procedures
SOG	Standard Operating Guidelines
SCBA	Self Contained Breathing Apparatus

3.0 Executive Summary

Thermal Imaging Camera usage in the emergency services has enormous potential if utilised effectively. With some facets of emergency response, such as the police air wing, its use is second nature. Even as we view the evening news, we have become accustomed to watching vision from thermal imagers as this aircraft scans a scene. Yet in many other areas within the emergency services, responders are unable to access this available technology to perform vital lifesaving and life protecting tasks.

The reasons responsible for this delay to accept this technology's potential is often due to cost, but underlying this is the lack of understanding of how a thermal imager can be utilised effectively and the productivity and safety benefits it can return. This report will compare the utilisation of thermal imaging in major US fire departments with that of Victorian fire services. It is based on the 2009 ESF scholarship tour undertaken by the MFB's Leading Firefighter Mick Whitty. This report and research, sponsored by the Emergency Services Foundation of Victoria, will look at the technology of thermal imaging cameras, the applications, specifications and standards developed for fire service usage. It will also discuss selection criteria for emergency services when they are working to maximise their buying potential. Finally, it will discuss the method of introduction or change required for emergency services and the training and skills required to be competent as an operator of a thermal imager.

The conclusion of this research identified that both the CFA and MFB have some modifications to make in order to achieve best practice deployment and training. (Although, it must be noted that the CFA is significantly closer to this best practice model than the MFB). It is hoped this report is utilised as an impetus for both these organisations and others in Australia as evidence to push for improved TIC utilisation and ultimately improved firefighter safety and community protection.

This report will make recommendations to various emergency services, with particular emphasis on the fire services. Among some of the key recommendations are:

- All urban primary fire appliances should have at least one thermal imaging camera (TIC) with competent operators.
- Firefighting TIC training must have a hot fire component.
- Standard Operating Procedures (SOP) need to be modified to reflect TIC best practice utilisation.
- National Fire Protection Authority (NFPA) standard 1801 on TIC should be adopted as a selection criterion in future firefighting TIC purchases.
- Specific features on TICs should be evaluated when considering the primary deployment of the camera – firefighting, overhaul, USAR, open area search, etc.

This research will show extensive proof exists that TIC usage by firefighters is a lifesaving technology. It has significant benefits to the occupational health and safety of responders and as such should be prioritised by fire service boards for implementation. It is without doubt a technology that will protect the most valuable asset a fire service has...its firefighters.

4.0 Introduction

As an operational firefighter with the MFB I work directly with structure fires and see their physical and emotional impact on families and the community. Personally, this impact has touched my own family with the death of my aunt in a house fire. This perspective has given rise to my personal focus on my organisation's legal obligation "to protect life and property"[1]. This focus has led me to evaluate the MFB's use of TICs and how maximising this technology could lead to improved responder safety and community safety.

The Heavy Rescue units (5) are where the MFB deploy their TICs for use at structure fires. This model of deployment does indeed ensure a TIC is available for all fires of second alarm[2] and above. However, this model fails to deploy a TIC in time to be of benefit for fire attack or primary internal search. It was in this realisation that I undertook a literature review and following this an ESF scholarship to the USA to see how TICs could be better utilised by our organisation and ultimately the Victorian emergency service community.

This report will identify how TICs are used in some major fire departments in the USA and how TIC applications, training and experiences can enhance the service delivery to the community and the safety of responders.

The scope of this report will be

- To identify areas for improvement in TIC applications for emergency services in Victoria.
- To suggest training methods to best understand TIC in emergency situations.
- To look at TIC technology advancements and the relevant implications to emergency services.
- To make recommendations to emergency services as to how they can maximise safety and service delivery to the community through TIC.

5.0 Methodology

An initial literature review was conducted into the use of thermal imaging in the emergency services globally, in particular fire services. This information was compared with the models of thermal imaging deployment in Victoria to identify if a service delivery gap existed.

It was quickly established that the model of thermal imaging deployment established by the MFB presented the largest gap in service delivery. The CFA had already embarked on a model of TIC usage that endeavoured to have a TIC on scene early in a fire's development in areas of high structural fire rates. The CFA had very few options for their deployment model, as unlike the MFB, they share the role of managing Rescue units with the SES, who are not trained for fireground operations, and could therefore not be responsible for attending with a TIC.

The method of investigating models of deployment was to visit major fire departments in the USA whose reputation for firefighting and thermal imaging came recommended from various sources. This visit would also investigate TIC usage in mutual aid between services, in urban search and rescue (USAR) and surveillance. This visit would enable comparisons of methods of usage, procurement, training and introduction of TIC into these services to compare with Victoria's emergency services and also to see how these departments might do things differently given their experiences with TIC introduction.

[1] MFESB Act Victoria 1965
[2] MFB GARS

6.0 Findings in literature

A review of literature surrounding TIC uses in emergency services, particularly firefighting, was sourced from several key areas.

- NIOSH reports into near misses, injuries and fatalities from firefighting and their recommendations.
- Magazine and Journal reviews, particularly Fire Rescue Magazine, Firehouse magazine and Advanced Rescue Technology magazine.
- LODD reports.
- Incident reports and commendation citations from various fire departments.

This literature review quickly pointed out the procedural and technological changes this technology has created in emergency services over the past decade. A TIC's ability to deliver better information more consistently to responders, the rapid fall in the cost of the technology and the rapid rise in its uptake into service by a significant number of major fire services are most obvious from this review. Captain Crickenberger[3], Charlottesville Fire Department commented "a combination of lower prices, more competition, better performing equipment, higher visibility, better education…are driving the thermal imaging market into high gear".

The review also indicated that the best utilisation of TIC is to deploy them on every front line appliance. "The earlier a thermal imager arrives at an incident, the more valuable it is…"[4] in assisting a trapped victim, firefighter safety or reducing fire spread.

An investigation into LODD of firefighters in the USA is a sobering task, which illuminates the risks inherently involved in the firefighting profession. The reports highlighted below demonstrated that firefighters had lost their lives due to risk factors that may have been reduced or eliminated had a TIC been deployed earlier or training in TIC been more thorough. The following are some examples of reports that include recommendations for use of Thermal Imaging Cameras.

LODD NIOSH 1999-47: Six firefighters died when they became lost in a large cold storage building fire in Worcester. It was recommended that TIC be used to locate lost or downed firefighters and civilians.

LODD NIOSH 2007-18: Nine firefighters become disorientated and die in a rapidly progressing fire in a furniture showroom – Charleston, South Carolina. Another nine firefighters barely escaped suffering serious injury. Among many recommendations was for the use of TIC for size-up and the search for unaccounted firefighters.

LODD NIOSH F2004-10: Firefighter dies after becoming lost and entangled in a restaurant fire. The report recommended the correct training of firefighters so as not to become too reliant on TIC, to know TIC limitations, their positioning with a crew inside a structure and their need to be available for a rapid intervention search to locate a downed firefighter.

Lieutenant Jeff Parker[5] pointed out in a recent article for Fire Engineering that not having a TIC at a structure fire was the 6th ranked risk factor in firefighter fatalities. NIOSH reports had identified that they had failed to be deployed in 38% of fatalities. Lieutenant Parker also pointed out that more than one TIC was required to be used to due the simultaneous needs on the fire ground of size-up, rescue and attack. He noted the need to move toward a TIC for each firefighter and lamented that "it is sad in today's world to see firefighters still getting lost in smoke…When considered what we primarily deal with – total darkness and heat – the TIC should be a required tool for every firefighter."

[3] Firehouse October 2000, Thermal Imaging Cameras: Training and Awareness
[4] Firehouse May 2004, Thermal Imaging: Deployment
[5] Parker, J. Fire Engineering, April 2010, Staffing and Tactics for firefighter survival, p173-192

The literature review also uncovered some research into quantifying the effectiveness of TIC use in searching for victims in a structure fire. The results indicate up to 75% reduction in time to locate a victim (civilian or downed firefighter) in a structure fire. The following summarizes some of this research.

- In February 1999 issue of Fire-Rescue Magazine, the editor cited a nationwide study of the effectiveness of thermal imagers, carried out in 60 test burns around the country.
- Without a thermal imager: 1) 60 percent of the time, firefighters were unable to locate the victim …With a thermal imager, 1) 99 percent of the time, firefighters were able to locate the victim, and 2) 100 percent of the time, firefighters found their way out of the burning house. The time required to satisfactorily complete a search with a thermal imager dropped by 75 percent.
- The August/September 2001 issue of Advanced Rescue Technology included an article about a thermal imaging study conducted by the Johnson City Fire Bureau, Tennessee. Their research found that a victim search without a thermal imager took eight minutes, 38 seconds. With a thermal imager, the same victim search took three minutes, 30 seconds. Use of the thermal imager resulted in an increase of nearly 60 percent in search efficiency.
- Chicago Fire Department Demonstration [6]
  During a news conference on May 27, 2003, at the Chicago Fire Academy, firefighters conducted a technical demonstration that illustrated the time rescuers save when they're using thermal imagers. Without a thermal imager, firefighters spent 4 ½ minutes looking for a downed firefighter, this was reduced to 2 minutes 15 seconds with a thermal imager.
- Burton, South Carolina
  Nine companies of firefighters in Burton, South Carolina conducted two sets of studies – one on the time required to find a fire and one on the time required to find a victim. Each drill was done with and without a thermal imager. Results: Without a thermal imager, the average time for all nine companies to find the room of fire involvement was four minutes, 48 seconds. With a thermal imager, the average time for all nine companies to find the fire was two minutes, 23 seconds (half the time). In the second set of tests, it took firefighters an average of six minutes, 46 seconds to find a victim without a thermal imager, and two minutes, 17 seconds to find a victim with the aid of the device (a 67% increase in effectiveness).

Real world evidence also exists to illustrate how lives have been saved from using TIC in structure fires. Citations for bravery in the line of duty such as Captain Marsilla, FDNY Ladder 134, who on the 2nd February, 2007, at 2347hrs used his TIC to locate a semi-conscious victim deep inside a 6th floor apartment and assist him to safety.

Lieutenant Allen, FDNY Ladder 13, on the 1st April 2007 at 0407hrs was in command of the forcible entry crew searching for a victim in a third floor apartment, but were being driven back by a developing fire. Before exiting to wait for the hose crew, he deployed his TIC and identified an unconscious victim on the floor. With protection from a 9-litre water extinguisher he was able to crawl to the victim and drag him to safety.

Franklin, Indiana firefighters Coble and Hash on the 9th October 1999, located a two-year-old victim unconscious and barely breathing in a house fire. "If we hadn't had the camera, Zachary's chances of surviving would have been slim," said Captain Mike Herron, Director of EMS for the Franklin Fire Department.

[6] http:www.bullard.com\thermal imagers

Cases are reported regularly of saves such as these now that TICs are becoming more widely available. London Fire Brigade instructor Paul Grimwood[7] perhaps best sums up thermal imaging in the fire service when he comments "in the not too distant future, fighting a fire without thermal imaging will be as unthinkable as firefighting without SCBA".

7.0 Discussion

7.1 **Organisations visited**:

The international component of this research culminated in visiting various fire departments and a Fire and Emergency Expo during July and August 2009. The aim of this personal visit was to meet with the key firefighters behind the introduction, development and training in TIC for their various departments. The mechanisms they employed to successfully bring change to their departments and the testing and procurement procedures they used to select the models their departments purchased were also investigated.

Los Angeles City Fire Department (LAFD) contact: Battalion Commander Christopher Logan. Shift stay with LAFD Station 2, Boyle Heights, East LA., CA

Los Angeles County Fire Department (LACoFD) contact: Captain Bob Lee. Shift stay with LACoFD Station 103 USAR /Specialist Rescue, Pico Rivera, CA.

Maryland Fire Rescue Institute (MFRI) contact: Associate Director Pat Marlatt. Maryland Fire and Rescue Institute, College Park, Maryland. MD

Fairfax County Fire Department (FairfaxCoFD) contact: Captain Scott Krause. Visit with Station 409 Mount Vernon, FairfaxCoFD, VA

Baltimore County Fire Department (BaltimoreCoFD) contact: Battalion Chief Jonathon Hart. Shift stay with Baltimore CoFD (Station 15) & Station 18 Randallstown MD

Fire Department New York (FDNY) contact: Firefighter Bob Athanas. Visit with FDNY Rescue 3 Bronx / Harlem, NY

Fire Department New York (FDNY) contact: Lieutenant La Rocca. FDNY Training Academy, Randall's Island, NY.

The study tour also included participating in Firehouse Expo 2009, Baltimore MD. Firehouse Expo is a large firefighting and EMS specific expo that consists of trade displays, practical classes and formal lectures. This section of the study tour enabled me to contact many of the manufacturers of TICs personally and also gave me the opportunity to meet with Battalion Chief Van Dorpe (Chicago FD) and a wide variety of firefighters from smaller fire departments (including volunteers) and discuss with them how they have integrated TIC into their organisations.

7.2 **Mechanisms of Change Required**:

The introduction of TIC to fire departments in the USA required firefighters and incident controllers to add to their skills of firefighting the understanding of how to use another piece of technology. In an industry where fire service tradition and mentoring by senior members is the expected practice the introduction of new technology can sometimes be met with resistance. However, TIC introduction in many departments was seen differently. Instead of the attitude of "now we have another piece of equipment to carry with us!" firefighters saw this new tool as something that was going to make their job safer and in terms of fire location and attack, easier. The flow on for the department was the improvement in service delivery to their communities.

[7] 3D Firefighting Grimwood et al Oklahoma State University p150

Firehouse honour boards in the US were an ever-present reminder to all that this profession is inherently dangerous and safety advances were important. Baltimore County FD has a reputation for the firefighters driving safety related change from the ground up to management. TIC was an example of such a safety drive along with speech amplifiers on SCBA face masks and new bunker boots. When technology is campaigned for by firefighters the acceptance is immediate and change occurs genuinely.

Battalion Commander Logan drove the introduction of TIC into the LAFD. Once again he pointed to the safety improvements for firefighters as to where the credibility for the introduction of the change rested. LAFD has experienced the loss of fifty nine firefighters in the line of duty and as such LAFD firefighters need little reminding of the importance of safety on the fireground. Chief Logan commented that a few firefighters still questioned "what's wrong with fighting fires the old way?" His reply would be "You can be outdated and stupid and fight fires the old way or you can be smart and safe (and keep those around you safe)…You can hand the flag over to a dead firefighter's daughter, look her in the eye and tell her that her dad is dead because you were lazy and stupid (for leaving the TIC in the truck)." LAFD quickly introduced TIC onto all engines and trucks as both management and firefighters recognised the value of TIC for firefighting safety and fire attack for the first due appliances.

The key message that came through continually as to how to manage the change surrounding TIC introduction and usage in the fire service was to introduce it primarily as a safety device for firefighters (accountability and fire behaviour monitoring). The need is then to educate and train staff to be aware that search techniques are just as important and unchanged either with or without a TIC and to be aware of its many applications. Finally, to locate it appropriately on the vehicle (safely in the cabin) so as firefighters move out of the fire appliance with the TIC as well as other basic equipment (SCBA, flare, personal radio & complete PPE).

The challenge this presents to a fire brigade such as the MFB in Melbourne is that despite severe injuries and several close calls in recent years, firefighters have not experienced a line of duty death operationally for about 40 years. This may have created an air of complacency or worse a confidence that "it will never happen to us… we're different". This attitude shared by senior operational staff and firefighters could make them think that even technology that is for their safety is less valuable than a traditional approach. Has our traditional approach served us well or have we simply been "dodging bullets"? Recent events would suggest the latter and the need to be educated as to how and why firefighting accidents occurred elsewhere is vital to dispelling this complacency.

The key in this sense is for management to embrace change that is driven from the ground up like in the case at BaltimoreCoFD. Continual education of firefighters of the risks associated with firefighting and how they have increased (higher fuel loads in structures, use of composite timbers and framing techniques, the effects of wind on structure fires, decreased time to flashover, hoarding, drug labs and smoke explosions, to name a few) will encourage firefighters to become conscious of the need to develop and create new strategies. Chief Logan LAFD commented that the MFB's safety record was commendable, "You've had a good time without a fatality…do you want to let it (LODD) happen because you've fallen behind (TIC deployment model)."

7.3 **Overseas Approach versus local fire services**.

	LAFD	LACoFD	FairfaxCo	BaltimoreCo	FDNY	MFB	CFA	NSWFB
Deployment	All primaries, aerials and specialist rescue	All primaries, aerials and specialist rescue	All primaries, aerials and specialist rescue	All primaries, aerials and specialist rescue	All primaries, aerials and specialist rescue	Heavy Rescue only for fire	Some selected primaries	Some selected primaries
Location	In cabin	In cabin	In cabin	In cabin	In cabin	Locker space in compartments	In cabin	In cabin
Training hours TIC instructors	2 days	2 days	2 days	2 days	5 days	Rescue training plus practical experience	2 days	
Training hours firefighters in TIC	½ day	½ day	2 days	1 day	2 days	Rescue operators only approx 1 hour	2 days	1 day
Who carries TIC	Officer	Officer	Firefighter	Firefighter	Officer	Firefighter	Firefighter	Firefighter
Type	Handheld	Handheld	Handheld	Handheld	Handheld	Handheld	Handheld	Handheld

Table 1: Comparison of international and local TIC approaches

The deployment model used by all the major fire services I visited in the USA is consistent on three fronts.

Firstly, they all realised that the tasks performed by a TIC are so varied and often occurred simultaneously, that you can't pick and choose which appliance you put them on. The roles of size-up, interior search, fire attack and command and accountability of firefighters happened concurrently, and one or two TIC could not manage to be everywhere they were needed.

All had started by putting them onto truck companies (for search) and then realised that the engine companies needed TIC for their roles.

Secondly, the positioning of the TIC in the cabin of the appliance was the key to have firefighters take it with them as part of their PPE package. With many departments the introduction of a new tool needed firefighters to consciously think about including it in their operations. By having the TIC in-cabin firefighters could include it in their "dressing for a fire" routine.

Thirdly, an important difference to note with the international approach compared to the local approach is the role of officers when working at a structure fire. In almost all cases the officer (USA) remains responsible for his crew; if they are working on an internal attack, the officer is also with his / her crew supervising and commanding this internal attack. Therefore the TIC in the hands of an officer in the departments I visited will still see it being used for fire attack, search and safe monitoring of the crew.

Locally, it is still rare for the officer in charge of the appliance in both the MFB and CFA to participate in the internal fire attack or search. Crewing numbers of three or four on a primary, first-due appliance (including the officer) means the officer in charge is required to "run" the incident, while their crew commence the attack. Even as more crews arrive the SOPs of these organisations have various incident control tasks (e.g. safety officer, sector control, staging, etc) that need to be taken on which prevent these officers from staying and working with their crews. The implications of safe crewing numbers, safe monitoring of

internal crews, number of appliances responded at each alarm level and the procedural importance of each role in incident command and the priority in which they are undertaken is something for these organisations to consider. However, serious consideration needs to be given to internal sector control as a priority leadership role.

7.4 Applications, Specifications and Standards

7.4.01 Handheld versus helmet mounted

Helmet mounted cameras have a huge potential in the fire service, particularly when integrated with either helmet manufacturers or self contained breathing apparatus (SCBA) face masks. The ability to view a thermal image and still have both hands free for working a handline or other tool is definitely a benefit. Currently three manufacturers of SCBA are also TIC manufacturers and therefore the potential for integrating the two technologies to create a heads-up display with a TIC image is possible. This will be a development that will be a feature of future internal firefighting protective equipment for each firefighter. No fire department that I visited in the USA had chosen to take up helmet mounted TIC as opposed to handheld. The move to helmet mounted will be far more suitable when a TIC is available for each firefighter, however a handheld TIC must still be the first step in firefighting TIC deployment.

Handheld TIC, as the initial TIC, is currently a far more suitable choice for fire departments for several key reasons:

- Most departments can only afford one camera per front line appliance
- They offer the flexibility of being used by different crew members
- They can be used in a way that more than one firefighter can see the image (i.e. a crew leader can show other firefighters the scene before they move into the room).
- They offer the ability to use features such as zoom, thermal colour control and temperature measurement while the TIC is in action and still view the controls
- They can be utilised in emergencies where use of SCBA and/or helmet is less relevant (i.e. overhaul, missing person search, open area casualty location...)
- They allow better options for truck mounted stowage, battery charging and battery maintenance.
- They can be put in places that you may not want your head / helmet to go
- They are not an extra weight to be balanced on structural helmets.
- They don’t create blind spots in a fire or search scene
- They can be left behind when entering a hazardous environment where intrinsic safety is important, but the helmet is still vital.

An important way to consider the potential of TIC is to examine how fire departments expect their firefighters to move when they are in the dark. It has long been the norm for fire departments to provide good quality lighting at an incident; a flare (torches) has been available for each firefighter to safely move through the dark for quite some time. In the same way lighting has become a safety norm, TIC technology will continue to develop and they too will become affordable for deployment with each firefighter so that they can safely move through thick smoke and simultaneously monitor the progress of each of member of their crew. It will be when fire departments are at this stage of deployment that helmet-mounted TIC will be of greater service.

7.4.02 **“Horses for Courses”**

Purchasing a TIC must be done with its potential applications in mind. No-one model will be the best camera for every application; however some applications require more specific features.

USAR: require a camera that is more sensitive to smaller temperature differentiations in a range from around 0-50°C. The camera needs to be very small and potentially able to be deployed on a remote pole. The specified TIC on the USA FEMA cache is unique in that it combines a low light camera with a TIC in a very small package.

Fire Attack and Fire Victim Search: requires a camera that has a low sensitivity mode that extends into very high temperatures, some models can operate successfully detecting temperatures around 1000°C. These cameras require outer casings capable of withstanding direct fire contact and simple controls that can be operated with bulky structural gloves. Colourisation is a feature that can be valuable as long as the operator understands what it is showing. For fire attack, colourisation is best to appear when the temperature is significant enough to represent fire or an ignition threat. The fire attack / fire victim search TIC needs to be very sturdy, capable of withstanding knocks and drops as well as regular doses of ash and water. The USA NFPA 1801 standard for TIC will ensure that approved TICs will have already satisfied the fire service readiness tests.

HAZMAT, Missing Person and Victim Search: requires a camera with a high definition screen and 4-x zoom. These cameras, if predominantly used in this manner, need to be sensitive to smaller temperature differentiations (low contrast) where the need to identify a person or chemical from a variety of similar temperature objects will be vital to their success. HAZMAT technicians need to ensure they use the TIC in a safe zone, hence the value of high definition screen and zoom. If used for surveillance these cameras require a colour palette that has a low back lighting feature so as not to illuminate the responder who is using the camera.

Overhaul and Wildfire: requires a camera similar to fire attack, but it is not necessary to be equipped to identify very high levels of temperature as with both of these the TIC is often deployed after the main front has passed or the structure is mostly extinguished. It is important that these cameras have a colour palette feature that allows the operator to continually identify the hottest item in the field of vision above ambient temperature. A feature like this is vital to assist the responder to identify hot spots precisely, which can be individually investigated and extinguished.

Wildfire Mapping: requires a TIC that is part of an aerial surveillance vehicle. The Police Air Wing are the experts in the use of forward-looking infra-red and systems of transmitting these images to a control centre. This requires incident control centre staff capable of interpreting this image. Air observers currently working with the State Aircraft Unit relay the observations of infra-red images and visual observations to control centres. With only 3 TI units state wide, deploying RAAF aircraft is required on days when several fire fronts need mapping. Video streaming mapping, m-View, trialled by Victoria's CFA and DSE is also designed to transmit fire fronts and is adaptable to infrared.

7.04.03 **Colourisation**

A common feature on TICs is the colourisation of the thermal scene on the TIC screen. This colourisation is designed to illuminate and differentiate temperature differences so as to aid responders in identifying specific features they are viewing. The relationship between colour and temperature is something that varies significantly between models and manufacturers and firefighters need to be particularly aware of this when changing TICs. The key is to identify how you want to apply this colour screen to the main function of the camera and whether you will allow operators to be able to change the palette.

Firefighting: front line primary appliances – use a colour palette that only introduces colour when the scene is actually hot. Introducing colourisation when the fire scene is at ignition temperature or already on fire will ensure firefighters don't drench a room every time a colour appears on the TIC. Disabling the "black – hot / white – cold" palette (the opposite to a standard TIC screen heat display) will prevent accidental activation of this colourisation and the confusion and risk associated with misinterpretting the screen.

Search and Rescue / Hazmat / Overhaul: In these roles primarily a TIC must have excellent low contrast scene qualities. Use a colour palette that helps identify the hottest or coldest

items in the scene. These items can then be assessed individually as part of overhauling a fire scene or searching for missing persons or hazardous material spread.

7.04.04 Video, Picture and Transmitting

Most TICs feature the ability to capture images and video during their operation. The video feature is usually an optional extra and ranges from no visual difference to the TIC exterior dimensions to significant changes in size and weight of the camera. These features have a range of value adding benefits including improved fire investigation analysis and the ability to learn from how a search or fire attack was conducted. Some cameras can be programmed to commence video recording when the power button is activated meaning not only is the scene captured, but also the time, date, and spot temperature within a structure. This information could also be of value should a responder become injured during this stage of the operation. This technology comes with an onus on emergency services that they have a clear procedure for who can access these images. They are clearly the property of the emergency services and the responsibility for storage location, duration of storage and access should be seriously considered. Freedom of Information legislation in each state would serve as appropriate avenues to access for external bodies.

Video transmitting (telemetry) allows for the thermal image of an incident to be transmitted in real time to a command position that may be several hundred metres from the incident. This would give command a thermal image of an incident scene and of the location within the scene of their crew. Some operational incident controllers would view this information and build it into their incident management system; others would not use it at all. In general the TIC image would not be a constant picture of the scene due to the TIC operator raising and lowering the TIC as they move through the scene. This would make for a transmitted video that would be hard to watch. An incident controller would have to request an image by radio in order to get a scene that is watchable at the time they are looking for it. Currently telemetry technology is inconsistent with its transmission through various structures

7.04.05 NFPA 1801

NFPA 1801 is a USA fire standard that was ratified in January 2010. The National Institute of Standards and Technology (NIST) had over several years been researching TIC performance and evaluating the needs and wants of responders. Any TIC approved under the standard will go through a number of fire services relevant tests, including expected image quality, spot temperature accuracy, heat, submersion and height drop tests. This will ensure approved TICs are designed to meet the rigors of fire service deployment. Each fire service I visited had put potential TIC models through similar extensive tests to help decide which models suited their deployment model. By having a TIC pre-tested under a USA national standard will simplify the elimination process for durability and suitability to the fire service.

NFPA 1801 will also standardise screen icons and some TIC controls to enable anyone who is trained to use an NFPA standard TIC to be able to use any other manufacturers NFPA approved TIC without retraining. Basically, from the time a responder presses the standard green power up button; all NFPA TIC displays in BASIC mode should look the same in terms of:

- Battery bar (four green squares each representing 25% power level),
- Colourisation (black [cold] to white [hot] with colourisation going from yellow to red),
- Spot temperature (in Fahrenheit or Celsius),
- Low sensitivity mode (green triangle illuminated), and
- Temperature indicators in number and green bar to show what temperature colourisation represent.

A BASIC PLUS mode will be available for fire services to tailor more specific features into the camera. However, each approved standard TIC must be able to return to BASIC mode by pressing the on / off button once.

The standard is not designed to limit the options available on a TIC but increase usability and ensure durability across manufacturers. Initially a small price rise will occur due to manufacturers having to make some changes and to meet the costs of testing to meet the standard. However, in the long run the standard should enable better price competition. Fire departments that buy an NFPA 1801 approved TIC will not be forced to continue to go back and use the same model as purchased previously (and be trapped by replacement pricing or out-dated technology) because the standard will mean their responders will be able to use a TIC from any manufacturer that meets the standard without retraining. This is a way of future proofing your training and TIC purchase.

Currently non-NFPA 1801 TICs have a range of operational differences that are not only confusing, but would require a fire department to spend time and money retraining their responders to understand these differences. Different coloured power buttons, temperature icons, mode indicators, battery level indicators, zoom capabilities, colourisation temperatures, button functions and terminology have made TIC as varied and confusing as many modern mobile phones. Colourisation, in particular, is a feature that can lead to confusing and even dangerous consequences if the operator fails to understand its meaning with an unfamiliar camera. The development of this standard has taken several years and was done in conjunction with key stakeholders in the fire service TIC industry. It is a step forward for firefighting and one that should be adopted as a standard to meet when specifying new cameras.

7.04.06 **Detector Options**

Most commonly, current TICs use micro bolometer technology. These detectors use either Vanadium Oxide (VoX) or Amorphous Silicon (AsI) as their base detector material. The difference between these two materials is more to do with the supplying detector manufacturer's key market than significant differences in image quality and price. Vanadium Oxide is linked closer to military thermal imaging technology and Amorphous Silicon with industrial and commercial platforms. Due to its industrial links AsI detectors are less impacted on international trade and security restrictions than VoX and are more regularly used in the fire industry.

7.05 **Selection Criteria**

Discussions were held with firefighters involved with the selection of TICs for their departments and brigades and there was found to be quite a variation in how cameras were selected. This variation ranged from simply viewing several TICs and putting them to use in selected stations and getting the crews to vote on their preferred model to full comparisons of features, extensive trials and almost testing to see the destructibility of the TIC. The key issue, when determining which TIC to select for your department, is to know in advance what the primary objective for the TIC will be. Will it be used for USAR or overhaul or initial fire attack? When you have answered this question you will have arrived at the key understanding of the features required to determine the type of TIC you need.

Knowing your department's procurement procedure is vital in how you proceed. Do you have a list of approved suppliers? Do you have to go through an advertised tender or bidding process? Does government have rules for large purchases designed to encourage local business? Keeping abreast of these rules via your Procurement Department will prevent you wasting time and effort unnecessarily. I know of situations where departments with an approved supplier list have missed the opportunity to take advantage of technological developments due to not looking outside of this list. Do your responders the justice of getting them the best TIC for their task that is available, and if this means keeping abreast of the technology and changing the approved supplier list then do so.

Selecting an evaluation team is significant to your successful result. This team must be educated to know how thermal imaging works and understand the technology and terminology. This team must be competent in fireground operations to be able to take the TIC through various scenarios confidently and safely. End-users who are willing to speak their mind regarding positives and negatives of the camera are required, regardless of rank.

It is also reasonable when asking a supplier to lend you a TIC for evaluation that you at least do them the courtesy of letting them know the intended purpose of the evaluation and how they will be assessed. This way they will help you to access the best model in their range and the most applicable features for the job. Manufacturers need to supply more than one camera of each model so that a battery failure or another technical glitch doesn't negatively affect the overall result. An evaluation should start with a product presentation. TICs are very technical tools designed to be used and interpreted by trained operators and they have technology that is progressing regularly, keep this in mind when selecting models for evaluation and the people conducting the evaluation.

I would then suggest matching TICs criteria for criteria, giving these a value based on importance. For example if selecting a TIC for USAR, then size and weight are higher valued criteria than when assessing a TIC for fire attack. (Size and weight should always be valued in terms of balance and ergonomics as well.)

Vital to the success of introducing technology and managing change is involving the end-users, the responders. It has already been discussed that change driven from the ground up is not only more accepted, but also more successfully implemented. Find a group of enthusiastic respected responders who know what they are looking at, motivated for genuine improvement and willing to say what they don't like as much what they do, and give them legitimate power to have a say in the process. After all it won't be the Research and Development Department that will be using the TIC when the heat is literally on!

SAFE-IR[8] recommends evaluating TICs in the following categories:

SECTION 1 — TIC CONTROLS—

The TIC may have several features controlled by exterior functions i.e. On / Off switch, stand by mode, zoom, etc. Rate the ease of use while wearing full PPE in a dense smoke environment.

SECTION 2 — LOW CONTRAST SCENES —

The TIC is often used in low contrast scenes such as when searching a large space remote from the fire, odour investigations, investigating an auto accident scene at night, HAZMAT use, identifying stairs, exits and other safety items. Rate the picture quality, ability to identify important components in the low contrast scene.

SECTION 3 — HIGH CONTRAST SCENES —

The TIC Image in high contrast scenes will change constantly. How well does the TIC show detail in high contrast scenes? Rate the TIC response to changing scene dynamics while scanning, shuttering, mode change, aperture adjustments, and the ability to identify important components in high temp scenes.

SECTION 4 — VIEW SCREEN —

Many things may affect the picture represented by the viewing screen. It should give a reliable picture in dense smoke conditions; ambient sun light for size up, it should allow viewing by more than one firefighter at a time. Field of view and depth perception are factors to consider. There should be no radio frequency interference.

SECTION 5 — FUNCTION INDICATORS / ON SCREEN INFORMATION—

The TIC will have several performance indicators showing on or near the viewing screen i.e. mode indicator, high temperature warning, and other warnings. Battery indicator: how easy is it to understand the condition of the battery.

[8] Bob Athanas, SAFE-IR – Sample thermal imaging camera evaluation handout

SECTION 6 — OVERALL EASE OF USE / WEIGHT / BALANCE / HANDLE—

The ability to pass a TIC to another firefighter, ease of use with carry strap/sling/lanyard. The ability to crawl and carry out other firefighting functions, ability of use during overhaul.

SECTION 7 —BATTERY—

The TIC is an electrical / mechanical device and battery performance should be considered. Rate the functions, battery change in dense smoke conditions while wearing full PPE, Battery life and performance, Battery Charger, Battery Charge time etc.

In general, some of the following make for other relevant areas for comparing TIC features:

Camera dimensions	Dimension with video or transmitter
Weight	Weight with video or transmitter
Balance	Ergonomics (1 hand)

Method of attachment to SCBA or PPE

Screen size	Screen definition

Zoom capabilities

Time from off to usable image	Viewing angle
Battery type	Battery operation time
Truck mount approved standard	Truck mount charging
Temperature range	Number of temperature modes
Colourisation features	Programmable colourisation to suit department

Colour palette change and how easy it is achieved

Quality of telemetry transmitting (vision / distance / protected signal)

Type of detector

Gloved operation: buttons / battery change / attachment to PPE

Standards: NFPA1801 / IP67

In conjunction with these comparisons come:

Cost

Relationship with supplier (are they only about when you spend money? / have you purchased from them in the past?)

Support from supplier (reliability / replacement camera / battery / warranty length / after sales back-up)

Delivery contract (Can you penalise the supplier for not meeting their commitment?)

Program updates when available to keep the TIC modern.

Will I need to retrain responders to use this model?

Operational Trials:

When conducting operational trials, keep in mind that if the TIC is to be utilised primarily for fire attack & firefighting roles, that a camera approved as NFPA1801 compliant will have already successfully passed a series of firefighting related durability and quality tests.

Otherwise it is vital to incorporate the TIC options into task specific training, it is probably best to use training rotations your department is already familiar with as well as some specific tasks. The following are some examples of operational firefighting selection tasks.

Submersion and wet operation	Accuracy of TIC spot temperature with calibration tool
Picture quality at a set room temperatures	Picture quality in low visibility
View thermal current	Locate hot spots behind a plaster wall
Locate a victim in hot environment	Identify fluid level in gas cylinder
View a cryogenic gas	View the hottest area of a structure fire
View doorways / exits in a hot environment	Carry, comfort and usability

8.0 TRAINING

Without question a TIC in the hands of someone who is untrained in how to use it is more dangerous than not having one at all. An understanding of image interpretation will enable the user to identify and act upon the scene that is shown on the TIC. A trained operator will take into consideration what the picture shows, what it doesn't, what their environment is telling them and together what it all means.

It is also of major importance that the users search techniques are well developed and maintained and follow the departments (brigades) expected operating procedures. Putting a TIC into the hands of a responder who doesn't have basic firefighting skills will not make them a better firefighter; it is likely to lead them (and possibly the crew) into more dangerous situations.

In short, be trained well as firefighter first and trained how to use a TIC second. This does not mean TIC shouldn't be introduced during recruit training, they should, but the timing of this skill acquisition is highly important.

8.1 Required training components for firefighting

Training in TIC specific to fire departments must contain several basic building blocks on which it is based. The basic blocks are:

- To ensure that skills in structural firefighting and search techniques are developed and maintained. This enables fireground safety to continue in the likelihood that the TIC fails during its use.
- Skills in structural firefighting and search techniques are performed in accordance with best practice and department (brigade) SOP / SOG.
- Training should occur using the equipment specific to that department (i.e. if TIC model X is on primary appliances for fire attack and search, then firefighters should be trained using model X).
- If more than one type of TIC exists for the same purpose (e.g. for fire attack and search), then firefighters need to be trained in the operation and interpretation of each type, except if they are NFPA1801 approved.
- TIC use for firefighting must be trained for in a hot fire environment in a way that demonstrates the tactical benefits of the TIC.
- Limitations of TIC must be part of training at all levels.

In cases where fire departments have large numbers of firefighters to train, the method employed to train them is usually to bring in a subject matter expert (SME) and use this person or company to "train the trainers" or instructors in that department. SMEs can be found in several ways. They exist within TIC retailers, who are obviously experts in their own equipment and use trained firefighters as instructors to departments that purchase their equipment. Private companies exist consisting of firefighters who are leaders in their field and who can be contracted to train according to the needs of a department. One such company is SAFE-IR, from New York. I contacted Bob Athanas, a firefighter with FDNY Rescue 3 and a director with SAFE-IR while in New York and also participated in his lecture at Firehouse Expo, 2009. SAFE-IR was used by LAFD, LACoFD and FDNY (along with a significant number of other US and Canadian FD) to train instructors and officers in utilising TICs. From my experience and the opinion of many of those that I visited, I would

consider SAFE-IR the worldwide leaders in this field. SMEs can also be developed within a department by combining interest, research, experience and the opportunity to learn from others.

SAFE-IR training in TICs for firefighters consists of two days training; however departments can negotiate with instructors the exact nature of training to be delivered. This training consists of both theory and practical, with practical also consisting of some hot fire experiences. Areas covered by one of these courses consist of the following components:

- TIC history and operation
- Thermal contrast
- Movement of convected heat
- Thermal layering
- Changing thermal conditions
- Thermal inversion
- TIC mode shift
- Colourisation
- Temperature measurement
- Search techniques
- Tactical use of TIC
- Scenarios for various applications and uses
- Limitations of thermal imaging [9]

The CFA in Victoria has a SME in Fire Officer Gavin Parker. To his and the CFA's credit they have developed an excellent training package for TIC use in the fire service. It is also a two-day course and incorporates most of the elements consistent with a SAFE-IR course and also is specific to the CFA environment. The CFA has also developed a one day training package specific to wildfire. Forest and wildfire specialists such as British Columbia Fire Service and the US Forestry have commended this course.

Due to the wide variety of applications TIC can be used for by responders, the difficulty for any training course is how many do you focus on in a basic course and which areas becomes part of specialist courses. The answer to this has much to do with the structure of the fire department and the manner in which it trains and responds its specialist operators and appliances. Therefore any training course needs to incorporate the training providers being aware of this response matrix. For example some departments, such as FDNY Rescue companies, operate specialist rescue units. These specialist rescue units have up to six firefighters with skills including extrication, overhaul, victim search, hazardous materials response, water rescue, salvage, high angle rescue, trench and urban search and rescue. A model such as this allows this group of firefighters to receive a higher level of TIC training specific to these areas. However in a model such within the MFB and parts of the CFA these specialist skills are separated into different responses with different crews for USAR, HAZMAT, extrication, overhaul and heavy rescue. This would mean specialised TIC training for each of these specialist skills, and a variety of above basic TIC operator courses.

Same as with firefighting, specialists need to primarily be competent in their specialist field and aware of department SOPs. It is also vital that specialist training is made as realistic as possible in order to gain the maximum value and assist with appropriate TIC interpretation skills.

8.2 **Duration of training**

[9] (Athanas, 2009)

To introduce TIC to a fire department will require several layers of training courses.

- **SME**: A department may choose to develop their own SMEs, these people will need to be educated by an appropriate SME in how to incorporate the requirements of the department, its response matrix, the facilities available, the type of TIC(s) being used, the range of specialists skills as well as basic model of TIC usage. Training of this nature would be expected to take between 40-60 hours, excluding time spent on background theory. Even if a department is introducing an external SME expert directly to the Department Instructor level, time will be required to brief the SME in departments operations.
- **Department Instructor**: This group of people will go on to train the firefighters. For a basic level of TIC instruction (fire attack / search / fire location / first due tasks) these instructors will require approximately 16-24 hours instruction, this will not include time required for specialist skills, and some background knowledge and experience may be expected. Specialist skills in TIC such as hazardous materials and USAR would require an additional 8-10 hours each.
- **Firefighter**: This group would require 10-14 hours training, depending on level of theory work and background knowledge that can be delivered at a station level. This training must incorporate access to practical props and hot fire to show the uses, limitations and benefits of TIC first hand.

Table 1.0 Comparison of international and local TIC approaches shows a consistent pattern of instructors receiving two days training. It also shows firefighters receiving between ½ day and two days training. In the case of LAFD Battalion Commander Logan commented that in hindsight this training duration would be longer, but that skill maintenance specifically in TIC and incorporating TIC into most drills keeps their training updated. LAFD did manage to train 3500 firefighters in 54 days, due to their commitment and the lead-up theory done in stations by each LAFD Captain. LACoFD USAR 103 specialist firefighter Rich Atwood commented that his departments firefighter TIC training should have been longer and that became an initial obstacle for TIC being successfully accepted by firefighters when they were first introduced across all engines and truck companies. Since then skills maintenance and experience in what a TIC is capable of providing in terms of safety and professionalism has seen TIC become a vital firefighting tool for LACoFD. Captain Scott Krautt, a Field Instructor with Fairfax County FD, trained their firefighters using the time available for training over many weeks to bring them up to speed in thermal imaging. They then incorporated TIC into skills maintenance training in a wide variety of firefighting training. This is a great way to introduce TIC into a fire service and educate firefighters to use it in a wide variety of tasks and incidents.

- **Recruit Firefighter**: Recruit firefighters need to be introduced to TIC as part of their recruit structure fire training for them to see it as a vital tool in fighting fires. The important element with recruit firefighters is to time the introduction of TIC after they have developed competent search and fire suppression skills. They then have the ability to manage on the fireground should they be deployed without a TIC or if it fails during an operation. Recruits are far more likely to be proactive about using a TIC in an operational sense because it will become part of their basic firefighting skill process. To leave this training until after they have left the training college would be a missed opportunity and likely to create a segmentation in their skills and mental process on what to take to a fire. Trained correctly, recuits will be an active reminder to those who won't automatically think to bring a TIC to a fire because it was not how they were taught.

  Recruits will still require the same length of training in TIC as any firefighter, but in their case it will be combined, both practical and theoretical, with much of their education and skill development in various fire and search technique instruction.

8.4 Limitations of TIC to be identified in a training course

Another vital element of a successful training course is to not represent TIC as machine that can solve any fireground problem. You can't force a door with a TIC or suppress a fire by pointing it at a fire. It is a tool that has many uses, these uses are an advancement for firefighting that has had a significant impact on safety and service delivery, but as a tool it needs to used and interpreted by someone competent and also recognised when it is not the ideal tool for the job.

Teaching the limitations of a TIC helps to educate the operator in how to interpret the screen image and when to use it in fireground operations.

Limtations:

Reflections: water, glass, some metals and polished surfaces can reflect heat to the TIC. The operator needs to be able to determine when an image is a reflection and when it is the true image. In most cases, when looking at an image of a firefighter holding a TIC you are looking at yourself. Try waving to confirm this. It is important not to misinterpret the fire location due to a reflection. A full room scan should always be conducted and thermal currents observed to ensure you are "attacking" the fire.

Tunnel vision: occurs when the TIC image is constantly observed. A TIC has a field of view (FOV) between 36-56° compared with a sighted vision of 150° plus. The TIC operator needs to observe all of the surroundings by moving the camera (six sided search or three level search) and use the TIC to observe and identify the surroundings, then move and search with traditional methods (left wall / right wall search). The TIC can be viewed whenever it is required to confirm surroundings, fire conditions or position within the structure.

Effects of water: Water has the ability to shroud or hide surroundings or thermal conditions. The TIC operator needs to observe the changes water makes to surroundings. The temperature of water will generally be identified in a screen as black or dark grey; this can sometimes lead an operator to mistake a hole in the floor for a puddle of water.

White is "hot": A TIC will display temperature differences, with temperatures above ambient temperature being shown as lighter than those below. At room temperature a white image may only show it is hotter than ambient and it is not a hot spot or a fire. Operators if unsure of temperature can use the spot temperature feature present on all modern cameras or do a comparison with something of known temperature (e.g. the back of your hand). Some TICs have colourisation features that illuminate increasing temperature yellow, orange and red. It is vital to understand what you are observing as red is not always hot or a fire as well. A feature on many cameras is white- cold / black – hot, this in my view is a dangerous option for firefighting and should be disabled from cameras so as to prevent confusion and misinterpretation.

Intrinsic safety: in hazardous environments intrinsic safety with any firefighting equipment is important. TICs are currently not fully intrinsically safe, however with many models achieving IP67 (short term total immersion in water and dust intrusion safe) they are very well sealed. Intrinsically safe models are likely to be available from some manufacturers in the near future.

Depth perception: Vision through a TIC alters the viewer's exact position in the scene. A TIC is often delivering an image that is held 0.5 metre in front of the eyes, but the brain is interpreting it at face level. Therefore, when attempting to touch or pick something up you will be short of the target. Negotiating stairs should never be done while viewing a TIC.

Over-relying on the TIC (sight is safety) and foregoing firefighter basics can lead to fireground mistakes. Basic firefighter skills must be competent and knowing the limitations of any tool is a vital step in using it correctly whether it is hydraulic spreaders, a ladder, communication system or TIC. Firefighters can also be tempted to walk with a TIC when without it they may have crawled.

Speed of search: In most cases a TIC will speed up the search process. Caution needs to be used when moving quickly through large structures, as SCBA air volumes may become exhausted while exiting if the firefighters go too deep and then lose the function of their TIC.

Training must be tailored to your specific camera and its particular features. In the majority of applications a basic TIC model will lead to less operator error and confusion as to what is being displayed.

8.5 Training in search and rescue / HAZMAT

The use of TIC in search and rescue, USAR and HAZMAT are more specific operations than general firefighting duties. Search and Rescue for victims in the open environment requires a camera that has a high definition screen and zoom capabilities (up to 4 x zoom currently available). This is where sensitivity at ambient temperatures and coloured palettes become more valuable. The ability to differentiate the environment with slightly varied temperatures will enhance the TICs ability to identify key features such as fellow responders and their positions, power lines, structures, flora and fauna, paths, water and victims. As with depth perception, responders should never walk and look through a TIC simultaneously. Responders need to train in a variety of light and environmental conditions in their response district to enable them to be familiar with how their environment alters throughout a day and as ambient temperatures change. Due to the length of some of these searches a battery charging procedure needs to be adopted.

USAR requires a specific TIC that is compact, lightweight and capable of working on a pole with a flexible controlled head. TIC models such as this work well in environments with small temperature variations and present images to a remote screen. The USA FEMA listed TIC is a dual mode low light and TIC where the head is only 49mm x 162mm. This camera is part of the cache for national and international USAR and emergency deployment as of mid 2009. Training with this camera should involve both deployment in a collapse environment and interpreting the screen image. Practicing use with the pole and moving the flexible head in a confined space will equip the responder to manage this task when on an emergency USAR deployment.

Hazmat TIC deployment is becoming an increasingly vital operation. It is important the TIC is used in conjunction with other hazardous environment detectors so as to ensure it is not in an environment where its lack of intrinsic safety will compromise safety. Hazmat units should move to intrinsically safe models when they appear on the market, in the interum Hazmat TIC should at least look to meet IP67 water and dust seal standard as a measure of reducing its intrinsic risk. Hazmat training should involve responders being capable of identifying fluid levels in containers (and differentiating from the effect of sunlight warming on containers), fluid leaks, hazardous materials on waterways, cryogenic gas leaks, victim locations and exothermic reactions. Putting a TIC into use with other HAZMAT instruments will give a range of information that will complement a safe abatement of a risk.

8.6 Incorporating TIC into Operating Procedures and Guidelines

In order to ensure best practice deployment and utilisation of TIC, fire departments should consider adopting changes to operating procedures that would ensure a higher level of responsibility on firefighters to use TIC appropriately.

Battery: Battery check on TIC becomes part of duties of a firefighter on the change of every shift. As with portable radios and truck fuel levels a minimum of ¾ charged should be maintained. Battery charging is best achieved with a cabin mounted TIC bracket and combined “trickle” charger to keep the battery at maximum charge constantly. A battery life replacement procedure should be negotiated with the supplier.

Change of shift checks: As with checks of battery level operation of the TIC should be checked at each shift change. This would mean switching on the TIC, checking charge, checking screen activation and icons and by pointing at a warm item (in cabin radios or TIC cabin mount and charger see the TIC is recognising temperature change). Any initial failure the TIC should be restarted, if this doesn't work or the fault occurs regularly the TIC should be reported to the appropriate facility services body for replacement.

Fireground procedures: Adopting a procedure where one of the responders in the rear of the appliance (unless it is determined that the officer will use for size-up) is responsible for taking the TIC to all reported structure fires, fire indicator panel alarms and smell of smoke calls will enable the TIC to be present when required. A TIC should be taken with the responder every time SCBA is donned according to procedure.

Internal Sector Command: Currently firegrounds are sectorised around the incident scene without always having an incident sector controller designated to the internal operations. An officer working with the fire attack and search crews inside the structure at the "coalface" with a TIC will be a valuable procedural change that will add a set of eyes to the specific tasks of monitoring the search, fire attack methods, fire progression, building integrity and the safety and location of the internal crews. This role, using the experience and knowledge that comes with becoming an officer, will have the ability to remove crews when internal conditions make it unsafe to continue with the current strategy. This combines technology and experience into a fire ground operation that can sometimes lack one or both.

Rapid intervention team (RIT) responsibilities: The role of rapid intervention is to be responsible for fireground rescue of any responder on scene. A TIC is a necessary tool for this task as they may be required to rapidly access a scene to locate a responder in distress, lost, trapped or injured. Victorian Fire Services need to adopt RIT more procedurally and train more specifically for the role than to assume two in two out will be sufficient in an emergency.

Training department and hot fire OHS: The training department needs to ensure a procedure of using TIC for each drill with limited visibility and hot fire. A TIC should follow each group's rotation through these environments and if fixed TICs are used then they need to be monitored during these training rotations.

9.0 Possible Future developments

Aerial surveillance unmanned:

TIC working in conjunction with either small-scale "cyberquad" aircraft or in larger scale "drone" aircraft. These would have roles of working in and around fire scenes, search scenes and tracking wildfire.

Heads up:

Currently this technology, while possible, is hindered by the need for SCBA and equipment integrally attached to it to be intrinsically safe. However, as TIC become more cost effective and more widely used, more money becomes available to invest in this direction with the thermal imaging technology.

Reduced size:

Without doubt reduced size and weight of TIC is constantly being progressed. One manufacturer has already developed a small "personal" issue TIC that has basic operations designed to be used in conjunction with a "traditional" handheld camera. Models similar to this will be developed by other manufacturers to compete in this category of TIC market.

10.0 Recommendations

General (Fire Service)

- TIC selection for emergency responders needs to be based specifically on their predominant task. (e.g. fire attack, overhaul, USAR).
- Primary Fire appliances operating in predominantly urban areas should have a minimum of one TIC.
- Fire services need to plan for and monitor TIC development in order to prepare for introducing a TIC for each firefighter on a primary fire appliance in predominantly urban areas.
- TIC Training for new operators must have a hot fire component.
- TIC Training for recruit firefighters should be built into structural firefighting training and search techniques as part of their recruit training.
- SOPs should be modified to ensure operations of TIC are at best practice.
- Specific advanced TIC training should be conducted for specialists in Heavy Rescue, HAZMAT and USAR.
- Future purchases of TIC should be of NFPA 1801 approved cameras when firefighting is their primary function.
- TIC should be available on each aerial appliance (ladder platform and teleboom)
- A “best practice training” course delivered by a SAFE-IR instructor should be conducted in Victoria.
- Internal sector control managed by an officer with a TIC as a priority safety deployment.

MFB

- All operational firefighters to be trained in a basic TIC course.
- TIC to be on every primary appliance (pumper, pumper tanker, water tanker, teleboom and ultra large pumper)
- Heavy Rescue units require a TIC with features specific to overhaul, HAZMAT and search and rescue.
- A small USAR specific TIC to be added to the USAR cache.
- Include wildfire specific TIC operational tactics to the Wildfire refresher skills maintenance training pre-summer.
- Implement changes to SOPs to reflect best practice implementation of TIC.
- Adopt the Rapid Intervention Team role into fireground practices and procedures.

CFA

- CFA TIC Training course should be delivered to recruit firefighters and built into elements of structural firefighting training, search techniques and wildfire training.

- Develop a TIC deployment and training model for urban and rural areas based around structural risks, call frequency, distance to TIC and willingness to undertake training and skills maintenance.
- Ensure a TIC is deployed at all structure fire events by directing Brigades leaders to identify and include a TIC equipped Brigade into their call assignment at 1st alarm (initial response) level regardless of Region boundaries or MFB mutual aid (except if deployment time exceeds 20 -25 minutes).
- Work towards increasing TIC deployments to all urban brigades (approx 220).
- Assist the selection process of TICs when brigades are fundraising for their own camera to ensure variety of TIC models does not become excessive and impact on training.
- Implement changes to SOPs to reflect best practice implementation of TIC.
- Ensure numbers of structural firefighters on the fireground is always sufficient to enable an adoption of the Rapid Intervention Team role into fireground practices and procedures.

DSE

- Develop a TIC course specific to wildfire and controlled burn usage that standardises with the CFA course.

SES

- Educate SES responders of scenarios of where TIC access via mutual aid would aid service delivery to the community and SES responder safety.
- Involve SES responders, via mutual aid arrangements, in TIC usage in search and rescue, flood scenarios and USAR.

Victoria Police

- Educate Victoria Police of scenarios of where TIC access via mutual aid would assist service delivery to the community and Victoria Police safety.
- Evaluate TIC resources and deployment rates to identify suitable resource and training needs.
- Conduct a “best practice training” course delivered by a recognised law enforcement instructor.

11.0 Acknowledgements:

The Emergency Services Foundation has a unique role in supporting and sponsoring research in Victoria.This research has a history of being of enormous benefit to responder safety and to community safety. It was therefore a great honour to be a recipient of a scholarship from the ESF and I have endeavoured to deliver a report worthy of this trust.

My dedication for this report was to my father, Graham Whitty, who sadly passed away three weeks before I left to conduct this research. He had been ill for a short period of time with an aggressive cancer, but he had made me promise that should he pass away while I was overseas I would not comprimise the research to attend his funeral. Such was the level of importance he credited this study with and I am confident I have done him proud. His cancer was to make this decision for both of us.

The physical effects of fire are easy to quantify and see. Yet, the loss of my father's twin sister, Merle, in a house fire has always been a poignant reminder of the emotional impact a fire can have on a family. I believe the fact that this research will lead to the saving of lives in the face of the brutality of house fires was why it was so important for my father and me.

The hospitality of the American firefighters was something that each organisation should individually be very proud of. Meeting firefighters who were leaders in their fields, still open to learning new things and willing to share their knowledge for the benefit of firefighting was inspiring. I was welcomed into each station and we shared stories of fires and life as a firefighter as is a tradition. It was great to see that professionalism in firefighting was paramount and that humour, great cooking and genuine love of station-life made each firehouse feel like home.

My journey to LAFD, LACoFD, MFRI, Fairfax CoFD, BaltimoreCoFD and FDNY took me across the US from west to east and it would be unfair to single any one department out, I learnt so much from each one and would have been honoured to be a firefighter for any of these departments. Gary Simpson, a fire service thermal imaging instructor based in Kentucky, was responsible for recommending many of my contacts that became invaluable to maximising my experience. Participating in Firehouse Expo, Baltimore was a great experience, the presenters are recognised as world class and it also gave me the opportunity to meet firefighters from some of the smaller fire departments, many of these volunteer. The professionalism and welcoming from these firefighters was also fantastic. A trip such as this, while focussed on returning vital information on TIC, also delivers so much more. The immersion into US firefighting has been a valuable education and one that has been a highlight of my career to date. It has exposed me to many other important elements of firefighting that are in need of further development in Victoria such as rapid intervention teams, educating on the effects of wind driven structure fires and the programs of firefighter safety sponsored by the National Fallen Firefighter Foundation. I hope the information on these topics I have provided to some of our brigade leaders will be investigated further.

12.0 **References**

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