Fire Research Report

The Cost Factors and Profile of False and Unwanted Fire Alarm Activations in New Zealand

Auckland UniServices Ltd

August 2006

The aim of this research was to undertake qualitative and quantitative analysis of fire alarm activation data and data from case studies, to provide a detailed and accurate information base that will contribute substantially to the efforts to reduce the number of unwanted fire alarm activations in New Zealand. The analysis also includes information on how frequently unwanted fire alarms occur, the type of unwanted fire alarm activations, and the industry sectors and buildings that are most prone, etc. By analysing this data, an estimation of the economic and social costs of unwanted fire alarm activations incurred by both the New Zealand Fire Service and the business community are included.

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THE COST FACTORS AND PROFILE OF FALSE & UNWANTED FIRE ALARM ACTIVATIONS IN NEW ZEALAND

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Executive Summary

New Zealand and overseas fire service agencies have been concerned about the steady increase in the number of false or unwanted fire alarm activations over the past decade. Of particular concern to the New Zealand Fire Service is the rise in the number of false or unwanted fire alarm activations in the Auckland CBD which has, proportionately, the highest rate in New Zealand. The high number of false or unwanted fire alarm activations represents an enormous waste of resources for the New Zealand Fire Service, businesses and the public.

Although there is a great deal of concern regarding the economic and social costs of false and unwanted fire alarm activations to the New Zealand Fire Service and the business community, there are few references within the context of the New Zealand urban business community. Many of the references that are available are vague on how they arrived at the exact costs of false and unwanted fire alarm activations. Moreover, there have been few detailed analyses of the profile and occurrence of false and unwanted fire alarm activations. That is, there has been little systematic analysis of how frequently false or unwanted fire alarms occur, the type of false or unwanted fire alarm activations (i.e. were they due to systems failures or human errors), the industry sectors and buildings that are most prone, or other factors, such as the effects of climatic conditions, that result in false and unwanted fire alarms,. One of the difficulties in undertaking such analyses is that the New Zealand Fire Service data on false and unwanted fire alarm activations is limited in terms of consistency at the point of recording and because of changes in classification over time. These omissions and limitations make policy and practice aimed at reducing the number of false and unwanted fire alarm activations within New Zealand problematic.

Therefore, the central purpose of this study has been to *provide a comprehensive picture of false and unwanted fire alarm activations* within Auckland CBD by applying a systems approach. In particular, the aims of the project have been to:

- Examine existing research on ways to reduce the number of false and unwanted fire alarm activations;
- Present an overview of the New Zealand legislation pertaining to fire alarms;
- Undertake an in-depth quantitative analysis of Auckland's and New Zealand's latest fire alarm activation data as provided by the New Zealand Fire Service;
- Undertake a qualitative case study analysis of fire alarm activations within the Auckland CBD;
- Provide a detailed profile of the false and unwanted fire alarm activations that have occurred in Auckland based on quantitative and qualitative data;
- Provide a means by which to estimate the economic and social costs of false and unwanted fire alarm activations incurred by the New Zealand Fire Service and Auckland business community; and
- Provide recommendations for further investigations and policy development on reducing the number of false and unwanted fire alarm activations.

As the data sources available were inconsistent and frequently subjective and because it was difficult to capture and measure all the cost elements associated with false and unwanted fire alarm activations, a number of methods had to be applied. In particular, the study analysed:

1. The time series data on fire alarm activation;

2. Attribute data on building type, system type and reason;

3. The language data available in the remark field of the fire alarm activation data set; and

4. Qualitative data from case studies.

Based on the findings, a number of conclusions have been drawn.

The first conclusion is that there is *not necessarily just one factor* that contributes to the level of false and unwanted fire alarm activations, but a range of different factors that can vary between buildings and fluctuate over time. For example, in addition to the age of the building and/or the fire alarm system, the type of building, the type of occupancy and the type of alarm system the time of day, day of the week and the month are all factors that contribute to false and unwanted fire alarm activations. A false or unwanted fire alarm activation can also occur as a result of several interrelated factors. For example, a smoke detector located inappropriately in the kitchen would activate an alarm every time someone burns the cooking.

Although there is not just one factor that contributes to false or unwanted fire alarm activations, some *causal factors are more pronounced*. By analyzing false and unwanted fire alarm activations with different variables, such as the time of day, the building type, etc. it is possible to see *clear patterns* of high or low incidences of alarm activations. Such information can be used as the basis of resource allocation for the New Zealand Fire Service. However, the documentation of reliable and usable data is critical in order to provide an accurate picture of the extent of the problem.

The second conclusion is that type and occurrence of false and unwanted fire alarm activations *are not static*. At a macro level, the Auckland CBD business and residential population has increased substantially and become more diverse over the past 20 years. There has also been a corresponding increase in the volume of false and unwanted fire alarm activations, as the New Zealand Fire Service data shows. In addition, New Zealanders have also witnessed major regulatory reforms concerning building and fire safety in which the legislation has shifted from one that was primarily prescriptive to one that relies more on the self-management of regulations and codes. As part of these reforms, enforcement by territorial local authorities has changed from a public sector model to a private sector model with an emphasis on profit driven objectives and "farmed-out" enforcement. These reforms to the building legislation have not only impacted on the quality of building design and construction, but also have had enormous implications for fire safety, including the installation and maintenance of fire alarm systems.

The third conclusion is that the problem of false and unwanted fire alarm activations *does not take place in a vacuum*. Fire safety is more than just the reactive compliance to the regulations governing smoke detectors and evacuation plans: it is an integral part of the building process and maintenance as well as public health and safety. Variables such as the type and use of the building, access to resources, the relationship with the fire service and other fire safety/alarm system advisers, etc. are recognised as having an influence on the type of fire alarm system installed and how well it is maintained. Solutions applied to false and unwanted fire alarm activations are meaningless unless they incorporate a network of multiple factors. Therefore, when trying to implement prevention strategies, it is more useful to include *all those involved* in the building and property management industries as well as fire safety engineers, fire alarm installers and more importantly officers from the New Zealand Fire Service *at the planning stage* of construction or redevelopment. Only then will the desired outcomes be achieved.

The forth conclusion is that there are *inherent conflicts of interest* between the different parties involved in the fire safety. Fire safety and the installation of fire alarm systems can be interpreted and explained by applying a conceptual framework that links the different parties – namely the regulatory enforcement agencies (i.e. TLA's and the New Zealand Fire Service), the building developers, owners and occupiers as well as those in the alarm industry. The interview data clearly shows that there are inherent tensions not only between each of the parties but also within each of the groups. Excellence in fire alarm systems is reliant on the commitment to fire safety from the building developers, owners and occupiers together with a best practice approach from those in the fire alarm industry. Ideally, there should be equilibrium between best practice in the installation and maintenance of the fire alarm systems and the safety behaviour of the occupants, as a lacuna in one area has a compounding effect on the other. Conversely, poor or inappropriate installation and maintenance of the systems will often coincide with poor fire safety behaviour of the building occupiers.

Finally, a reduction in the number of false and unwanted fire alarm activations could lead to a more efficient and effective New Zealand Fire Service, with reduced response times and more time available to carry out their other duties. Attention to the causes and reduction of false and unwanted fire alarm activations could also have the beneficial effects of increasing the level of reliability and integrity of fire alarm systems, increasing the level of public compliance and reducing the economic and social costs associated with responding to false and unwanted fire alarm activations.

Recommendations

Based on the findings in this study, the following recommendations are proposed:

- It is recommended that the *legislation* covering fire safety be urgently reformed so that it is consistent with *other safety legislation* in terms of the structure (*one* act enforced by *one* authority covering *all* buildings) as well as powers of enforcement. It is recommended that the New Zealand Fire Service be the sole agency responsible for enforcing fire safety regulations and promoting fire safety practices. In particular, it should be *mandatory* for the New Zealand Fire Service be involved in major building and redevelopment work at the *planning stage* of the process and that they be kept fully informed when changes to the design are made. It is also recommended that, where possible, areas of confusion in the legislation be eliminated, for example the confusion over when to install a Type 4 or a Type 5 alarm system.

- It is also recommended that the New Zealand Fire Service, together with those in the alarm industry, continue to *regularly review* the way in which the *alarm activation data* is collected, stored and analysed. The high number of false alarms recorded as "other" or "no reason" diminishes the value of any comparisons that can be made or trends identified. When a false alarm occurs there must be a reason. If the reason does not fit into the currently available definitions then those definitions need to be adjusted. The affinity testing revealed an alternative grouping regime. It is understood that the New Zealand Fire Service is implementing new data collection methods and programmes in 2006, and that the "*reason"* groupings will be changed. It should be noted however that, while this will improve available data and future analysis, it will make precise comparison with past data difficult.

- It is recommended that the fines collected for false or unwanted fire alarm activations are used exclusively for their reduction and to support the proactive efforts by the New Zealand Fire Service to assist the public in installing the correct and appropriate alarm systems.

- It is recommended that the successful New Zealand Fire Service's targeted "Top 30 Buildings" approach to reducing the incidence of false fire alarm activations be replicated to *target the fire alarm industry's poor performers*. This could also provide the Fire Protection Association (NZ) with the impetus to review that way in which registrations are granted and licenses issued or revoked for failure to meet standards.

- It is recommended that those operating in the building and fire safety industries continue to take an active and participative role in reducing the incidence of false and unwanted fire alarm activations. The interview data reveals that there are a number of serious issues which developers, builders, and installers need to address, such as poor construction and service, and lack of fire safety knowledge.

- It is also recommended that those operating in the rental business (landlords/landladies and property mangers) take responsibility for ensuring that there are good fire safety provisions in each tenanted dwelling. In particular, they should ensure that tenants are fully cognisant of the evacuation procedures (as outlined in the regulations) and that each tenant has a basic fire alarm guide in a number of prominent languages.

- Finally, it is recommended that a working group representing the key stakeholders be established to investigate, in the first instance, strategies to reduce the number of false and unwanted fire alarm activations in the Auckland CBD and later, to examine ways of improving fire safety in general.

1 Introduction

The steady increase over the past decade in the number of false and unwanted fire alarm activations[1] and the associated costs in New Zealand, particularly within the Auckland CBD, has concerned the New Zealand Fire Service and the business community. According to the New Zealand Fire Service's website, there was a 40% increase in the number of fire alarm activations between 1996 and 1998 and 96% of these were avoidable and unwanted. Overseas studies show that 80-85% of all fire alarm activations are false or unwanted, with each activation costing a minimum of $1,200 to $3,000 (Chow; Fong, & Ho, 1999; Weiner, 2001, Office of the UK Deputy Prime Minister (ODPM), 2004; Karter, 2005; Lee, 2005).

Studies also show that there are a number of negative impacts as a result of false and unwanted fire alarm activations (Tilyard, 1997; Conforti, 1999; HM Fire Service Inspectorate, 2000; Tu, 2003; NZ Fire Service Commission, 2003a). In particular, false and unwanted fire alarm activations are a drain on the resources of fire brigades, business owners and residents. In addition, they divert response vehicles away from possibly life-threatening incidents. Moreover, the problem is not exclusively a fire brigade problem since false alarms also erode the confidence of end-users in the value and reliability of AFD systems and can cause costly interruptions to businesses (UK Fire Service Examination Board, 2002:4).

Although there is a great deal of concern regarding the economic and social costs of false and unwanted fire alarm activations to the New Zealand Fire Service and the business community, there are few references within the context of the New Zealand urban business community. Many of the references that are available are vague on how they arrive at the exact costs of false and unwanted fire alarm activations. Moreover, there have been few detailed analyses of the profile and occurrence of false and unwanted fire alarm activations. That is, there has been little systematic analysis of how frequently false or unwanted fire alarms occur, the type of false or unwanted fire alarm activations (i.e. systems failures or human errors), the industry sectors and buildings that are most prone, or other factors, such as the effects of climatic conditions, etc, that impact on false and unwanted fire alarms,. One of the difficulties in undertaking such analyses is that the New Zealand Fire Service data on false and unwanted fire alarm activations is limited in terms of the consistency at the point of recording and because of changes in classification over time. These omissions and limitations make policy and practice aimed at reducing the number of false and unwanted fire alarm activations within New Zealand problematic. Therefore, the central purpose of this research is to provide *a detailed information base* that will contribute substantially to the efforts to reduce the number of false and unwanted fire alarm activations. Rather than arriving at an arbitrary monetary figure

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[1] Although there are technically subtle differences in the meaning of "false" and "unwanted", both terms are frequently used as synonyms in the literature and as such we have endeavoured to use the cited authors' preferred term. However, we have used both terms throughout the report.

of the entire costs of false and unwanted fire alarm activations, this research will instead identify *factors* that are associated with the costs of false and unwanted fire alarm activations, such as, employee downtime; loss of business, etc., and the issues surrounding efforts to reduce false and unwanted fire alarm activations. A spreadsheet of the various cost elements will also be provided which can be utilized by both the New Zealand Fire Service and those in the fire safety industry to give an estimate of the costs involved and provide a targeted response to reducing false or unwanted fire alarm activations.

The primary **aims** of this project are:

- To undertake a comprehensive literature review on the subject;
- To examine existing research on reducing the number of false and unwanted fire alarm activations;
- To present an overview of the New Zealand legislation pertaining to fire alarms;
- To undertake an in-depth quantitative analysis of Auckland's and New Zealand's latest fire alarm activation data as provided by the New Zealand Fire Service;
- To undertake a qualitative case study analysis of fire alarm activations within the Auckland CBD;
- To provide a detailed profile of the false and unwanted fire alarm activations that have occurred in Auckland based on quantitative and qualitative data;
- To provide a means by which to estimate the economic and social costs of false and unwanted fire alarm activations incurred by the New Zealand Fire Service and Auckland business community; and
- Provide recommendations for further investigations and policy development on reducing the number of false and unwanted fire alarm activations.

Keeping in mind the New Zealand Fire Service Commission's research objectives and their desire to reduce the number of false and unwanted fire alarm activations, the **objectives** of the project are:

- To review and critique all the relevant literature on the topic and in particular outline the debates surrounding the definitions of "false" and "unwanted" fire alarm activations and the various costs associated with false and unwanted fire alarm activations;
- To illustrate the differences and linkages between each of the regulations and regulators pertaining to fire alarms;
- Using a sample of New Zealand Fire Service data, collate and categorise unwanted fire alarm activations in terms of: malicious false alarm; false alarm with good intention; and unwanted or avoidable fire alarm;
- To undertake six case studies in order to highlight key issues and provide a basis for an estimate of the economic and social costs of false and unwanted fire alarm activations incurred by the New Zealand Fire Service and business community;
- To investigate under what conditions false and unwanted fire alarm activations occur and how frequently they occur;

- To identify the industry sectors and type of buildings most prone to false and unwanted fire alarm activations;
- To create an excel spreadsheet example which can aid in the estimation of the costs involved in false or unwanted fire alarm activations;
- To produce a set of recommendations based on this and international research on how best to advance the research and policy developments on reducing the number of false and unwanted alarm activations for the New Zealand Fire Service;
- To contribute to the largely under-researched literature on false and unwanted fire alarm activations in New Zealand and in particular, Auckland.

The report commences with a review of the literature on false and unwanted fire alarm activations. In particular, discussion on what constitutes “false” and “unwanted” fire alarm activations and the extent of the problem are outlined. The literature on the economic and social costs of false and unwanted fire alarm activations is examined in which highlights issues on extracting precise monitory figures. As a result of reviewing the literature, key gaps are identified and research questions formulated which in turn provide the basis of the study. In the following section, the methodological approaches and the way in which the different forms of data were collected and analyzed are discussed. The findings and analysis from the case study data as well as the analysis of the New Zealand Fire Service data are presented. Finally, the report concludes with a number of recommendations and suggestions of further areas for research.

2 "False" or "Unwanted" Fire Alarm Activations

As noted above, there has been increasing concern in the rise in the number of false and unwanted fire alarms over the past decade. Alongside this increased level of concern, there has been a corresponding interest in the root causes and the management of false and unwanted fire alarm activations. The literature specific to false and unwanted fire alarm activations, however, is not easy to locate and is difficult to draw upon. Instead, the topic is dispersed among multiple disciplines, such as fire safety (e.g. Bukowski & Reneke, 1999; Gottuk, et al, 2002), electronics (e.g. Liu & Kim, 2003), engineering (e.g. Chubb, 2002; Arup, 2002), design (e.g. Qiyuan, Hongyong & Huiliang, 2004), construction (e.g. Chow, et al, 1999; Proulx, 2000), law (e.g. Tilyard, 1997; HM Fire Service Inspectorate, 2001), economics (e.g. Roy, 1997; Weiner, 2001; Dennison, 2003; Goodchild, et al, 2005) and quality control (Kamoshita, 1996). In addition, the more advanced literature highlights the complexities of false and unwanted fire alarm activations and reinforces the idea that it is more useful to adopt a multidisciplinary approach to the topic (e.g. Dooley, 2004; Lee, 2005).

The question is whether the literature has given any attention to the estimated economic and social costs or analyzed the profile and occurrence of false and unwanted fire alarm activations? Unfortunately, the empirical research on false and unwanted fire alarm activations is often restricted by a predilection for a singular approach and the topic is treated as a one-dimensional technical problem in which the hidden economic and social costs of false and unwanted fire alarm activations are frequently overlooked.

The purpose of this section is fourfold. First, examine the various debates regarding what constitutes "false" and "unwanted" fire alarm activations and arrive at suitable definitions that will be applied throughout the report. Second, highlight the extent of the problem concerning the false and unwanted fire alarm activations. Third, critique the literature on the costs of false and unwanted fire activations, focussing in particular on the costs associated with: a) anticipating the risk of fire (e.g. the installation and maintenance of fire alarms; b) false and unwanted fire alarm activations; and c) responding to false and unwanted fire alarm activations. Finally, an overview of the legislation framework pertaining to false and unwanted fire alarm activations will be presented and the responsibilities of the parties involved in fire alarm systems will be illustrated.

2.1 Defining "False" and "Unwanted" Fire Alarms

Arriving at a suitable definition of "false" and "unwanted" fire alarm activations presents several difficulties as there are a range of perspectives to be considered, each imposing its own emphasis and thereby creating its own biases. At its most simplistic, "a false" or "an unwanted" fire alarm activation is defined as:

> "A fire signal resulting from a cause other than a fire." (Office of the Deputy Prime Minister, 2004:2)

Or:

> "A signal transmitted by an automatic fire detection system reporting a fire where on the arrival of the brigade an uncontrolled fire has not occurred." (Tu, 2003:1)

However, these definitions belie the complexities that underpin "false" and "unwanted" fire alarm activations. Fire regulations both in New Zealand and overseas separate the terms: "unwanted alarms" and "false alarms". *Unwanted alarms* are those in which the either equipment has worked correctly but the alarm was unwarranted, for example, when cooking fumes trigger the smoke detector alarm or when the equipment is defective (e.g. faulty wiring), (HM Fire Service Inspectorate, 2001; Tu, 2003; also refer to British Standard BS 5839, 2002)[2]. Under the Fire Service Act, 1975, S47 C[4], the NZ Fire Service can claim partial reimbursement by charging $1,000 if they respond to an unwanted alarm.

False alarms are typically classified as either of "good" or "malicious" intent (Fire Service Act, 1975; Office of the Deputy Prime Minister, 2005). A false fire alarm of *good intent* occurs when a person or system generated the alarm believing a fire to exist, and this normally does *not* incur any cost to the person concerned or the building owners. However, a fire alarm as a result of a person *maliciously* setting off a fire alarm when no fire exists is an offence under the Fire Service Act, 1975, S88[c] and [d] and will incur a fine.

The distinctions between "false" and "unwanted" fire alarm activations are clearly set out by the New Zealand Fire Service as follows:

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[2] The New Zealand Fire Service note that: "A fire alarm system activation resulting from burning toast, for example, is generally an unwanted alarm, as repeated activations may be avoided by relocating or replacing toasters, or relocating or replacing smoke detectors. A false alarm arising from defective apparatus is an unwanted alarm whether or not the cause of the fault or faults was foreseeable and preventable through routine maintenance. Defective apparatus means defective fire alarm equipment not other apparatus like a vacuum cleaner that burnt out and activated a smoke detector."

"A "false alarm" is any call attended by a fire brigade, where there was no genuine fire or other emergency requiring intervention to prevent injury, death or property loss. There are three types of false alarm:

1. *A malicious false alarm* is where a person knowingly, wilfully or recklessly gives, or causes to be given, any false alarm of fire: a malicious false alarm is an offence under S88(c) and (d) of the Fire Service Act 1975;
2. *A false alarm of good intent* is where a person genuinely thought there was a fire or emergency, which later proved not to be true, such as steam mistaken for smoke; or
3. *An unwanted fire alarm* is a response to almost all other fire alarm system activations".

In recent times, definitions of unwanted or false alarm activations have become more inclusive, partly as a result of jurisdictions shifting from national fire safety standards to an integrated risk management system. Changes in the way false and unwanted alarm activations are now viewed is illustrated by the following UK definition:

> "[Unwanted/false fire alarms are] caused by the failure of a fire alarm and detection system as a result of a system malfunction due to poor design, poor installation or poor maintenance of that system and its components and/or caused as the result of poor management of the system or its surrounding environment." (*Fire*, 2004: 98)

Efforts have also been made to provide a better understanding of the root causes of false and unwanted fire alarm activations both in New Zealand and overseas[3] and to undertake a more comprehensive analysis of the data on the causes. These efforts have, in turn, brought about changes to the way such activations are catalogued[4]. For example, the New Zealand Fire Service, as well as other fire service agencies (refer to the British fire safety standards BS 5830 and MFB, 2005) now require monitoring organisations to categorise false and unwanted fire alarm activations as follows:

- *Unwanted Alarms*: alarms caused by fumes from cooking, steam, tobacco smoke, dust, insects, etc. as well as alarms due to faulty equipment;
- *Malicious False Alarms*: the malicious use of an alarm;
- *False Alarms with Good Intent*: these occur when an individual suspects there is a real risk of a fire and activates the alarm;

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[3] For a more comprehensive study of the different types of smoke and heat detection equipment and systems in the context of false or unwanted fire alarm activations, see Tu (2002) "Assessment of the Current False Alarm Situation from Fire Detection Systems in NZ & the Development of an Expert System for Their Identification" Department of Civil Engineering, Canterbury University.

[4] For more details refer, for example, to NZFS Codes of Practice on fire and heat detection systems, e.g. ` Code of Practice for the Automatic Fire Alarm System (28/4/2005) & `Certification for Automatic Fire Alarm Service Providers' (22/12/2005).

- *Unknown False Alarms*: where the cause could not be identified.

Within each of these broad categories, there are a number of sub-categories. For example, under the category of unwanted fire alarms there are a number of different causes, as outlined in Table 1 (Office of the Deputy Prime Minister, 2004; AFA Monitoring Ltd, 2005; Lee, 2005; NZ Fire Service 2005a)[5].

Cause	**Examples of Causes**
Building Work – Builders/Subcontractors	Builders, Concrete Cutters, Flooring Specialists, Painters Electricians, Data Technician, Lift Engineer, Plumbers, Water blasters, Air Conditioners/ Refrigeration Engineer, Cleaners, etc.
Device/Component Failures	Heat Detectors, Smoke Detectors, Manual Call Point (MCP), Sprinkler Pipe, Sprinkler Head, Sprinkler Valve, Panel Fault, Direct Brigade Alarm (DBA) Fault, Wiring, Battery, Water Leak, Transmitter, Lightning, End of Line (EOL), Anti-Interference Switch, etc.
Environmental Effects	Cooking, Toaster, Steam from Showers and Cooking, Smokers, Smoke Machine, Insects, Dust, Vehicle Fumes, Fluctuating Water Pressure, Hairsprays/Fly sprays, Candles/Incense, Heater Fumes, Water Leak, etc.
Incorrect Building Maintenance	Dirty Smoke Detector, Heater Dusty, Water Leak, Leaking Roof, No Call Point Glass, etc.
Poor fit for Purpose or Installation Fault	Heat Detector with Low Tolerance Temperature Limit, Improper Selection of Smoke Detector, Improper Installation, Different Detector, DBA Fault, etc.
Mechanical Damage	Forklift, Truck, etc.
Operator Error	Agent, Owner, etc.

Table 1: Sub-categories of Unwanted Fire Alarms
Source: NZ Fire Service (2005a)

A number of overseas jurisdictions use a causal and chargeable/non-chargeable category of false and unwanted fire alarm activations. Charges for false and unwanted fire alarm activations are largely based on a proportion of the costs of response, as detailed by Lee (2005) in Table 2. The New Zealand Fire Service also defines false and unwanted fire alarm activations in two ways. First, it cross-references the causal categories of both false and unwanted fire alarm activations with the different fire alarm systems – thermal, manual and sector panels. Second, New Zealand Fire Service further categorises false and unwanted fire activations in terms of "non-chargeable fire alarm activations" and "chargeable fire alarm

[5] Refer to Appendix 1 for another example of a detailed categorisation of unwanted and false fire alarm activations.

activations", as outlined in Table 3, in which the New Zealand Fire Service can charge $1,000. (plus GST) per unwanted fire alarm activation. The New Zealand Fire Service notes that the list of false and unwanted fire activations is not finite. However, for the purposes of this report, the authors will adopt the New Zealand Fire Service's categorisations of unwanted and false fire alarm activations.[6]

The rationale for charging owners of commercial buildings for false or unwanted fire alarm activations is outlined in the following New Zealand Fire Service press release:

> "Owners of commercial buildings with monitored fire alarm systems will now be charged $1000 for false alarms. This is part of a Fire Service push to reduce unwanted and avoidable false alarms by at least 30 percent. The new charge is double what building owners have faced in the past. Building owners will get two "free" false alarms, and the charge will apply to the third and subsequent call outs. However, Fire Service responses to genuine emergencies or calls made in good faith will not attract a charge ... The emphasis is on reducing false alarms, not making money. It applies only to commercial buildings with monitored alarms. It does not apply to homeowners. Constant false alarms reduce occupants' reaction to genuine calls and contribute to delays in evacuation. It also means a cost to business, the community and the Fire Service … The increasing number of alarm systems being connected is, in turn, increasing the false alarms … 40 percent of false alarms come from incorrectly installed, or unsuitable, smoke detection systems ….Twenty-four percent of false alarms are caused by component failure and about 18 percent by trades people working in buildings ... False alarms from fire alarm systems in New Zealand increased from 8247 in 1994 to 11599 in 1999… A Fire Service campaign to raise awareness among building owners is being run in conjunction with the Fire Protection Association, AFA Monitoring Ltd, the fire alarm industry, Fire Protection Inspection Services and the Property Council of New Zealand." (Mears, October, 2000)

Charging for responding to a false or unwanted fire alarm activation, however, is not necessarily straightforward and the literature and interviews with stakeholders highlight a number of issues – namely, whether or not to charge, who to charge (that is, the occupier or building owner or both) and how much to charge. In addition, there is debate as to the core purpose of charging for responding to false or unwanted fire alarm activations – is it a deterrent or a way of recovering lost revenue or both? To date these questions remain unanswered, however, as outlined in the next section, false or unwanted fire alarm activations are a significant problem.

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[6] Australian States also use causal and chargeable/ non-chargeable categories of unwanted and false fire alarm activations – refer to Lee (2005).

Jurisdictions	Charges
Metropolitan Fire and Emergency Services Board (Melbourne Metropolitan area).	$405.25 per 15 minutes per appliance time out of station
New South Wales Fire Board	$250
Queensland Fire Rescue Service	$860
Canada (Calgary Fire Department)	• First: No charge • Second: No charge • Third: $250 (Canadian dollars) • Fourth: $250 (Canadian dollars) • Fifth or more:$500 (Canadian dollars)

Table 2: Examples of the Charges for False and Unwanted Fire Alarm Activations
Source: Lee (2005)

Chargeable	Non-chargeable
Systems Maintenance: defective equipment, flat battery; corrosion of detectors; defective or absence of maintenance; fire alarm panel defect; system wiring defect; pressure drop within system	*Detection of heat or smoke* by a fire alarm for which the system was designed to detect
Building Maintenance & Internal Environment: flooding or water leaks; dirt or dust; humidity; insects, birds, rodents or other animals; high air flows/draughts	*Good Intent*: where the fire alarm was activated with good intent as the caller genuinely thought there was a fire or emergency
Building Usage: Dust or powder released during work process; fumes from chemical released during work process; fumes from hot work or machinery during work process; fumes from food processing (including toasters); fumes from vehicle exhaust or other combustion engines; fumes from fumigation activities; steam from bathrooms, saunas, steam rooms, boilers, etc.; aerosol spray from fumigation, painting or other work process; water vapour/mist from water blasting or other work processes; accidental alarm activation by moving objects	*Action of persons remote from the property*: for example workers creating dust or fumes on a public street or on a neighbouring property
Internal Occupant Activity: accidental alarm activation by any person (resident/ worker/contractor/visitor); malicious alarm activation by any person; alarm activation caused by other criminal activity on site (non-fire-related)	*Accidental activation by the alarm agent*: where the system has been activated by mistake by the agent
External Environment: lighting strike (insurance claim); flooding or leaks; power surge; water pressure drop; wind; radio interference	*Upgrade system*: when the building owner(s) agree in writing to upgrade the fire alarm system

Table 3: Chargeable and Non-chargeable Unwanted and False Fire Activations
Source: NZ Fire Service (2005a)

2.2 The Extent of the Problem

A number of countries and regions have endeavoured to assess the scale of the problem of false and unwanted fire alarm activations. In the UK it has been estimated that there were 477,100 false and unwanted fire alarm activations in 2004, in which (60%) were the result of false alarms activations, compared to 519,400 genuine fire callouts. In the US the total of reported genuine and false alarms has averaged about 3.6 million since 1980 (National Fire Protection Association, 2005). In 1993, there were approximately 1,646,500 false fire alarm activations in the US, in which the single largest cause was malfunctioning automatic fire alarm systems, resulting in an estimated 670,000 false fire alarms (Cholin & Moore, 1995). By 2003, US fire departments had responded to 2,189,5000 false fire alarms, a 3% increase from the previous year and equating to approximately 86% of all fire department responses (National Fire Protection Association, 2005). In Queensland during 2001 to 2002, only 1.4% of all fire alarm activations were due to a genuine fire (Queensland Fire and Rescue Service, 2005) and other Australian States reported similar figures (Lee, 2005).

These overseas trends in false and unwanted fire alarm activations are mirrored in New Zealand. In 2004, the number of false alarm activations and good intent calls in New Zealand was almost 13,000, approximately 92% of all fire alarm activations. As shown in Figure 1, there has been a 13% increase over 5 years.

Figure 1: New Zealand Fire Service Recorded False or Unwanted Fire Alarms

However, compared to the rest of the country, the Auckland CDB rates of false and unwanted fire alarm activations are high. Although the Auckland CBD represents only 1.5%[7] of New Zealand's population, as seen in Figure 2, it has 26% of New Zealand's false and unwanted fire alarm activations. Within the Auckland CBD false and unwanted fire alarm activations (that is, false and good intent alarm activations) represented 90% of all fire alarm activations in 2004.

[7] This percentage figure is based on both residents and workforce in 2004.

Figure 2: The Extent of the Problem in Auckland Compared to the Rest of NZ (2000-2004)
Source: NZFS, 2005

The types of alarms systems that generate false and unwanted fire alarm activations also vary. Figure 3 illustrates the number of false and unwanted fire alarm activations in Auckland by the different types of alarm systems. Given that automatic PFA's are the main alarm systems, it is not surprising that they cause the most false fire alarm activations (NZ Fire Service, 2005). In addition, the percentages of false fire alarms generated by PFA's are higher in Auckland than the rest of the country. However, there appears to be a gradual decline in the number of false fire alarm activations since 2000, as portrayed in Figure 4. We could speculate that the reason for this is that as PFA systems are replaced with more sophisticated and more appropriate models for the building use, they are less likely to be the cause of false alarms.

It is also possible to highlight the major sources of unwanted or false fire alarm activations using New Zealand Fire Service data. Activations "due to defective apparatus" account for the majority of responses by the fire services, as seen in Figure 5. Defective apparatus is also major source of unwanted or false fire alarm activations in the UK (54%) and the US (36%) (ODPM, 2005; NFPA, 2005). Unintentional or "accidental operations" fire alarm activations, triggered by things such as cooking, dust, the actions of trade people, etc, also resulted in many of the false fire alarm activations in New Zealand. There is empirical evidence that many of the false and unwanted fire alarm activations are as a consequence of the systems not being fit for purpose. That is, the alarm systems may be antiquated or inadequate or designed for a different building use. However, the key reasons for the high number of unintentional fire alarm activations are unclear.

Figure 3: False Fire Alarm triggered by Different Alarm Methods in Auckland CBD

Figure 4: Percentage of False Alarms from Auto PFA Systems

Figure 5: Major Sources of False or Unwanted Alarms in NZ

There is an indication from national and international fire response data, that some establishments are not only more prone to unwanted or false fire alarm activations than others but they are also more prone to a particular source of unwanted or false fire alarm activation. For example, in the UK, hospitals and related buildings were responsible for 56% of all unwanted or false fire alarm activations, while educational establishments and sheltered housing and hostels had activated 24% and 12% respectively of all unwanted or false fire alarms (UK Fire Brigade Union, 2005). Melbourne fire safety data also indicates that educational institutes, apartments and hospitals experience the highest number of false and unwanted fire alarm activations compared with other building types. Based on New Zealand Fire Service 2000 data, Figure 6 shows the establishments that had the highest number of false or unwanted fire alarm activations. However, it should be noted that it was not possible to identify all the types of buildings from the data as 82.5% of the entries were listed as "unknown". Nonetheless, the data indicates that throughout New Zealand commercial buildings had the highest number of unwanted or false fire alarm activations (42.5%) followed by residential (19%) and educational (17%), as illustrated in Figure 6 (New Zealand Fire Service, 2004). Typically, educational establishments have the highest number of unintentional and malicious fire alarm activations (New Zealand Fire Service, 2005). However, the question: "What are the most susceptible buildings to false and unwanted fire alarm activations in the Auckland CBD?" remains unanswered.

Figure 6: New Zealand Fire Service Data of Unwanted or False Fire Alarm of Different Establishments (2000)

The New Zealand Fire Service data not only gives us a snapshot of which establishments had the highest number of false or unwanted fire alarm activations 2000, but it also gives us an indication of the emerging “problem buildings”. That is, the data highlights those buildings which are becoming progressively worse and those which appear consistently at the lower end of the list. As those buildings with the highest number of false and unwanted fire alarm activations are approached by the New Zealand Fire Service and begin to remedy their chronic problems, thus reducing the number of false and unwanted fire alarm activations, other buildings begin to experience problems with their fire alarm systems and in turn take the place of those buildings with the highest number of false and unwanted fire alarm activations.

It is also possible to show the particular time of the year and particular time of the day the most false or unwanted fire alarm activations occur in the Auckland CBD.

This is illustrated in Figure 7and Figure 8. It is clear that while false and unwanted fire alarm activations peak around mid-day, genuine fires can occur at various times of the day or night, as indicated by comparing the figures below. However, what is not clear is the reason why false and unwanted fire alarm activations differed so dramatically in 2000 compared to subsequent years.

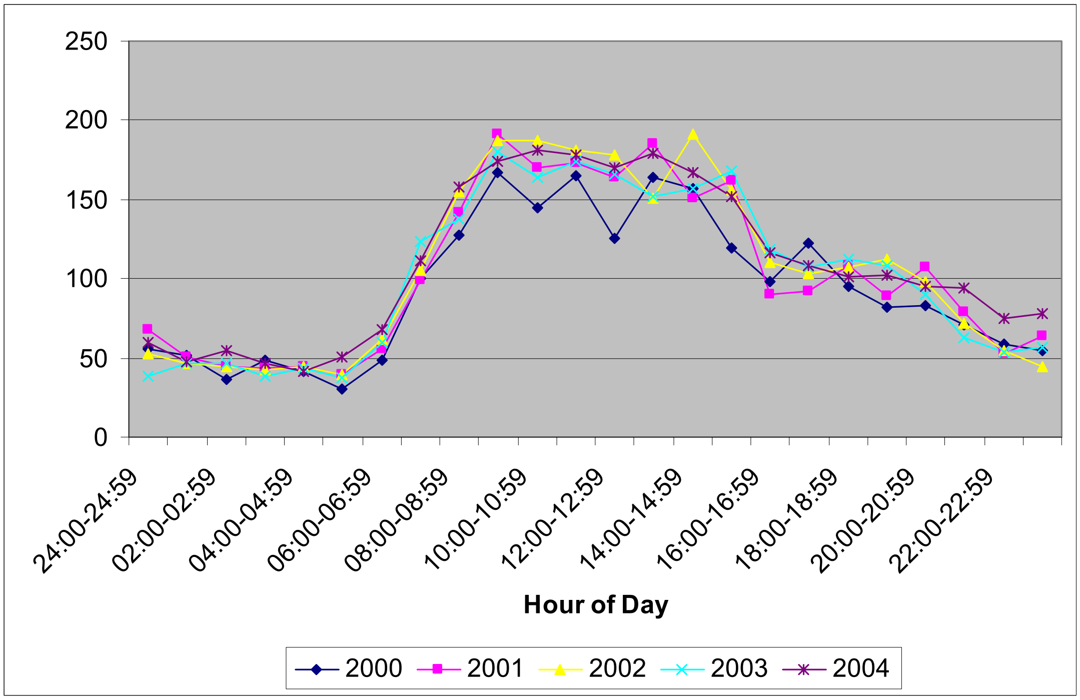

Figure 7: False & Unwanted Fire Alarms on the Day of Week in Auckland CBD in Total (2000-2004)

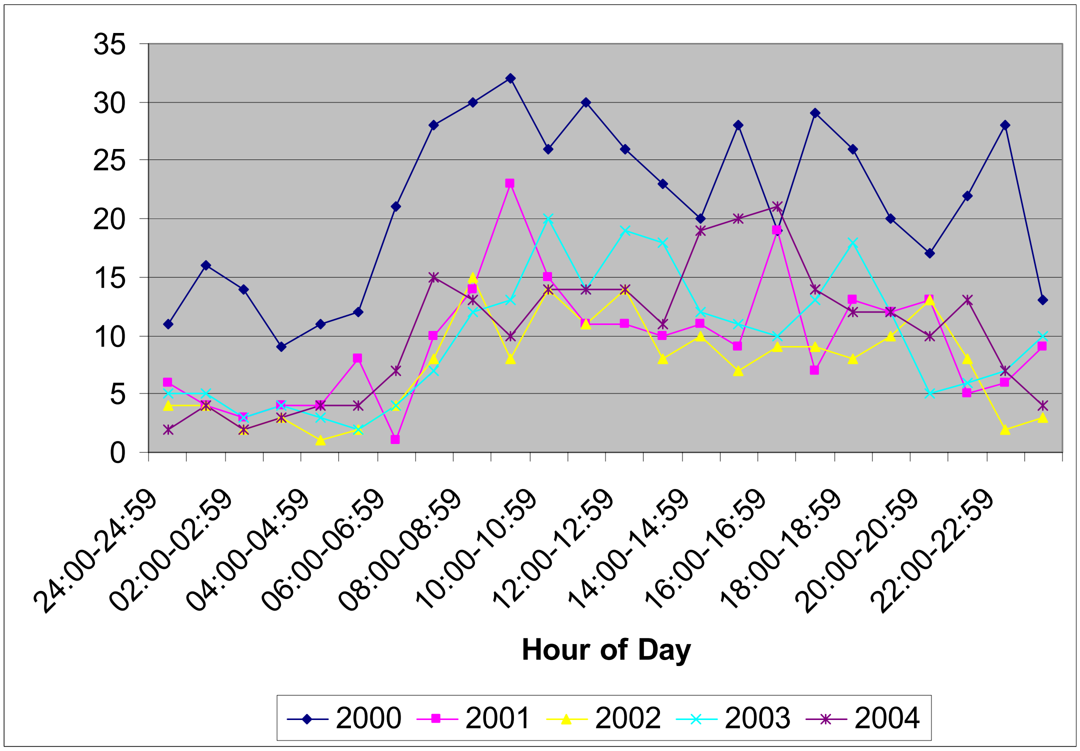

Figure 8: Genuine Fire Alarm in Auckland City (2000-2004)

In summary, international and national figures indicate that the levels of false and unwanted fire alarm activations have remained high. However, ascertaining the extent of the problem is reliant on the accuracy of data collection, documentation and analysis and typically, international and regional databases show this is not always the case. As with many other countries, the New Zealand Fire Service database had conflicting entries, inaccurate recording of events and “unknown” and “other” represents over two-thirds of all the entries. Moreover, the lack of standardization of the data impedes national and international comparisons. Nonetheless, with new recording systems being introduced in late 2005, major improvements to the way in which data on fire is collected and recorded in New Zealand (and internationally) are underway.

2.3 Costs of False and Unwanted Fire Activations

The cost of false or unwanted fire alarm activations has dominated recent government reports both in New Zealand and overseas[8]. In particular, more recognition has been given to the indirect economic costs as well as the *societal losses* (disruptions to daily life, the associated with false or unwanted fire alarm activations (ODPM, 2005).

There are a number of different ways in which these impacts can be categorised. In trying to determine the estimated costs of commercial and residential fires in the UK, Roy, (1997) and Dennison (2003), (as well as subsequent UK researchers), introduced an approach in which the total costs as a consequence of fire were broken down into three categories. The first category grouped costs associated with protection and prevention measures that prevent or mitigate the damage caused by fire. The costs in the second category are the costs of fire damage to property, individuals or the environment in which the costs are borne by a range of victims. The costs in the third category are those incurred as a result of the fire services responding to, extinguishing and clearing up after a fire.

Adapting Roy's and Dennison's classifications to accommodate false and unwanted fire alarm activations, the following categories have been developed and will be used as the basis for the subsequent discussion on the economic and social costs of false and unwanted fire alarm activations:

1. *Costs in anticipation*: these are installation and maintenance costs associated with fire alarm systems used to prevent or mitigate the fire damage. Underlying these costs are the principles of risk management.

2. *Costs as a consequence*: these are costs incurred by both business and the public as a result of false or unwanted fire alarm activations, for example, "opportunity costs", such as lost customers and loss of time. Fines can also be incurred for repeated false or unwanted fire alarm activations.

3. *Costs in response*: these are the costs incurred by the fire services as a result of attending false or unwanted fire alarm activations in terms of lost time, diversion of scarce resources, usage of equipment, reporting etc.

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[8] For a more detailed analysis of the cost of fire damage refer to *The Cost of Managing the Risk of Fire in New Zealand*, Goodchild, Sanderson, Leung-Wai and Nana, (2005:6), BERL, May 2005. According to Goodchild, et al, (2005:1) "The actual economic cost of fire to New Zealand is determined. Distinction is made between the costs of fire risk management (including the costs of reducing the risk of fire and the costs of readiness and response to fire) and the consequential recovery costs of an actual fire. These costs are allocated between residential, commercial and public sectors. The total cost of fire to New Zealand is estimated to be about $NZ1 billion per annum."

Costs in anticipation

The costs associated with anticipating and preventing fire through the installation and maintenance of fire detection and warning systems are predicated on the concepts of risk and risk management. Therefore, it is necessary to briefly examine these concepts prior to addressing anticipated costs associated with false and unwanted fire alarm activations.

Gordon (2002: 1) argues that the concept of "risk" and "risk management" contains the following key features:

- Risk is the possibility that harm may occur from an identified hazard;
- Risk analysis is the process of evaluating the frequency and consequence of the hazard;
- Risk control uses methods of reducing the frequency or consequences of a hazard; and,
- Risk management is the ongoing process of daily decision-making given the existence of an identified hazard and that all practical and reasonable measures have been taken to minimize any potential impacts it may have.

Attempts have also been made to contextualise "risk" and "risk management" within the parameters of fire safety engineering. For example, in his New Zealand report on the impact of fire alarms on safety, Enright (2003:3) defines fire risk as:

> "When defined as risk of an event or scenario, the combination of the probability of that event or scenario and its consequence [or] when defined as risk of a design, the combination of the probabilities and consequences of all events or scenarios associated with the design."

As part of a research project into fire safety design, undertaken by the Department of Fire Safety Engineering at Lund University[9], Frantzich (1998: 6) and Olsen (1999: 5) have defined risk as:

> "… the correlation between the frequency of an activity's possible failures and the consequences resulting from those failures. Risk is also a combination of the frequency, or probability, of occurrence and the consequence of a specified hazardous event…. The concept of risk always has two elements: the frequency or probability with which a hazardous event is expected to occur and the consequences of the hazardous event…. Risk can be seen as a measure of economic loss or human injury in terms of both the likelihood and the magnitude of the loss or injury…. Risk can also be expressed as individual risk or as societal risk…. Individual risk measures consider the risk to an individual who may be at any point in the effect zones

[9] A number of studies on fire risk management have emerged as part of the project, "Design Based on Calculated Risk" which is supported by The Swedish Fire Research Board (BRANDFORSK) and The Development Fund of the Swedish Construction Industry (SBUF).

of incidents, while societal risk measures consider the risk to populations that are in the effect zones of incidents.

In defining risk management within the context of fire safety, Olsen (1999: 5)[10] states that:

> "Risk management can be divided into three different steps. It is first necessary to calculate the risk by performing a risk analysis where systems are defined, hazards calculated and the risk estimated. Then the risk must be evaluated. These two steps can be called risk assessment. The final step is to take appropriate measures to reduce and/or control the risk." (Refer to Figure 9)

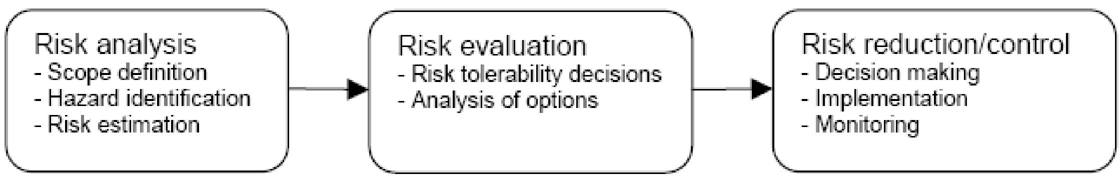

Figure 9: Model of Risk Management
Source: Fredrik Olsson (1999: 5) *Tolerable Fire Risk Criteria for Hospitals*, Department of Fire Safety Engineering Lund University, Sweden

Charged with reducing the incidence and consequence of fires under section 20 of the Fire Service Act 1975, the New Zealand Fire Service Commission has also adopted *a* risk management policy that informs all decisions concerning the operation of the Fire Service, in particular the way it seeks to promote fire safety (New Zealand Fire Service, 2005). As with other similar risk management models, the New Zealand Fire Service model rests on two principles. First, that there is a likelihood that a fire threat or fire hazard exists and will produce a fire, and second, that there is a likelihood that an exposure of a given value (represented by the people, property, heritage, environment or disruption affected) is present when the fire occurs. In addition, the practice of risk analysis plays an important role in helping Fire Service managers identify target audiences for fire safety promotional programmes and develop strategies for managing responses to private fire alarms (New Zealand Fire Service, 2005). In particular, risk analysis has been applied to measure the New Zealand Fire Service's resources, evaluate station locations and staffing levels, target risk reduction activities, and develop messages that promote fire safe practices (New Zealand Fire Service, 2005).

However, the Australasian Fire Authorities Council's (AFAC) Committee on Unwanted False Alarms Reduction (2005:7) argues that risk management is not the sole responsibility of the fire service and that preparedness must involve the community. In particular they state that:

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[10] For a more detailed analysis of risk management, refer to Frantzich, Håkan (1998) *Uncertainty and Risk Analysis in Fire Safety Engineering*, Lund University Sweden, Institute Of Technology Department Of Fire Safety Engineering, Report Lutvdg/(Tvbb-1016).

> "A preparedness of the community to create a culture that: (1) allows the developer and the architect to design coordinated system installations that maximise the potential of the automatic fire alarm system, air-management ducting, system quality, external/internal environment considerations; (2) the community's culture places performance first, rather than avoidance of performance standards in the name of alternatives to achieve minimal cost incursions to meet Building Code obligations; and (3) the developer has responsibility for the satisfactory performance of the automatic fire alarm system for the first 6 years of the premise's operation. The level of business and public infrastructure growth and complacency, which is occurring in Australia and New Zealand, highlights a correlation between increased 'Unwanted False Alarms' and the consequential need to reduce those incidents in order to improve public safety."

Anticipating the risk of fire also necessitates the installation and maintenance of fire alarm systems (Enright, 2003)[11]. Such systems range from single battery-operated smoke alarms to a sophisticated digital automatic smoke/heat automatic fire detection and alarm system. Irrespective of the type of fire alarm system, Proulx (2000:1) notes that there are four principle objectives for any fire alarm system. They are:

1. Warn occupants of a fire;
2. Prompt immediate action;
3. Initiate evacuation movement;
4. Allow sufficient time to escape.

However, not all the various forms of fire detection are suitable for every application. In order to specify the appropriate form of fire detection for any application, categories have been developed. For example, the British standard BS 5839-6:2004 for "the Design of Fire Detection Installations for Dwellings", defines six different "grades" of system, from Grade A being the most sophisticated, to Grade F being the simplest form of fire alarm, (see Todd, 1998: 28). In New Zealand, Department of Building and Housing (2005) has issued regulatory descriptions and usage for fire alarm systems. More specifically, the types of fire alarms to be provided in buildings "…shall be determined in accordance with Part 4 of Approved Document C/AS1, (Department of Building and Housing, 2005:13). Under the New Zealand Building Code F7/AS1, different types of fire alarm systems have been categorized in terms of their suitable application, as outlined below in Table 4.

Type 1 Domestic Smoke Alarm System	Type 5 Automatic fire alarm system with modified smoke detection and manual call

[11] See the 2003 NZ Fire Service Commission Fire Research Report, *Impact on Life Safety of the Type 5 Alarm* by Enright for a more detailed account of the linkages between fire risk management and fire alarms.

	points.
Type 2 Manual fire alarm system	Type 6 Automatic fire sprinkler system with manual call points.
Type 3 Automatic fire alarm system activated by heat detectors and manual call points	Type 7 Automatic fire sprinkler system with smoke detectors and manual call points
Type 4 Automatic fire alarm system activated by smoke detectors and manual call points	Type 8 Voice communication system

Table 4: Types of Fire Safety Precautions[12]
Source: "The Approved Document for NZ Building Code Fire Safety Clauses" 2005.

As indicated above, there are also a number of potential failures of fire alarm systems, for example: failure to maintain the system, inappropriate system for building use; human error or action (e.g. accidental activation or activation based on good intent or malicious activation). Studies show that the lack of maintenance of the alarm systems and the installation of alarm systems that are not fit for the purpose of room or building are some of the major causes of false fire alarm activations (Bukowski & Reneke, 1999; Davis, 2000; Rodricks, 2000; Gottuk, et al 2000; NEMA, 2002; Liu & Kim, 2003; Freestone, 2004; Ahrens, 2004; Lee, 2005). For example, in a recent survey of the operational status of 46,339 fire alarm systems conducted by the California State Board of Fire Services, 73% of the respondents cited lack of maintenance for the cause of system failures (National Electrical Manufacturer's Association (NEMA), 2002).

In a New Zealand study of false alarms, Tu (2003: 84) argues that the top three causes for false and unwanted fire alarm activations are building work, component failure and environmental effects. He adds that seasonal effects on false fire alarm activations are not obvious from the fire call data provided. He concludes that fire alarm systems installed before 1995 have a very high component failure rate, whilst the systems installed later are more susceptible to failure due to environmental effects. In addition, it appears that the longer the system has been installed, the less familiar a technician will be with its components.

Proulx (2000) also states that the degree to which fire alarm systems are effective in terms of alerting people to evacuate varies widely and depends on the building and the occupancy. For example, school teachers and pupils appear to have a high degree of compliance to fire safety rules and procedures while shoppers in large malls tend to ignore fire alarms. Proulx (2000) notes that occupants may ignore a fire alarm signal for one of three reasons:

- Failure to recognize the signal as a fire alarm
- Loss of confidence in the system because of nuisance alarms
- Failure to hear the signal.

[12] Refer to Appendix 2 for a more detailed description of types of fire safety precautions. Also refer to Enright (2003) *Impact on Life Safety of the Type 5 Alarm*, Connell Mott MacDonald, NZFS.

Costs associated with preparedness (e.g. evacuation plans, etc) and the correct installation and maintenance of fire alarms and smoke detectors are also promulgated by legislation, for example, the Building Act, 2005 (in particular, the 2005 Approved Document for NZ Building Code Fire Safety Clauses – Part 4 Requirements for Fire Calls, pursuant under the Building Code 1992), Fire Service Act, 1975, the Fire Safety and Evacuation of Buildings Regulations, 1992 and Health and Safety in Employment Act, 1992 (see below for a more detailed discussion). Such costs are borne by building owners and tenants[13], as Goodchild, et al, (2005:11) note:

> "Compliance costs for building owners relate to expenditures on establishing building evacuation schemes and undertaking trial evacuations. Trial evacuations also affect building tenants and owner-occupiers through opportunity costs associated with short periods of employee down-time."

Parallel to the discussions on the problems associated with the installation and maintenance of fire detection and warning systems are proposed strategies *on how to reduce* the number of false and unwanted fire activations. The most common strategies listed in the literature[14] are:

1. Consideration of local factors including, but, not limited to, demographics, economics, political climate, size and costs;
2. Thorough investigation and evaluation of all known possible programmes;
3. Consistent and regular review of effectiveness of the programmes;
4. Provision of adequate staff to administer the programme;
5. Inclusion of appropriate representatives from at least the following constituencies in developing the local programme:
    - Law Enforcement,
    - Legislators
    - Alarm Industry
    - Citizens
    - Business Community
6. A process that all of the parties can take ownership in.

Thus, the costs associated with anticipating and preventing fire are based on the notions of anticipating and managing *risk* in which the corollary is the installation and maintenance of fire detection and warning systems. However, the question

13 For a more detailed discussion on compliance with fire safety regulations see Lamm et al (2003) *Fire Safety in Small Tourist Accommodation Businesses: Working Towards Developing Best Practice Models,* New Zealand Fire Service Commission, Wellington. Also see BRE (1996) *Quantifying the cost of Meeting Building Regulations Fire Safety Requirements in New Buildings*.

14 See False Alarm Reduction Association (FARA) (2002) "False Alarm Reduction Strategies White Paper" for an overview of the most common reduction strategies. Also see Australasian Fire Authorities Council (AFAC) 'Unwanted False Alarms Reduction Committee: Business Plan 2005-2010' (2005) Report that advocates strategies involving all stakeholders in the reduction of unwanted false alarms as outlined in Appendix 3 .

remains: "*Is it possible to arrive at a cost for fire risk management?*" The literature is united in the opinion that it is not easy to obtain reliable estimates on costs of fire risk management and that, though the principles involved are straightforward, the identification and measurement of the costs are much less so. As Roy (1997: 6) notes: "…the overall design of any given building is likely to provide a given level of fire safety; in choosing it there would be a rather complicated *trade-off* between design, fire safety, cost and other advantageous or disadvantageous features (including any non-monetary inconveniences to occupants)." Johansson (2001:1)[15] adds that a more useful approach to investigating the costs associated with fire risk management is to *analyze the normative decision-making processes of individuals.* That is, examine why individuals choose to install particular fire alarm and smoke detector systems; and determine if the decision is based on cost or safety or both. Taking Johansson's premise further, fire safety scholars have begun to link research on the public's decision-making processes concerning safety and the behaviour of individuals during a fire. In particular, there is growing recognition that the investigation of both public behaviour during the threat or occurrence of a fire *and* the costs of fire damage are useful starting points to determine effective risk management strategies and the associated costs (Baron & Pate-Cornell, 1999; Mitchell, 2001; Firenze, 2005).

In spite of the fact that it is a complicated and difficult task to obtain reliable estimates on costs of fire risk management, Goodchild, et al. (2005:6) have attempted to provide approximate New Zealand figures. They state that the total cost of fire risk management in New Zealand is "…estimated to be $690-$700 million per annum or about 0.54% of total nominal Gross Domestic Product". As outlined in Table 5 they add that:

> "…risk reduction accounts for about 64% of the risk management costs with readiness and response accounting for the remaining 36%. The household sector accounts for a very small proportion of the fire risk management costs (but a large proportion of the recovery and consequence costs). Overall, fire risk management costs are dominated by fire protection measures in commercial buildings, and the readiness and response costs of providing emergency services in the public sector." (Goodchild, et al., 2005:6)

	Household	**Commercial**	**Public**	**All sectors**
Risk reduction $ million % of total	$77 11%	$297 43%	$72 10%	$446 64%

[15] For more details on the relationship between cost, decision-making analysis (in particular, Bayes theorem) and fire risk management refer to Henrik Johansson (2001) *Decision Making in Fire Risk Management*, Department of Fire Safety Engineering, Lund University, Sweden, Report 1022, Lund.

Readiness and response $ million % of total	 $0 0%	 $17 2%	 $232 33%	 $249 36%
Costs of risk management $ million % of total	 $77 11%	 $314 45%	 $304 44%	 $695 100%

Table 5: The Composition of Risk Management in New Zealand
Source: BERL, Goodchild, et al., 2005:6

In summary, the costs associated with fire safety preparedness are part of the costs of managing risk and occur at various stages of the risk management process – namely, the costs incurred with the initial installation of fire detection and warning systems and the costs associated with their maintenance. There are also economic and social costs associated with the inappropriate installation, damage and poor maintenance of the fire alarm systems. A number of strategies have been developed to overcome such problems. For example, in order mitigate the inappropriate installation of fire detection and warning systems, fire safety agencies have categorized fire detection and warning systems. Yet, as New Zealand and overseas fire activation figures show, the number of false and unwanted fire alarm activations has not substantially reduced and, as a result, there has been increasing attention on the costs resulting from unwanted or false fire alarm activation.

Costs as a Consequence

As a consequence of false and unwanted fire alarm activations, there are a number of social and economic costs[16]. That is, there are costs incurred by businesses and the public in terms of lost revenue, lost opportunities, lost customers (which may result in a gain in orders for another competing firm), lost goodwill and inconvenience as well as employee downtime (Roy, 1997; Tu, 2003; Goodchild, et al., 2005). The costs for business can also be viewed in terms of short-, medium-, and long-term costs. For example, there are costs associated with an evacuation in terms of short term adjustments for individuals, such as momentary employee down-time, (ODPM, 2005: 17). There may also be some long-term economic costs for business if false and unwanted fire alarm activations occur on a regular basis requiring frequent evacuations.

There have also been attempts to provide a monetary figure for the costs associated with the consequence of false and unwanted fire alarm activations. For example, in the UK, the cost of false and unwanted fire alarm activations is estimated to be approximately £1 billion per year, (HM Fire Service Inspectorate, 2001; Office of the Deputy Prime Minister, 2005). It has also been estimated that false fire alarms can cost a UK medium-sized company up to £126,000 per year (Office of the Deputy Prime Minister, 2005: 2). In the report entitled *The Economic Cost of Fire: estimates for 2003*, international comparisons of estimated costs of fires (including false fire alarms) have been made across four countries, (Office of the Deputy Prime Minister, 2005: 28). As indicated in the Figure 10, in the USA and Canada, costs are high (1.8% and 1.7% respectively) compared to the other countries. However, economic losses are greater in England and Wales and Denmark when compared with the USA and Canada. According the authors of the report, the costs as a percentage of national income vary between 0.9% in Denmark and 1.8% in the US (2005:28). They argue that:

> "This difference can partly be explained by the category 'other economic costs', which has not been included in estimates for Demark and England and Wales, but has been for the USA and Canada. This category largely consists of estimates of the cost of building fire protection into equipment other than buildings (for example, computers). " (Office of the Deputy Prime Minister, 2005: 28)

[16] Although most of the literature is concerned with the cost of *fire damage*, it should not be excluded as there are a number of key similarities germane to this study, particularly the cost associated with the losses for business (e.g. Office of the Deputy Prime Minister's report *The Economic Cost of Fire: estimates for 2003*, (2005).

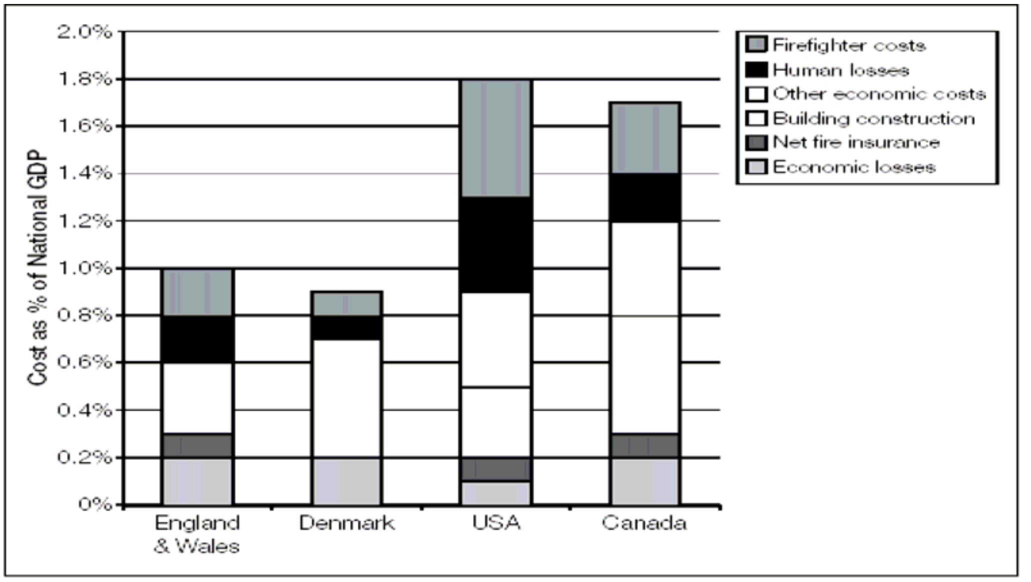

Figure 10: International Comparisons of the Economic Cost of Fires
Source: Office of the Deputy Prime Minister, 2005: 28.

In a regulatory impact assessment report on fire damage and false fire alarms undertaken by the Fire and Resilience Division of the Office of the UK Deputy Prime Minister, the authors note, however, that:

> "It is difficult to calculate the cost savings for business in terms of false alarms. These will vary depending on whether an evacuation of the building is necessary, and on the amount of 'downtime' involved. However, the cost per hour of a false alarm in a large department store has been estimated at between £30,000 and £50,0000. In general, the cost of false alarms to small businesses is difficult to establish. Few of the businesses consulted as part of the Small Firms Impact Test were able to give an assessment of the full cost of false alarms. However, if we take into account only the lost labour, and not the lost output, we estimate the cost of each false alarm to a small business with an average of 6 employees is a minimum of £100 (based on the average hourly labour cost of £14: at managerial level this rises to £22.80). For the purposes of the cost/benefit assessment, and taking into account the number of small businesses in England and Wales, we estimate a broad range of savings between £1m and £3m (on the basis that each false alarm lasts for about one hour of a firm's time). If the cost of lost output were included, this figure would of course be larger." (ODPM, 2003: 7)

In New Zealand, Goodchild, Sanderson, Leung-Wai and Nana, (2005:25) state that the estimated cost of false fire alarms is approximately $46.2 million per annum, which includes the New Zealand Fire Service false alarm revenue of $1.5 million, as outlined in Table 6 below. In addition, the authors note that false fire alarms are estimated to account for 18% of the total New Zealand Fire Service appliance hours, representing about $44.7 million per annum in terms of New Zealand Fire Service operational recourses (Goodchild, et al., 2005:25).

	Commercial	**Public**	**Total**
False Fire Alarm Revenue	$1.2m	$0.4m	$1.6m
Opportunity costs (e.g. employee down-time, lost customers, etc)	$0.7m	$0.2m	$0.9m
NZFS Resources		$43.8m	$43.8m
TOTAL	**$1.9m**	**$44.4m**	**$46.3m**

Table 6: Summary of Estimated False Fire Alarm Costs
Source: Goodchild, et al., 2005:25

Goodchild, et al. (2005:13) also note that there are *opportunity costs* associated with employee down-time from evacuations – whether or not the evacuations are planned or as a result of false or unwanted fire alarm activations[17]. Using regression equations based on a sample of local council areas and based on the average number of FTEs (full-time equivalent employees) per non-residential building, Goodchild, et al. (2005:13) estimate that:

> "The total number of FTEs in trial evacuations is estimated to be about 279,025 per annum. This total is dominated by the cities, which account for 55% of evacuations and 61% of FTEs. Based on NZFS response times it is estimated that the average duration of an evacuation for employees is 20 minutes, which indicates that total employee down-time is about 93,000 hours per annum. These hours are converted into a monetary value based on an average FTE wage per hour. The total opportunity cost of evacuations is estimated to be about $1.8 million per annum.

However, the overseas literature warns that it is *impossible to calculate precisely the true economic and social costs of false or unwanted fire alarm activations* and ipso facto, the New Zealand figures should be treated with caution and that NZ estimates of $46.2 million per annum are possibly conservative (Roy, 1997; Dennison, 2003; ODPM, 2003, 2005, Unwanted False Alarms Reduction Committee, 2005). Moreover, it is frequently unclear as to *how* the exact figures have been calculated.

[17] Goodchild, et al (2005) gives an indication as to how they calculated the "opportunity costs" in their report (pages 12-15) in which they state: "The magnitude of *opportunity costs* associated with employee down-time from evacuations depends on the number of employees per non-residential building. This parameter will change according to a number of factors such as the population size and density of the area in question. The average number of FTEs per non-residential building was estimated by BERL using regression equations based on a sample of local council areas."

Direct comparison of the costs between countries is also difficult as there is little or *no common methodology* to estimate the costs of false or unwanted fire alarm activations. Therefore, comparing costs and specifying exact figures of false or unwanted fire alarm activations can, at best give us an indication of the scale of the problem and it may be more useful to examine the *different forms* these economic costs take.

Implementing effective solutions for false or unwanted fire alarm activation is also fraught with problems, as Blackstone, Hakim, and Spiegel (2001:26) note:

> "Local jurisdictions differ in their methods of coping with the problem; they use cost recovery, punitive, technological, and educational methods. Unfortunately, most methods fail, have a temporary impact, or involve high transaction costs and unjustified cross subsidization. From an economic viewpoint, the solutions are either inefficient or inequitable or both. The reason for the failure is that consumers, dealers, and central stations lack the motive to eliminate false activations."

They conclude that only fire services are truly motivated to eliminate the problem as they bear most of the costs in terms of responding to fire alarm activations. As stated earlier, one of the primary ways in which fire services deter repeated offenders is to charge for responding to false and unwanted fire alarm activations[18]; as noted in the Australian Fire Authority Council report (2003: 6): "… charging is an important false alarm prevention strategy". In New Zealand the penalties outlined in the Fire Service Act, 1975, Sections 47C(4) and 47C(5) provide an incentive for alarm owners to inspect and maintain their systems and take corrective action to prevent false alarms. Charging for repeated false and unwanted alarm activations began in earnest in the early 1990s and initially slowed the rising trend in unwanted fire alarm calls-outs. By 2000, however, the numbers had begun to substantially increase and this prompted the New Zealand Fire Service to charge $1,000 (plus GST) per unwanted fire alarm activation. In 2003, it was estimated that 97% of all fire calls were false alarms or were not genuine fires, however, the NZ Fire Service only charged for approximately 11% of these calls[19]. In addition, interviewees from the New Zealand Fire Service noted that some Auckland businesses and residential apartment blocks had accumulated fines of between $10,000 and $15,000 for repeated false or unwanted fire alarm call-outs – a financial burden not only for business owners and residents but also for the New Zealand Fire Service.

It is clear, therefore, that calculating the consequential economic and social costs of false and unwanted fire alarm activations is not an easy task and that, although there have been valiant attempts, the figures are open to criticisms. It may be more

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[18] For example, Swedish Rescue Services Agency (2004) `Unwanted alarms from automatic fire detection systems' http://www.srv.se/. Bushby, S. (2001) `Integrating Fire Alarm Systems with Building Automation and Control Systems, *Fire Protection Engineering*, Summer, pp5-11.

[19] Ibid

prudent, therefore, to provide a model that can be used by the New Zealand Fire Service, fire safety engineers, property managers, etc. to estimate the social and economic costs of false and unwanted fire alarm activations. Furthermore, the lack of standardised, rigorous and valid data makes the task almost impossible. Identifying the root causes and applying preventative strategies appears to be a more useful approach. However, such an approach is not without its weaknesses and the strategies being developed in both New Zealand and overseas are still in their infancy and require more evaluated research to indicate their success or otherwise.

Cost of response

The need to reduce the costs associated with responding to false or unwanted fire alarm activations has generated a great deal of discussion, particularly from fire service and related government agencies. One of the starting points of the discussion is an understanding of the nature of response services, such as the fire service. Services can be either public good or private good. In most countries, fire services are treated as a "public good" in which their purpose is to provide rapid mitigation of fire, rescue and medical emergency services as well as maintain a safe community with public education and fire prevention (New Zealand Fire Service Commission, 2005). Buck, Blackstone, and Hakim, (2004: 3) argue that:

> "Economic theory should be applied in the search for an optimal solution to the false alarm problem. Efficient provision of response to requests for emergency services, including alarms, requires understanding the nature of the service. Services can be either public goods or private goods. The categorization hinges on whether non-payers can be excluded from consumption (excludability) and whether consumption by one person reduces the amount of the service available for others (rivalry) … It is very costly or even impossible to exclude anyone from consuming a public good, and each and every person consumes the full amount of the output. Without government forcing all to share the cost, each person would have a strong motive to become a "free rider", or to pay less than the socially optimum amount. Thus, there is essentially no alternative but for government to take responsibility for the supply of public goods."

As fire departments cannot presume a call is a false or unwanted alarm and therefore must respond as they would to a fire, such activations have a major impact on the fire service for the following reasons[20]:

[20] *See* "The Future of the Fire Service: reducing risk, saving lives - The Independent Review of the Fire Service (known as the "Bain Report") December 2002; Tu (2002: 9); Sampson (2004: 6)

- False and unwanted fire alarm activations divert essential resources, rendering them unavailable, with the possibility of delayed attendance to further calls;
- The false alarms also impose financial burdens on fire authorities in relation to fuel costs, wear and tear on appliances and additional maintenance.
- Mobilising creates risk to fire crews and members of the public when appliances are responding under emergency conditions;
- They are disruptive to work routines, particularly training and community safety activities;
- The effect on personnel attending a high number of false and unwanted alarm activations is demoralising;
- They impose an additional financial burden on the Fire Service, particularly in respect of part-time turnout fees and fleet costs;
- Increased overtime payment to staff;
- They adversely impact upon employees who release part time staff for operational duties.

It is also recognised that the above negative impacts will incur monetary costs. Typically, the response costs are allocated to different incident types on the basis of the staff hours spent attending them. These hours are calculated from fire response statistics detailing the average amount of time spent by fire appliances at each incident and an assumption of the number of fire-fighters operating each appliance (the "ridership factor") (Roy, 1997; Weiner, 2001; Goodchild, et al., 2005:25). Also the cost of responding to false or unwanted fire alarm activations are frequently included in the total cost of fire since false alarms would not occur without the risk of fire (ODPM, 2004). The HM Fire Service Inspectorate (2001) goes further and calculates that a false or unwanted fire activation takes:

- A minimum of 30 minutes to respond;
- An average response of two appliances and 8 personnel;
- As well as the fuel costs, wear and tear on appliances and additional maintenance[21].

However, there are a number of issues that need to be taken into account when endeavouring to calculate the costs associated with responding to false or unwanted fire alarm activations. Firstly, Goodchild, et al. (2005:25) warn that "implicit in these *incidence-based* allocation methods is the assumption that the cost of operational readiness (standing costs, overheads, etc) can be apportioned between fire and non-fire risk on the same basis as the appliance time spent on response and suppression". That is, the majority of personnel, equipment and stations would still be required even if fire protection was the only service provided by fire brigades, and that the provision of non-fire services has only been made on an incremental cost basis (Goodchild, et al. 2005:25). In New Zealand, the level of operational

[21] Tu Yen-Fang (2003) also applied the UK equation to his New Zealand research on false fire alarm activations.

readiness, however, has been dogged by controversy and has been the source of a decade of industrial dispute (Rasmussen & Lamm, 2002). The times when professional fire-fighters are not attending emergencies is regard by some as "non-productive" and "costly" during which personnel are "lazing around" (ibid). However, Fryer (2000) argues that such views do not take into account the nature of the occupation or the principles of risk management.

Secondly, in the short-run, the marginal cost of attending an additional fire (false/unwanted or genuine) is likely to be significantly below the average cost, since most fire services operate with sufficient spare capacity to enable them to respond to every incident (ODPM, 2004:19). Therefore, caution should be exercised when assuming that the cost of response would be a realisable saving in the event of preventing a given number of false or unwanted fire alarm activations. Thirdly, in the vast majority of jurisdictions, the cost of responding to false alarms is not recouped through fines and jurisdictions that try to recoup costs generally omit the lost-opportunity costs, potentially a significant part of the equation (Sampson (2004: 6). Finally, the costs of responding to false or unwanted fire alarm activations within New Zealand will differ substantially across regions, thus distorting any national estimated costs. Therefore, it is more productive to focus on *one geographical area* in New Zealand.

There is also growing debate as to how best to respond to fire alarm activations, given that most will be false or unwanted. Lee (2005) argues that there are three levels in which fire services can attend emergency situations. At the first level, the fire service provides an immediate emergency response in which a full squadron of fire-fighters will be dispatched. At the second level, in the absence of any confirmation call, the fire service will attend, based on a risk assessment of the fire fighting requirements. However, the attendance may be "…made *under non-emergency conditions*, thereby maintaining the availability of resources for other confirmed emergencies and protecting the public from the risk that arises from fire engines responding under emergency conditions" (Lee, 2005:23).

At the third level, fire services do not respond until a confirmation of fire is received from the premises using the 999 or 111 systems. Once a confirmation has been made, an emergency response may be initiated, "…resulting in an initial attendance based on an assessment of the fire fighting requirements that will be not less than one fire engine, (Lee, 2005: 23).

The causal loop diagram[22], outlined in Figure 11, provides a graphical illustration of the numerous interconnected factors that impact on the costs of responding to false and unwanted fire alarm activations for the fire service.

[22] Refer to the section below "Language Data Analysis & Causal Loop Diagrams" for a more detailed description of the different notations.

Figure 11: Fire Brigades and False Alarm Loops
Note: Factors that move in the same direction are notated by an **s** or a positive **(+)** sign. Factors which move in opposite direction are notated by an **o** or negative **(–)** sign.

In summary, the costs associated with responding fire call outs are considerable set against a backdrop of stretched fire service resources. There has also been national and international concern, for example the so-called "Bain Report" (2002), on how fire departments can best service their communities more effectively and efficiently. As a result reducing false and unwanted fire alarm activations has become a priority but how this can be achieved is still debatable.

2.4 Legislation

New Zealand's legislative approach to fire safety has been influenced by a number of countries, particularly the United Kingdom and Australia and visa versa. As a consequence, these countries share many common fire safety issues, although they do so under different conditions. The purpose of this section is to outline the key points of the current fire safety legislation. However, given the limited scope of this section, it is impossible to give attention to the legal minutiae of the different fire safety statutes.

As outlined in Figure 12, the main legislation[23] covering fire alarm systems and evacuation procedures is as follows:

- Building Act, 2004 (Amended 2006); and the 2005 Approved Document for NZ Building Code Fire Safety Clauses – Part 4 Requirements for Fire Calls, pursuant under the Building Code 1992
- Fire Service Act, 1975
- Fire Safety and Evacuation of Buildings Regulations, 1992;
- Health and Safety in Employment Act, 1992.

The various pieces of legislation control different aspects of fire safety, in particular, the installation and maintenance of fire alarms. Not only are there a number of governmental regulatory agencies responsible for administering each of the statutes and regulations but there are also an assortment of stakeholders, ranging from private companies with inspectorate roles to those owner/occupiers who are required to comply. However, the complexities of the legislation and the various enforcement agencies have created a great deal of confusion. Public submissions made to government clearly show that the proliferation of fire safety regulations is one of the most contentious issues facing New Zealand businesses (Ministerial Panel on Business Compliance Costs, 2001). The debate surrounding fire safety in New Zealand is to a large extent concerned with the key differences between the Fire Service Act, 1975 (administered by the New Zealand Fire Service) and the Building Act, 1991 (administered by local territorial authorities)[24]. Primarily these differences arise out of a variation of emphasis in each of the statutes which in turn creates public confusion. This has been highlighted in the case study data.

[23] Forest and Rural Fires Act and Regulations 1977 are concerned with the control of vegetation fires and therefore not directly relevant to this study.

[24] For more details on both the review of the fire legislation and the current statutes, refer to http://www.dia.govt.nz/diawebsite.nsf/wpg_URL/Legislative-Reviews-Review-of-Fire-Legislation-Index?OpenDocument.

Figure 12: The Main Statues Pertaining Fire Alarm Systems and Evacuation Procedures

The Building Act, 2004, Building Code, 1992 and Codes of Practice

New Zealand building legislation is concerned with the regulations pertaining to the construction of buildings and provision of a safe building for the occupier. The Building Act, 2004 is the primary statute and outlines the legal proceedings, offences and fines and also details the responsibilities of the different agencies involved. It applies to the construction, alteration, demolition and maintenance of new and existing buildings. The purpose of the Act is to ensure that:

(a) people who use buildings can do so safely and without endangering their health; and
(b) buildings have attributes that contribute appropriately to the health, physical independence, and well-being of the people who use them; and
(c) people who use a building can escape from the building if it is on fire; and
(d) buildings are designed, constructed, and able to be used in ways that promote sustainable development.

Under the Act, the territorial local authorities' building technical advisors are responsible for overseeing the Act's fire safety requirements, including fire alarm systems. The New Zealand Fire Service is also charged with giving "alternative design" building consents for certain applications and ensures that those involved in the building work provide protection by limiting the extent and effects of the spread of fire, particularly with regard to household units (whether on the same land or on other property); and other property (refer to Section 4 and Sections 46-52).

Pursuant under the Building Act is *the Building Code, 1992*, which sets out the mandatory construction requirements for all building work in New Zealand. Similar to other overseas building codes, such as those in the UK and Canada, the format of the New Zealand Building Code is performance-based, although it has maintained its prescriptive requirements, such as the calculations required for any occupancy with fire loads exceeding 1500 MJ/m (Bukowski, 1996). The emphasis is on how the building must be designed and constructed (Department of Building and Housing, 2005).

However, the legislative emphasis on building codes rather than on fire safety implies that:

1. Fire safety is not of intrinsic concern under the building legislation, except insofar as fire safety may have a direct bearing on the purpose of the building;
2. Fire safety is not given equal weighting with building restrictions (such as height to boundary, etc.);
3. There are fundamental differences in the legal test of compliance in the Fire Service Act and the Building Act - that is, the latter applies a more lenient legal test of safety, taking into account mitigating factors and with punishment in the nature of fines;
4. Those who administer the building legislation are only required to have technical knowledge in the area of building planning and construction rather than the highly specialised knowledge of fire safety.

In addition, submissions to the review of the Building Act 1991 and Building Act 2004, were critical of the additional bureaucracy and costs of compliance. The following comments by representatives from AMI Insurance Ltd (2002:1) are typical:

> "[The costs associated with compliance] will discourage people seeking TA [Territorial Authority] advice and in fact encourage works requiring Building Consent being carried out without proper consents being obtained. TA's have a vested interest in using the consent process as a revenue gathering exercise. When the charges made by different TA's are compared there is significant evidence to suggest that some are doing this. Whilst the Act should clearly retain the "purposes and principles" espoused in it, any changes should attempt to reduce the level of bureaucracy and cost associated with administering it. I would much prefer the that the Act and its exemptions were written sufficiently clearly that any person proposing to undertake building work (including lay persons) could easily decide by themselves whether a building consent is required in the particular situation." (Submission Number: 13)

The regulations and codes of practice pertaining to automatic heat and smoke detection alarm systems are also being continually revised, expanded and developed. The key changes can be located in the amendments to the Building Act, the Building Code and the Approved Document for NZ Building Code Fire Safety Clauses. In particular, amendments to the Building Act and Building Code now require that new buildings (other than a residential), must be have "emergency warning systems for fire or other dangers". The Building Code amendments also specify performance criteria for smoke alarm systems and the New Zealand Fire Service and Department of Building and Housing will continue to review whether hard-wired or other more advanced systems of smoke detection and alarm should be required (Department of Building and Housing, 2005).

The amendments also require all new buildings, houses and consented alterations to have smoke alarms installed. The "Acceptable Solution" approach allows smoke alarms to be battery powered and not interconnected, but must be listed or approved by a recognized authority (as complying with at least one of: UL 217, ULC S531, AS 3786 and BS 5446 Part 1). In addition, the alarms are required to be fitted with a hush facility with a minimum duration of 60 seconds and have a test facility located on the smoke alarm (readily accessible to building occupants). Smoke alarms should be located on the escape routes on all levels within the household unit. On levels containing the sleeping spaces, the smoke alarms should be located either in every sleeping space, or within 3.0m of every sleeping space door. In this case, the smoke alarms must be audible to sleeping occupants on the other side of the closed doors. Preferably, smoke alarms should be installed on or near the ceiling in accordance with AS 1670.6 and the manufacturer's instructions and should be regularly tested and maintained. The amendment to the Building Act also *removes* the previous requirement for smoke alarms in some apartment-type dwellings to be listed on a compliance schedule and, consequently, are no longer subject to an annual inspection regime.

The New Zealand Fire Service has also been developing a range of codes of practice on fire alarm systems to complement existing fire safety legislation. Examples can be seen in `The Code of Practice for Monitoring of Private Fire Alarm and Sprinkler Systems' (2003) and the `Code of Practice for the Automatic Fire Alarm System' (2005). The aims of most of these codes of practice are to establish minimum standards and promote effective alarm systems as well as to create protocols between the New Zealand Fire Service and the alarm system industry. For example, New Zealand Fire Service developed the `Certification for Automatic Fire Alarm Service Providers', in order to provide service providers with a model for their management systems. The Code is based on a variety of standards, such as ISO9001:2000 and the Telarc Q-Base Code and incorporates other documents, specifically the Australian Standard AS 2201.2-2004. Before undertaking monitoring services of automatic fire alarms, service providers are required to be certified. Certification demonstrates that service providers have implemented management systems, including a quality management system, and operate within a "Grade C2 premises as detailed in Australian Standard AS 2201.2-2004". In addition, the service provider's system must be technically robust and be able to transmit fire alarm signals from fire alarms to the New Zealand Fire Service communication centres rapidly, reliably and unambiguously. Other requirements are: to provide for new fire alarms to connect in a straightforward manner, to provide for all connected fire alarms to be monitored and service agents notified of non-normal events; and *promote reduced incidence of false alarms from connected fire alarms*.

The Fire Service Act, 1975, the Fire Safety and Evacuation of Buildings Regulations, 1992 and Health and Safety in Employment Act, 1992.

In contrast to the Building Act, the core purpose of the Fire Service Act is "the protection of life and property from fire and to provide other emergency services" (Fire Service Act, 1975). The Act also mandates the provision of a National Fire Service and a levy to pay for it. It sets out the functions, duties and powers of enforcement of the New Zealand Fire Service and the Commission. In promoting fire safety, the New Zealand Fire Service Commission is required to:

> "(a) Reduce continually the incidence of fire and attendant risk to life and property:
> (b) Achieve unity and completeness of fire safety law and practice" (S20).

While there are fundamental differences between the Fire Service Act and the Building Act, both make reference to the *Fire Safety and Evacuation of Buildings Regulations, 1992*. The Fire Safety and Evacuation of Buildings Regulations outline specific requirements for buildings, building material and product standards, fire safety and evacuation procedures in buildings. It is divided into three parts:

- Part I outlines: fire safety provisions such as the categories of buildings, management of means of escape, evacuation procedure, use of appliances in premises, control of open flames, packing and unpacking goods, storage of goods and materials inside and outside buildings, firefighting equipment for use by building occupants and offences and penalties.

- Part II outlines: the owner's requirement to submit a draft evacuation scheme; the contents of a draft evacuation scheme, grounds for determining if an automatic sprinkler system is inadequate and to put into effect and to maintain an evacuation scheme.
- Part III outlines: the Fire Service's obligation to maintain and supply information on evacuation schemes, need to ensure that there is no limitation of normal access or activities for persons with disabilities and the training of staff of institutions of care places of lawful detention or custody.

As stated, the Fire Service Act and Fire Safety and Evacuation of Buildings Regulations make a distinction between evacuation schemes and evacuation procedures. However, the common purpose underpinning their implementation is to provide "procedures for the safe, expeditious, and efficient evacuation in the event of fire' (S5 and S14a, FSEBR, 1992). Fire safety provisions can also be found under Sections 12 and 14 of the Health and Safety in Employment Act, 1992. Under Sections 12 and 14 of the Act, the employer must inform the employee of what needs to be done in the case of an emergency or imminent danger and to involve the employees in the development of health and safety procedures.

Under the Fire Service Act, the Fire Safety and Evacuation of Buildings Regulations and the Health and Safety in Employment Act, all buildings must have *an evacuation scheme*. Section 21A of the Fire Service Act stipulates that: "an evacuation scheme must ensure that:

(a) The appointment of building wardens and floor wardens be reviewed at intervals of not more than 6 months; and
(b) The duties of the building wardens and floor wardens be provided for in the scheme; and
(c) There be trial evacuations at prescribed intervals; and
(d) The means of escape from fire shall be monitored by the owner and properly maintained; and
(e) Special provision is made for the avoidance of panic on the part of members of the public who are lawfully in the building at the time the building is required to be evacuated; and
(f) Special provision is made for:
    - Young children, the elderly, the sick and persons with disabilities, where the building or part of it is for their care; and
    - Those in lawful detention, where the building or part of it is for their detention."

However, as previously noted, there has been a growing number of criticisms regarding the Fire Service Act and associated legislation (refer to the *Ministerial Panel on Business Compliance Costs,* 2001). In particular, there is confusion over the differences between an evacuation *procedure* and evacuation *scheme* and the way in which the Fire Safety Act and Building Act are administered are subject to public complaint. The comments below epitomise these complaints:

> "What experiences with approval of evacuation schemes? We have had several experiences where additional alarms and especially many additional signs have been required before approval was granted to an evacuation scheme. This is despite the buildings in question holding current compliance certificates.
>
> The Fire Service appears to be continuously applying pressure to increase the fire safety measures installed in commercial buildings. This is inspite of commercial buildings, complying with the building code, having exemplary safety records. The only commercial buildings in recent times where loss of life has occurred through fire have been those where the building code was being flouted to a major degree. This suggests that the building code, when complied with, is entirely adequate for the protection of life." (AMI Insurance Ltd, Submission Number: 13, 2002:2)

Although the building and fire safety legislation has undergone major reforms, there is still pressure to extend these reforms to include the administration and enforcement of the fire safety legislation. Many of the criticisms focus on the lack of consistency in enforcing the legislation and the diversity of agencies with responsibilities for fire safety, as outlined in more detail in the next section.

Shared Responsibilities

Because the New Zealand Fire Service and the territorial authorities each have regulatory duties pertaining to fire safety, as outlined in Figure 13, there is an incorrect assumption that their administrative duties are interrelated. Officers of the New Zealand Fire Service have an obligation to send any recommendations on fire safety to the territorial authorities when:

> "A territorial authority has made a decision in respect of the fire safety of a proposed or exiting building which, in the opinion of the Commission, is contrary to good fire safety practice, the Commission shall consult with the territorial authority and may make such recommendations to [the Minister of Local Government] in relation to that decision as it considers desirable." (S22)

Functions and duties of the territorial authorities are:

> "… to receive and consider applications for building consents: to approve or refuse any application for a building consent within the prescribed time limits: to determine whether an application for a waiver or modification of the building code, or any document for use in establishing compliance with the provisions of the building code, should be granted or refused: to enforce the provisions of the building code and regulations: to issue project information memoranda, code compliance certificates, and compliance schedules: any other function specified in this Act." (S24)

Under section 80(1)(b) of the Building Act, the territorial authority may prosecute any person who uses a building, or permits any other person to use a building, for a use in which the building is not safe or sanitary, or has inadequate means of escape from fire (Department of Building and Housing, 2005). However, the Fire Service Act and the Fire Safety and Evacuation of Buildings Regulations have no provisions that allow the Fire Service to require or specify building work, or specify the performances required for building work (MacGregor & Cahin, 2002; Department of Building and Housing, 2005). If an officer of the Fire Service is concerned that the building is dangerous because of an inadequate means of escape (and this could include the lack of a fire alarm system), the correct procedure is for the officer to notify the territorial authority accordingly, as required by section 29 of the Fire Service Act. If the territorial authority agrees, then it can issue a notice under section 65 of the Building Act requiring the owner to do building work to reduce or remove the danger, for example by installing a fire alarm system (Department of Building and Housing, 2005).

However, as noted above, this situation of shared responsibilities between the New Zealand Fire Service and the TLA's is problematic. *At the heart of the problem are the differences in emphasis of each organisation.* One on hand the New Zealand Fire Service is primarily concern with *fire safety*, while on the other hand the TLA's are concerned with a range of civic responsibilities. Furthermore, these shared responsibilities have left the public frequently bewildered by the duplication of the fire safety legislation, the multiple administrative authorities and the complexities of the regulations, as seen by the submissions to Building Act Review (Building Act Review, 2002). Because of the multiple administrative authorities, there is a potential for the incorrect fire alarm to be fitted. For example, a common scenario begins with the fire engineer issuing instructions to the developer that a "Type 5" alarm system must be installed in the building. Constrained by costs, the developer instead installs a lesser grade of fire alarm system, such as a "Type 4" or "Type 3". The Fire Protection Inspector notes only that a "Type 4" or "Type 3" has been fitted and not what *should have been* installed. The information, minus the original instructions, is then recorded by the local territorial authority. When the situation comes to the notice of the New Zealand Fire Service, the incorrect fire alarm system has already been installed and remedial action costs more than the installation of the "Type 5" at construction stage. In an attempt to provide some clarity as to the responsibilities of the different parties, the diagram below (Figure 13) sets out the key duties of care of the key stakeholders.

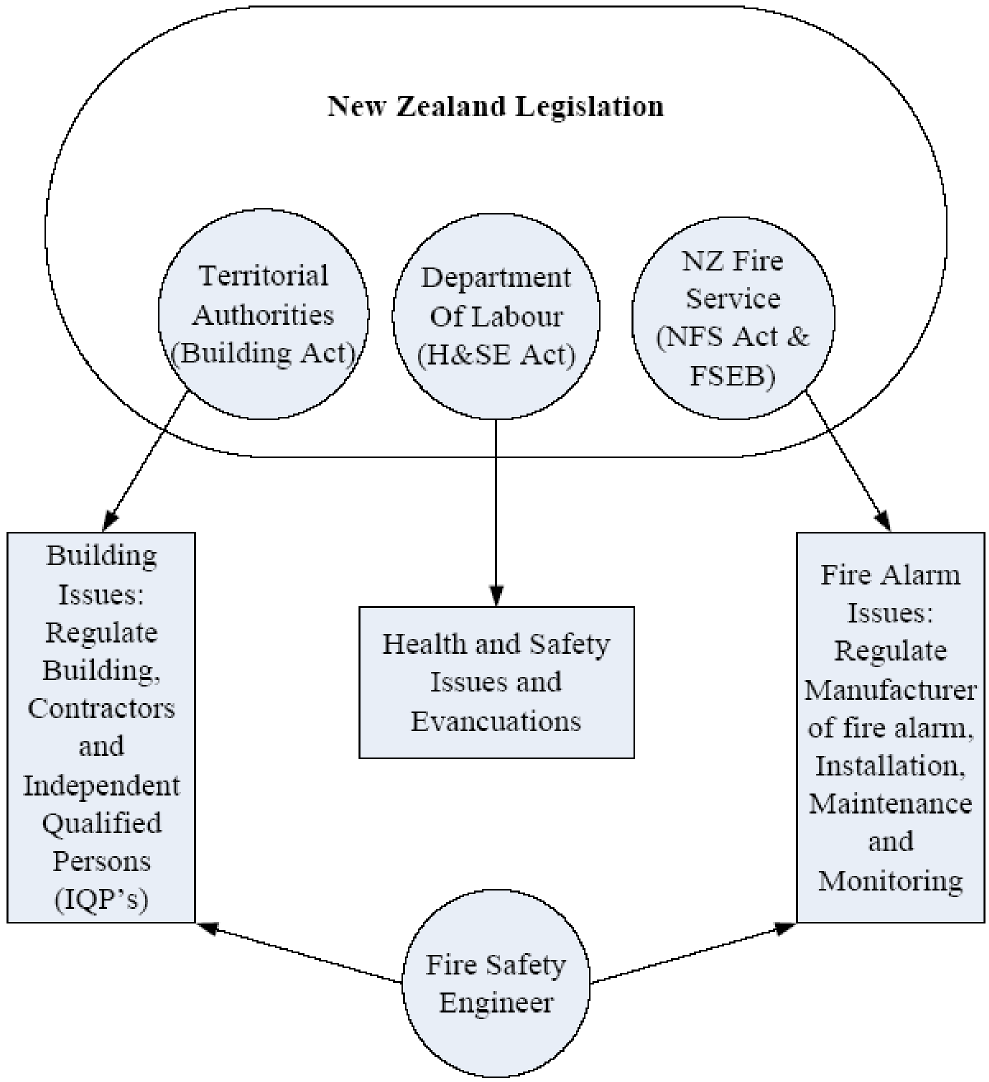


Figure 13: The Parties Involved in New Zealand Fire Alarm Legislation

2.5 Summary

There are a number of key themes that have emerged from the literature review. First, defining false or unwanted fire alarm activations is complex. There are also different ways in which false or unwanted fire alarm activations can be categorised, for example, the nature of the alarms and the type of alarm systems involved. Second, overseas and New Zealand statistics show that there has been an increase in the number of false or unwanted fire alarm activations and in some sectors significantly, as is the case in converted apartment blocks and educational institutions. Third, it is difficult to accurately determine exact costs associated with anticipating fire, the consequences of fire and responding to false or unwanted fire alarm activations. The reasons for the inability to determine exact costs range from compromised data collection processes to the lack of a robust method that can exclude both the output that is not lost due to alarm activations, but simply transferred to other firms, and the output regained by the firm through more productive working in the time after the alarm has ended (ODPM, 2004: 19). Finally, while there is general agreement that there are economic and social costs associated with unwanted fire alarms, most of the research has been conducted overseas with the focus on economic costs, and little mention of the social costs.

It is evident that the causes and issues surrounding the reduction of unwanted fire alarms are complex. In addition, there is a scarcity of New Zealand and in particular Auckland-based research concerning the profile, occurrence and costs of the false and unwanted fire alarm activations and determining precise economic and social costs is fraught with difficulties. Therefore, the central questions that underpin this research are:

- How frequently do false and unwanted fire alarms occur?
- What are the key causes of false or unwanted fire alarm activations?
- What are the types of false or unwanted fire alarm activations (i.e. systems failures or human errors; the effects of climatic conditions; fire systems not fit for purpose)?
- What industry sectors and buildings are most prone to false or unwanted fire alarm activations?
- What are the economic and social impacts of false or unwanted fire alarm activations to the businesses and residents of the Auckland CBD? and,
- Can analytical tools be developed that will assist in providing a more detailed understanding of false or unwanted fire alarm activations?

3 Methodology

Undertaking research on New Zealand false and unwanted fire alarm activations is demanding because the data sources are inconsistent and frequently subjective and because there is difficulty in developing a sufficiently robust method to capture and measure all the costs associated with false and unwanted fire alarm activations. Therefore, in order to overcome these problems as well as ensure that the aims and the objectives of the study are achieved and that the findings are valid and reliable, an exploratory and triangulated research approach was adopted. Exploratory research approach is useful in this study as it incorporates analysis of secondary data, (such as reviewing available literature, analyzing existing statistical data), conduct of interviews with key stakeholders and undertaking case studies. A triangulated approach incorporates multiple sources of evidence (e.g. NZ Fire Service statistics, case study data, etc) converging on the same set of facts or findings (Yin, 1993). In addition, the research design was developed to: 1) combat the problems related to conducting research on false or unwanted fire alarm activations; 2) ensure the validity and reliability of the research; and 3) ensure a more holistic understanding of the topic (Kamoshita, 1996). Undertaking research also requires the utmost confidentiality. Therefore, in accordance with the ethical directives of the University of Auckland, every effort was made to protect the anonymity of the interviewees as well as ensure that the interviewees did not feel threatened or intimidated by the interviewer.

The key areas of investigation of this study are:

- The five years of data, from 1999-2004 on fire alarm activations provided by New Zealand Fire Service and AFA were collated, categorised and analysed.
- Using a sample of 200 statements listed in the remarks column in the 2004 New Zealand Fire Service/AFA, a language data analysis, using an affinity testing exercise, was undertaken by the research team in order to establish categories of false and unwanted fire alarm activations (refer to Appendix 4).
- Qualitative data was collected in the form of six exemplar cases studies within the Auckland CBD. The inclusion of case study data was necessary in order to ensure the reliability of the findings and to provide contextual meaning to the quantitative data.
- Multiple interviews with senior fire safety officers as well as industry associations and fire safety consultants were undertaken throughout the study.

3.1 Case Studies

In addition to the analysis of the fire activation data from New Zealand Fire Service, six exemplar case studies were chosen representing a cross-section of activities and building types. A targeted approach was adopted – as opposed to a random approach

– to generate the maximum information about specific types of cases (such as: building and system differences, individual differences, fire safety practices, etc). More importantly, the case studies were chosen on the basis that they had an above average number of false and unwanted fire alarm activations and that they were located within the Auckland CBD which has the highest number of false and unwanted fire alarm activations. The cases throw much needed light on the cost of false alarm activations

The number of fire appliances, personnel etc, that the New Zealand Fire Service sends in response to a call-out within Auckland CBD is based on the operational rules of four appliances/pumps to one call-out and the ratio of 4.5 fire fighting personnel per appliance. The table below (Table 7) outlines the resources at the disposal of New Zealand Fire Service when responding to a call-out within the Auckland CBD.

Station	Personnel	Fire Appliances*
Auckland Central Station	8	2
Parnell Station	6	2
Ponsonby Station	4	1
Balmoral Station	4	1
Avondale Station	8	2
Mt Roskill	4	1

Table 7: Profile of NZ Fire Service Auckland Central Fire Stations & Resources
* Note: This only includes front-line operational appliances and not specialist appliances.

Auckland's CBD covers a similar land area as the Sydney CBD, around twice the area of Wellington, Christchurch and Brisbane. The dominant sectors represented in the Auckland CBD are financial and insurance services, together with hospitality and culture, communications, property and business, and government administration. In terms of employment, Auckland, Brisbane and Wellington are all of a similar size (59-60,000). At just over 8,300 people, Auckland's CBD has a large residential population compared to other New Zealand cites and most other Australian cities. On average, around 2.2 people live in each Auckland CBD household. The average age of Auckland's CBD residents is in the low to mid-30s and the residential population is more diverse than other New Zealand cities. Currently, Auckland has 50% European residents and 32% Asian residents. Given the density of the business and residential population within the confined area of the CBD, there is clearly a need for sophisticated fire alarm systems and a population that is fire safety conscious, as illustrated in the causal loop diagram in Figure 14.

Figure 14: The Necessity of Having Appropriate & Functioning Fire Alarms
(**Note**: Factors that move in the same direction are notated by an **s** or a positive **(+)** sign. Factors which move in opposite direction are notated by an **o** or negative **(–)** sign.)

The semi-structured questionnaires were designed to be applied to the case studies. Face-to-face interviews were undertaken with buildings managers and businesses owners as well as home owners and tenets (refer Appendix 4). The questions that dealt with biographical details and the fire alarm systems remained consistent. However, where necessary, questions were adapted to the particular interviewee; for example, questions were included that were pertinent to only the building managers interviewed.

A multiple-case study method with a sample of 6 case studies restricts somewhat the applicability of the findings to the larger Auckland business and residential population in that the findings are not necessarily definitive. Nonetheless, descriptive statements can provide broad *guidelines* about false and unwanted fire alarm activations in central Auckland

3.2 Language Data Analysis & Causal Loop Diagrams

Possible causes of false or unwanted fire alarm are recorded by the fire service officers in the database currently managed by the New Zealand Fire Service. The recorded descriptors are based on either the fire service officer's observations and/or the observations of others. There were a number of inconsistencies, however, in the descriptions of false and unwanted fire alarm activations and in some instances the descriptions were vague and unclear. Therefore, there was a need to clarify and categorise the data in order to assist the New Zealand Fire Service to design a "user-friendly", durable and reliable database.

To this end a language data analysis using an Affinity Diagram Method to identify underlying circumstances leading to false alarms was conducted. The exercise entailed examining and grouping a random sample of 200 descriptions (or remarks) of false and unwanted fire alarm activations from the New Zealand Fire Service datasets. The reason for randomly selecting 200 descriptors was that the number of activations was large. Affinity testing exercise is a group consensus method for clustering a number of separate items that need to be organised into groups (Ozdal and Aykanat, 2004; Takai & Ishii, 2004). As many of the descriptions will be similar, the exercise enables the researchers to reduce large numbers of descriptors into a small number of representative categories. The exercise allowed for different degrees of specificity; that is, there were a number of broad, primary categories and subset categories that were more specific. In this instance, the descriptions of false and unwanted fire alarm activations were written out on cards and the group systematically put them into categories. Next, the participants named each cluster so that it most appropriately represented the primary or sub-categories. An affinity diagram was then created which collated and recorded these categories and sub-categories.

Although the exercise has the advantage of categorising together data items that are meaningful for the group's participants, it is acknowledged that it is subjective and bias may occur if there is a strongly opinionated participant(s). Furthermore, in a dataset, some correlations can exist between different items due to their co-occurrences (Ozdal and Aykanat, 2004). An individual item might also induce different relations in different contexts. For example, a false fire activation caused by "human error" could be either as the result of someone with good intentions who either activated the alarm in error or through accidental damage, say by a workman.

As a result of combining the findings from the language data analysis with the interview data, it was possible to establish *causal links* and *identify patterns* using causal loop diagrams. A causal loop diagram is a technique for showing the casual relationships among a set of factors of which operates in a system (Burchill, 1996). More precisely, it is a conceptual tool which reveals a dynamic process in which the chain effects of a cause are traced through a set of related factors, back to the original cause (Kirkwood, 1998). The basic components of casual loop diagrams are factors (i.e. situation, action, decision, condition which can influence and can be influenced by other factors) and links (i.e. arrows). The factors that move in the same direction are expressed by using "**s**" or the positive sign **(+)**. Those factors that move in an opposite direction are expressed by using "**o**" or the negative sign **(-)** (Kirkwood, 1998). Furthermore, for most systems there will be a time lapse between a cause and its effect; that is a delay, which is represented by an = sign (Kirkwood, 1998).

The other essential element of causal loop diagram is the *feedback process*. In general, there are two types of feedback. The first type is a reinforcing (**R**) or positive feedback loop representing growing or declining actions that have taken place. The second type is a balancing (**B**) or negative feedback loop, which endeavours to stabilise, counteract and regulate the actions of the reinforcing feedback loop in order that the goal is achieved. In general, a feedback loop that has *an even number* of factors moving in an opposite direction (o or -) is treated as a reinforcing (**R**) feedback loop whereas a feedback loop that has *an odd number* of factors moving in an opposite direction is treated as a balancing (**B**) feedback loop (Kirkwood, 1998).

The basic steps that were taken when developing a causal loop were as follows:

1. Establish the pathways relationships of relevant variables;
2. Ascertain the direction of casual influence between the pairs;
3. Fit together the causal pairs into closed loops; and
4. Test for loop polarity.

In summary, language data analysis together with causal loop diagrams are not only useful tools that can provide meaning to complex data but the subsequent results were used to modify the new data collection format being developed by the New Zealand Fire Service so as to take into account the significant factors influencing false alarm activation.

3.3 The Statistical Data

The data on fire alarm activations were received from New Zealand Fire Service in the form of two datasets: one covered the period January 2000 to December 2003 (Data Set 1) and another covered 2004 (Data Set 2). It should be noted that there were a number of inconsistencies within the data and many entries were missing. Efforts were made to overcome these problems and to reconcile the differences in order to provide meaningful information that could be used to identify patterns of false and unwanted fire alarm activations and assist the New Zealand Fire Service with resource allocation.

In addition, it was decided to test the following hypothesis:

1. The average number of activations in a day does not depend on the day of the week

2. The average number of activations in a month does not depend on the month of the year.

3. The average number of activations in a year has not changed over the years 2000- 2003

It was also decided to analyse the usable data for pattern of activations based on building type, system type and reason attributed using cross tabulations and other graphical tools. In order to identify trends and seasonality presented in the data, the number of activations in a day as a time series was analysed. The number of activations in the different (six hourly) periods of the day was also analysed.

Based on the findings of the hypotheses, an analysis of variance (ANOVA) was undertaken on the number of activations using the factors: the Period of the day, Day of the Week, Month and Year. This analysis was particularly useful when endeavouring to predict the number of activations at a given time of day, day of month and year (e.g. based on previous years, what would be the predicted number of activations on Wednesday, 5th June 2006?).

3.4 Summary

As the data sources were inconsistent and frequently subjective and because it was difficult to capture and measure all the cost elements associated with false and unwanted fire alarm activations, a number of methods were applied. In particular, we analysed:

5. The time series data on fire alarm activation;

6. Attribute data on building type, system type and reason;

7. The language data available in the remark field of the fire alarm activation data set; and

8. Qualitative data from case studies.

4 Results

The effects of false and unwanted fire alarm activations impinge on three important areas: the costs associated with preparedness, the costs as a result of fire alarm activations and the costs associated with responding to alarm activations. Although the impact of false and unwanted fire alarm activations on fire service staff and the public will vary, there is a high level of agreement on the significant consequences of false and unwanted fire alarm activations. The project's results indicate that there are not only complex causes of false and unwanted fire alarm activations, as highlighted by the analysis of the New Zealand Fire Service data, but also that there are key issues as a consequence of false and unwanted fire alarm activations, as portrayed by the case study data.

This section has been divided into the areas of analysis. They are as follows:

- Case Study data
- Affinity Testing Results
- Analysis of the New Zealand Fire Service database.

4.1 Case Studies

As noted, the case study data are based on interviews with property managers, occupiers and fire safety officers as well as public documents and records from the New Zealand Fire Service and Auckland City Council. The case studies represent the diversity of Auckland businesses and residential accommodation in terms of types and ages of the buildings as well as the type of alarm system used, as seen in Table 8 and Table 9. The selected buildings also experienced some of the highest number of false and unwanted fire alarm activations in Auckland CBD, approximately 12-14 per year; earning them a position on the New Zealand Fire Service "Top 30 Buildings List" and special attention from the Auckland New Zealand Fire Service officers. This targeted approach by the New Zealand Fire Service has been adopted by other fire services in both the UK and Australia. Typically, the false and unwanted fire alarm activations occurred in the case study buildings during Friday, Saturday, Sunday and Monday and nearly always around midday. This differs from the data for the Auckland CBD; which shows an even spread over the weekdays and a reduction in the weekends. New Zealand Fire Safety records also highlight the range of reasons for false and unwanted fire alarm activations. However, as stated earlier, such incident descriptions are frequently inconsistent and vague and therefore the data must be treated with some caution. Based on interview data, estimated costs associated with installing and maintaining/repairing (or preparedness) fire alarm systems for each of the case studies is presented in Table 9. Based on interview data, Table 10 lists the average direct economic cost of a false or unwanted fire alarm activation for each of the case studies. The causal loop diagram,

Figure 15, also highlights the disruption of work in terms of types of economic and social costs.

Individual case studies are presented below in order to illustrate the complexities surrounding the causes and costs of false and unwanted fire alarm activations. Each interview with key representatives of the case study building began by discussing the building which had been identified as an exemplar of the problem (refer Appendix 4). The interview then progressed to a set of semi-structured interview schedules in which the interviewee was able to express his/her views on the key issues surrounding managing fire alarms systems and major reasons for their building's level of false and unwanted fire alarm activations as well as various aspects of the fire protection and monitoring industry. Interviewees were also questioned about preventative mechanisms that could reduce false or unwanted fire alarms.

Based on the interview data, generic themes were then further identified and examined. It must be stressed, however, that the qualitative results presented below can only represent the statements of those surveyed and interviewed and as a result these statements may or may not be true for the wider Auckland and New Zealand population.

Case Study	Designated Use of Building[1]	Age of Building	Number Occupied Units	Type of Ownership
GHL#1	Shopping Mall/ Offices	1920's	15 retail 3 residential 14 businesses	Private Company
GHL#2	Retail/offices/ apartments	1890's	2 retail 54 Apartments	Body Corporate
NP#1	Education/ Public Display	1985	1	Private Company
HR#A	Apartments/	2004-2005	37 Residential	Body Corporate
HR#B	Apartments	2004	209 Residential	Private Company
HR#C	Offices/ Apartments	1924 (Changing building use over 10 years)	12 Residential 12 Business 4 Retail	Body Corporate

Table 8: Profile of the Case Studies (a)

[1] "Designated use of the building" may not accurately depict the true use the building; e.g. apartment residents may be using their dwelling for commercial purposes.

Case Study	Type & Age of Alarm System[1]	Number of False Activations 30/6/03-30/6/05	Principle Reason for False Activations	Approximate Costs Associated with preparedness 30/6/04-30/6/05
GHL#1	Sprinkler/Smoke 8 years	24	Environmental effects	$170,000 combined cost of system and maintenance
GHL#2	Sprinkler/Smoke 12 years	25	Building work (builders/contractors)	$250,000 combined cost of system and maintenance
NP#1	thermal/smoke 20 years	30	Incorrect building maintenance & Operator error	$90,000 repairs/maintenance
HR#A	Thermal 10 months	13 (30/1/04-30/6/05)	Poor fit for Purpose	$30,000 cost of repairs/maintenance
HR#B	Smoke 1 year	12 (30/6/04-30/6/05)	Malicious	$200,000 cost of system $10,000 cost of repairs/maintenance
HR#C	Manual/Smoke 7.5 years	24	Poor fit for Purpose	$60,000 cost of repairs/maintenance

Table 9: Profile of the Case Studies (b)

[1] The age of the alarm was at September, 2005

Items	Cost (excluding GST) per fire alarm activation
NZFS Attendance Charge	$1,000
Monitoring Company Reset after activation	$200 - $300
Monitoring Company Disconnect/Reconnect for contractor work	$180 - $250
Cost to rewire/isolate alarms (Type 5)	$200 (per each unit)
MCP and Extinguisher covers	$200 each

Table 10: Estimated Economic Costs as a Result of Fire Alarm Activations

Figure 15: The Disruption of Work in Context of Economic and Social Costs
(Note: Factors that move in the same direction are notated by an s or a positive (+) sign. Factors which move in opposite direction are notated by an o or negative (–) sign)

Case Study GHL#1

Although there is a mixture of businesses in the building GHL#1, most are retail businesses. The building also has three residential apartments. The building was constructed in the early 1920s and since then it has had a number of renovations. The fire alarm system installed is a thermal/smoke detection system and some of the alarm connections are over 60 years old. Between the 30th June 2003 and 30th June 2005 there were 24 alarm activations. Most of the activations appeared to be as a result of smoke, steam or dust. According to the building manager, businesses using machinery and/or processes that exude smoke or stream were the main reasons for setting off the alarms. Subcontractors have also contributed to the number of false alarms. For example, there were reported incidences of subcontractors cutting alarm wires. The service agency charges at least $140 per attendance to a false or unwanted fire alarm activation, which given that the building had 24 activations over a two year period, equates to $1,680 per annum. However, the property manager interviewed stressed that there were other costs incurred with the fire alarm system, such as the costs to remedy the malfunctioning systems, the cost to maintain the system and the New Zealand Fire Service charges for attending false and unwanted fire alarm activations as well as the lost labour costs and loss of business. The property manager estimated that the costs associated with unwanted fire alarm activations would be in an excess of $5,000 per annum per business.

Nine of the occupiers of the building were also interviewed and a brief profile of each of the businesses surveyed is outlined in Table 11. All the businesses surveyed are small and most have occupied the building for more than 5 years. It was interesting to note that *none* of the business surveyed stated that they were responsible for any of the 24 false or unwanted fire alarm activations, which does not equate with the New Zealand Fire Service information. The disruption to their business as a result of a false or unwanted fire alarm activation was on average 30 minutes and the estimated costs incurred ranged from $50 to $5,000. Those interviewed rated the level of inconvenience from annoying (2 responses) and disruptive (5 responses) to unacceptable (2 responses). Because of the large number of false and unwanted fire alarm activations, there is now a high level of complacency towards evacuations amongst the occupiers, with some locking their doors and pretending that they were not in. In spite of this situation, interviewees estimated that it took approximately 5 minutes to leave the building, as summarised in Table 12. Those offering professional services commented that they were greatly affected by the alarm activations as they had to temporarily halt whatever they were doing and evacuate the building, thus resulting in a loss of business revenue.

Businesses[1]	**Number of Staff**	**Length of Occupancy**
Architect	8	13 years
Immigration Consultant	3	5 years
Restaurant	5	1 year
Retail 1	3	1 year
Retail 2	3	3 years
Retail 3	3	10 years
Retail 4	9	8 Years
Retail 5	4	9 years
Retail 6	3	35 years

Table 11: Profile of Occupiers in Building GHL#1

[1] Twelve occupiers were asked to responded and nine agreed to be interviewed

	Average Length of time to evacuate the building	Average length of disruption due to evacuation	Estimated $ costs of staff downtime	Average Estimated $ costs of loss of business
Architect	5 minutes	30 minutes	$400.	-
Immigration Consultant	5 minutes	15 minutes	$300.+	-
Restaurant	2 minutes	10-15 minutes	$15.	$200
Retail 1	2 minutes	15-20 minutes	$11.25	$50+
Retail 2	1 minute	30 minutes	$14.	$1-$5,000
Retail 3	2 minutes	30 minutes	$12.	-
Retail 4	1 minute	30 minutes	$28.47	$68
Retail 5	5 minutes	20 minutes	$30	-
Retail 6	2 minutes	30 minutes	$22.5	$200-$1,000

Table 12: Profile of Evacuations in Building GHL#1
Note: The NZFS estimates that the disruption to work as a result of a false or unwanted fire alarm evacuation is closer to 1 hour.

With the exception of the property manager, most of the respondents were ambiguous as to the main causes of the false or unwanted fire alarm activations and were unclear as to what had been done to resolve the problem. However, most commented that the age of the building and the antiquated fire system did little to help reduce the number of false or unwanted fire alarm activations. According to the property manger, because the building and the alarm system were old, there were a number of problems faced when trying to reduce the level of false and unwanted fire alarm activations. The first problem was that the alarm system was obsolete and as such there were very few companies that have the expertise to maintain and repair the system and the parts required are difficult to obtain. The age of the system also meant that it broke down frequently, it was less protected from contaminants (e.g. dust particles) and it took more effort to maintain it. The second problem was that the wiring was old, dangerous and in disarray. The age of the building also meant that any renovation could be hazardous. Therefore, according to the property manager, few firms were willing to undertake the job of repairing, maintaining and replacing the alarm system. The third problem was the cost of replacing the antiquated system and finding a contractor that would undertake the job. The average price quoted for replacing the system was $170,000 to $180,000, a cost that would be borne by the owner in the first instance. Typically, the owner would subsequently pass on some or all of the costs onto the tenants in the form of increased rents. However, the property manager complained that it was almost impossible to engage a contactor as "… it's just not worth their while…they take a look at the job and they don't want to know…because it's too complicated. With an old building, it's not straightforward, so they don't know what they're going to strike."

Case Study GHL#2

The building is 115 years old and for most of those years it had been occupied mainly by businesses. However, in 2003 the building was re-developed and there are now more residential occupiers than businesses. In total, there are 54 apartments and 2 retail businesses. Between June 2003 and June 2005, the building experienced at least 25 false and unwanted fire alarm activations, approximately one a month. Most of the false and unwanted fire alarm activations during that period were the result of the activities of the construction workers in which "cut fire alarm cable" and "fumes from wielding" were typical of the descriptive causes.

More recently, however, the main perpetrators of the false and unwanted fire alarm activations have been the residential occupiers. The types of false and unwanted fire alarm activations listed for this building fall primarily into three categories. In the first category, smoke from cooking fumes or cigarettes are some of the main causes of smoke alarms activations. An alarm in the apartment is the first to be activated, closely followed by the activation of the smoke/heat alarm in the corridor as a result of the tenant opening their front door to defuse the smoke. Because this type of false alarm occurs regularly, it is estimated that many of tenants have taken to covering up the detectors (interviewee GHL#2a, 2005). Although each new resident is given instructions on how to prevent false and unwanted fire alarm activations, many of the residents are either unable to read the instructions in English or "they've just have no idea about how live in apartments" (interviewee GHL#2a, 2005).

In the second category, the causes of false and unwanted fire alarm activations are as a result of damage to the equipment either by the tenant or the sub-contractor. In the third category, malicious alarm activations have also increased with the advent of more residential tenants. The emergency buttons located near the front door were frequently set off by unruly residents or visitors often wanting to gain unauthorised access. To combat both the damage to the equipment and the malicious activations, the property manager installed cameras on every floor and placed anti-tampering devices over the emergency buttons.

According to the interviewees, a typical evacuation takes approximately 30 minutes for all the occupiers to leave the building and for the fire appliance to attend. However, the high rate of unnecessary evacuations has created a climate of complacency amongst the tenants, with many reporting that they frequently ignore the fire alarms. In addition, the costs of the false and unwanted fire alarm activations (that is, the New Zealand Fire Service charge of $1,000 per callout, plus any other expenses) are, in the first instance, borne by apartment owner who then passes the bill over to the tenant. If in the event, the owner and the tenant do not pay, the body corporation will pay and recoup the outstanding amount when the apartment is sold.

Because of the building's high number of false and unwanted fire alarm activations, New Zealand Fire Service fire safety officers had been taking a special interest.

According to the property manager, the New Zealand Fire Safety Officers had been very helpful in discussing ways in which to reduce the fire alarm activations, such as fitting covers onto each fire alarm to prevent on-going damage to the alarms.

The interviewees also noted that the high number of false and unwanted fire alarm activations in their apartment block was a universal and serious problem. As one interviewee noted:

> "You imagine if there were 4 apartment blocks and there were 2 real major fires and 2 of them were false alarms …oh God, there will be a problem…" (Interviewee GHL#2a, 2005)

Case Study NP#1

The core business of Case Study NP#1 is to provide educational public displays as well as undertake scientific research and offers a range of experiences, including groups staying overnight. The entrance fees are $26.00 for an adult and $12.00 for a child. The first part of the complex was opened in 1985 and was added to in 1994. By 2005 the centre had 400,000 visitors, approximately 1,000 people per day.

However, the organisation has experienced a higher than average number of false and unwanted fire alarm activations. Between 30 January 2003 and 30 June 2005, the organisation has had at least 30 false and unwanted fire alarm call-outs – one per month. Summer periods and Thursdays had particularly high rates of false alarm activations and there were almost twice as many false alarms recorded in the morning than during other times of the day. According to the interviewees, each evacuation took approximately 30 minutes, 10 minutes to evacuate the entire building and for the fire appliances to arrive and another 20 minutes for the professional firefighters to identify the cause of the false or unwanted fire alarm activation. The loss of business is more difficult to calculate but if there are approximately 65 visitors per half hour multiplied by the number of adults and children, the losses are significant (e.g. 30 adults @ $26.00 each + 35 child @ $12 each = $1,200). Moreover, when interviewed about the repeated false fire alarms and subsequent the loss of business, one of the interviewees stated:

> "… all of your goodwill, all of your advertising can be so quickly undone by someone just having a bad experience like that…they go back out there and [say] "Don't go to [Case Study NP#1], you'll get thrown out with the fire sirens all the time…". How many thousands of dollars we'd have to put back into advertising to get people back again. You can't put a figure on that." (Case Study NP#1a)

One of the main reasons for the high rate of false and unwanted fire alarm activations was the installation of a fire alarm system that was a poor fit for purpose.

The decision not to install a more sophisticated fire alarm system during the second major development was based on two factors. The first factor was that, at the time of the second stage of the development, analogue addressable systems were just coming on the market and were more expensive ($80,000+) than existing systems. The second factor was that the innovative development was extremely costly and funds were tight. In short, the building owners could not afford the added expense of installing the latest fire alarm technology.

Because of the age and the type of the original system, maintenance was critical. However, the data shows that most of the causes of the false and unwanted fire alarm activations were incorrect maintenance and operator error. According to the interviewees, the service agency's staff or their sub-contracted staff were not always competent to maintain the fire system and as a result they were frequently responsible for unnecessary fire service call-outs (Case Study NP#1 a & b). On other occasions, the activities of building contractors also contributed to false and unwanted fire alarm activations. Recently, because of the high costs incurred as a result of the numerous false and unwanted fire alarm activations, the building owners have decided to change their alarm panel to a more reliable analogue addressable panel.

Case Study HR#A

The construction of apartment block HR#A was almost complete at the time of the interview. The apartments range in price from $300,000 to $450,000 and are predominately owner occupied. The fire alarm system installed is thermal. Between 30th September 2004 and 30th June 2005 there were 13 false and unwanted alarm activations in which most of the activations appear to be as a result of "a defective system".

There were three primary faults with the fire alarm system. The first fault concerns the inappropriate installation of thermal sensors, particularly in the bathrooms. Because of the inappropriate sensors, tenants found that when using the clothes drier or having a barbeque on their balcony, the fire alarms were regularly activated, automatically calling the New Zealand Fire Service. The thermal sensors currently installed are activated at 57 degree heat. Instead, the correct thermal sensors which should have been installed are those that are activated at 70 degrees. The only solution to the problem is to replace all the sensors with the more appropriate 70 degree sensors. With regards to the second fault, there is no separation between the individual units and the brigade activation function of the alarm system. This means that if an alarm is activated in one unit then the New Zealand Fire Service is automatically called. The best practice solution is to have the initial alarm activate in individual units. When activated a silencer button can be pushed in the apartment, allowing the occupants to clear the smoke or steam. If the air is not cleared within a set time then the New Zealand Fire Service is alerted. The third fault concerns the incorrect installation of the alarm system circuitry in which all the common areas are linked to each apartment's alarm system. At the time of the interview, the Body Corporate was in the process of remedying the problem by installing separate circuits at considerable cost. Interviewees complained that the process of remedying the faults was taking longer and was more costly than if the repairs had been done prior to occupancy. Furthermore, the repairs have had a negative aesthetic effect on the building as new wires are housed in capping rather than hidden in the wall cavity.

The Body Corporate has subsequently taken the Developer of the apartment block to court in an effort to recover the costs of the repairs. The Court has ordered the Developer to pay $20,000 towards the costs of ensuring that building is compliant with the fire regulations. The Body Corporate is seeking a further $25,000 to meet future proofing requirements. There has been no response from the Developer regarding these future proofing costs. Therefore the tenants must cover these costs until the developer pays, or is ordered to pay by the court. The new system installed has effectively stopped the incidence of unwanted false fire alarm activations in the building ***HR#A***, but at a cost of $30,000 thus far.

Case Study HR#B

Built in 2004, the alarm system installed in Building HR#B is a "Type 5", one that is activated by the presence of smoke and has audible alerting devices to warn only the firecell occupants and the building management. In spite of having a more sophisticated system than most of the other case studies, costing upwards of $200,000, there was still a high number New Zealand Fire Service call-outs as a result of false and unwanted fire alarm activations. Between 30th June 2004 and 30th June 2005 there were 12 false and unwanted fire alarm activations, one a month. The majority of false activations were caused by malicious activations by either the tenants or visitors.

Recently, the malicious activations have been reduced by installing covered units for the manual call points (MCP) and fire extinguishers. When the covers are removed a localised siren sounds, which will not automatically alert the New Zealand Fire Service unless the actual MCP is switched, or the extinguisher removed. The covered units cost approximately $200 each. The interviewee suggests that covering the units should be included in the initial fire system design for all large inner-city apartment buildings.

There were also an increasing number of false and unwanted fire alarm activations as a consequence of tenants' actions, such as smoking in prohibited areas or burning toast, etc. Moreover, tenants interviewed generally had little understanding of how the fire alarm system functioned. As part of the regular alarm system monitoring inspections, it was not uncommon to find smoke detectors in the individual apartments covered with cling-film, plastic bags and even rubber gloves. In a recent (scheduled and forewarned) inspection 4% of the detectors were covered and there is an expectation that at any time up to 20% of detectors would be covered. One of the reasons that tenants cover the detectors is in order to smoke in the apartment with out setting off the alarms. Smoking in the corridors can also activate the alarms which will automatically call-out the New Zealand Fire Service. Although covering the sensor will not activate the alarm; each sensor is connected to a circuit and if that circuit is broken (by trying to remove it, or dislodging it while covering) the alarm will be activated.

Residents were also caught hanging clothes, plants and ornaments off the sprinkler heads. The service agent complained that the sprinkler system is full of high pressure water and if broken there would be a deluge into the apartment. He added that it was only a matter of time before such accident occurred and caused substantial damage.

The building managers were extremely concerned about the high rate of compromised sensors and misuse of the sprinkler system as these actions have the potential to risk not only the tenant's lives and property but any delay in activation could also put the other residents' lives in danger. In order to discourage tenants from damaging or disabling the fire system, the building policy is to evict any tenant responsible for tampering with the fire alarm.

Case Study HR#C

The building was originally constructed in 1924 as an office block but was extensively renovated in the mid-1990s to accommodate primary residential apartments (now 80% of occupancy) with some commercial/retail offices (20% occupancy). Between 30th January, 2003 and 30th June 2005, there were 24 false and unwanted fire alarm activations. Although there are a variety of reasons listed for each of the false and unwanted fire alarm activations, the underlying cause is that the original fire alarm system currently in use is not fit for the new purpose of the building. In particular, unsuitable sensors are in use and they are positioned incorrectly (for example, smoke detectors positioned directly over stoves).

At the time of the renovations, the existing system apparently met the fire safety regulations and the developers were under no legal obligation to upgrade the fire system. The property manager interviewed argued that the regulations are ambiguous and that the members of the Body Corporate are uncertain of what exactly is required. Nonetheless, property manager stated that the owners have had to pay the New Zealand Fire Service $1,250 charges and $200 to the monitoring company for each of the activations. As the problem escalated, the New Zealand Fire Service approached the building owners with an ultimatum to repair the system. As a consequence of both the threats and incentives, the Body Corporate has made the decision to upgrade the existing fire alarm system to a Type 5, at a cost of $50,000 – $60,000. There were also added costs involved in replacing the smoke/heat detectors. Replacing each detector with a more suitable one costs about $300 to $400 each and there is the added cost of $200 plus to disconnect and reconnect the fire alarm system each time work on the system is undertaken.

Although most of the false and unwanted fire alarm activations were the result of the system not being fit for purpose, building contractors were responsible for many of the remaining false and unwanted fire alarm activations in Building HR#C. If construction/renovation work is being carried out, the sensors in the vicinity of the work must be isolated from the alarm system. According to the property manager, although most contractors will take these precautions, there a small number who do not and, as a result, the heat, dust or smoke from their work sets off the fire alarm, adding to the costs and the frustration of the residents.

Because of the high number of false and unwanted fire alarm activations there is a great deal of complacency amongst the residents to evacuate to the building. The property manger recalls one incident that typifies the attitude of many of the residents:

> "Well, I caught this young guy on the 7th floor when the last alarm went off and I said to him "get out now". He said "I'm not going anywhere; we've had so many false alarms". I said, "I don't care how many false alarms we've had, if you hear a fire alarm go off, you get out, no buts". "You get out, you're a real bad manager 'cos it goes off so much" he said. I said, "Whatever, I don't give a damn what you think of me, if you hear that alarm you get out of the building!" (Case Study - HR#C)

4.2 Emerging Themes for the Case Studies

There are a number of the key themes that emerged from the interview data, namely:

- Differing reasons for false and unwanted fire alarms:
- The perceived roles of the various parties
- Tenants' role in false and unwanted fire alarms:
    - Their lack of understanding of what triggers off the fire alarm system;
    - The rise in the incidence of malicious activations;
    - Their increasing complacency;
- The domination of major players in the fire protection industry**;** and
- The interpretation and application of the regulations pertaining to the installation and maintenance of fire alarms.

Differing reasons for false and unwanted fire alarms

In analyzing the New Zealand statistical data, it is possible to identify a number of key reasons for false and unwanted fire alarm activations. However, an unexpected finding emerged from the interviews and New Zealand Fire Service data, as outlined in Figure 16, in that there were conflicting reasons given for false and unwanted fire alarm activations. These differences occurred not only at the point of recording the possible reasons for the alarm activations by the attending New Zealand Fire Service officer but were also apparent amongst the building occupiers and property/building managers. For example, an attending New Zealand Fire Service officer may classify a tenant burning toast as a "false alarm/accidental operation" while another officer may classify the event as "false alarm/environmental effects".

However, building/property managers interviewed stated that real causes for many of the false and unwanted fire alarm activations was that the fire alarm system installed was simply "*not fit for the purpose of the building*" and that this underlying reason was not always reflected in the New Zealand Fire Service database. Another example is the conflicting accounts of false and unwanted fire alarm activation incidents given by the building occupiers. When asked to state exactly what triggered off a false or unwanted fire alarm activation, occupiers interviewed typically denied their involvement in setting off the alarm which did not match New Zealand Fire Service data. Therefore, the reasons recorded can hide the underlying cause of the false alarm activations. Table 13 outlines the summarised reactions of the building/property managers to the New Zealand Fire Service's recorded reasons of false and unwanted fire alarm activations.

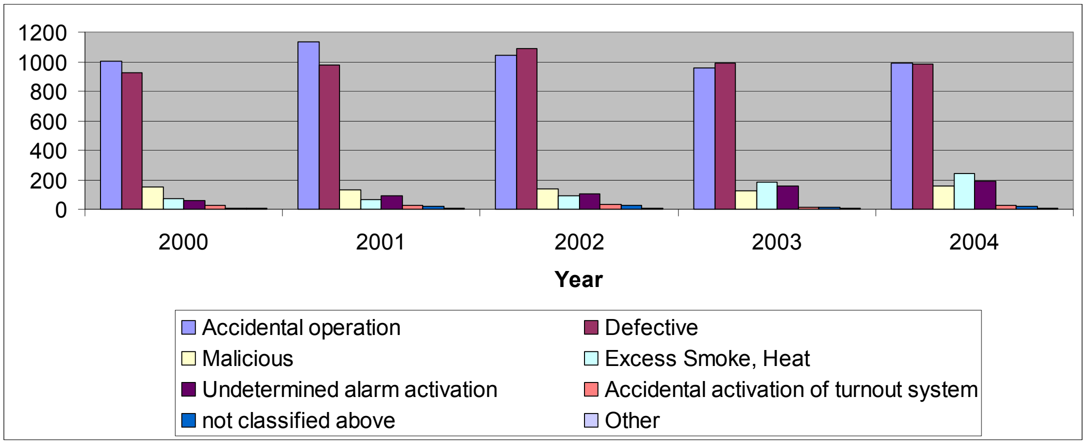


Figure 16: New Zealand Fire Service Data - Major Causes of False or Unwanted Fire Alarms in Auckland City

NZFS Reason	**Summarised Reactions by Building/Property Mangers**
Building Work	*"Reasonably sensible, usually disconnect alarm when welding, sanding…can happen once or twice then they learn"*. No consequence for owners as attributable to building company so they pay or it becomes an insurance claim. Example of welder setting off sprinklers in apartment complex.
Component Failures	Tied in with pffp. As technology improves so do the components. Older buildings develop problems as wires corrode.
Environment Effects	Occasional *"little bit of dumb activity by occupants like ironing on the carpet"*. Also tied in with pffp as if the wrong sensors are installed for the environment then the alarm will be activated more often.
Good intent	not often
Incorrect Building Maintenance	Corrosion of pipes major cost of repair due to non-water tight building took 2 years to find cause of activations 20 call outs. General consensus that System Maintenance companies are unprofessional and deliver a poor standard of service
Installation Fault (PFFP)	Primary reason, *"dumb installation"* or *"bad system design", "with the building boom we've enjoyed over the last five years there are less and less qualified people doing installs"* leading to a "*reasonable number of poor systems out there"*. Activations usually occur in the first six months of occupation.
Malicious	Contrasting opinions, *"no examples of malicious damage touch wood"* to *"80% to 85% of all activations"*
Mechanical Damage	not often
Operator error	not often

Table 13: Summarised Reactions by Building/Property Mangers to New Zealand Fire Service Recorded Reasons for False and Unwanted Fire Alarm Activations.

Documenting accurate New Zealand Fire Service data is hampered by the fact that it is reliant on the subjective views of the parties involved in setting off an alarm and investigating what occurred. Having ambiguous/conflicting descriptions recorded in the New Zealand Fire Service database has also meant that it is difficult to ascertain the real reasons for false and unwanted fire alarm activations and hard to develop targeted strategies.

The Perceived Roles of the Various Parties

While the focus of this project has been on identifying the cost factors of false and unwanted fire alarm activations, it is also important to acknowledge the role played by the various parties in contributing or reducing the false and unwanted fire alarm activations and how each of the different parties are linked. The main parties highlighted in findings are: building developers; alarm system installers; owners and occupiers of the premises; territorial local authorities; and the New Zealand Fire Service. Data analysed from the interviews and the survey revealed that there were reoccurring and fixed *perceptions* of the different roles each party plays. The interviewees' perceptions also reveal *the interests* of each party as well as the *problems* facing each group. These perceptions are presented thematically below and provide the basis for the subsequent themes. In addition, the casual loop diagram, outlined in Figure 15, illustrates the inter-connectedness of the various players and the different elements of the topic of false and unwanted fire alarm activations. In particular, it sets out the links between educational element, the public awareness element and servicing of the fire alarm systems as well as highlighting the many difficulties (or delays) in maintaining a functioning fire alarm system.

The summarised interviewees' perceptions of the different players and key issues are as follows:

Building Developers:

- Installation decisions are frequently based on short-term, cheaper costs rather than costlier options that will have long-term benefits for the prospective owners;
- Some in the building industry are viewed as condoning poor workmanship and non-compliance;
- There is also lack of knowledge of fire prevention and safety systems amongst most developers.

Alarm System Installers:

- They frequently have to deal with problems arising from the changing status of building use, (e.g. from commercial to residential) in which they are asked to install systems retrospective of the redevelopment;
- Endeavoring to maintain systems that are not fit for the purpose of the building and/or are antiquated;

- There are often poor tracking systems in the building process in which ad hoc changes to the installation of the fire alarm system or changes to the design of building are not documented or have not been officially approved;
- There is a perception that some installers in the alarm industry have a tendency to install sub-standard/inappropriate and cheaper fire alarm systems and are able to "get away with it" based on their loose interpretation of the building and fire regulations.

Owners/Occupiers

- The relationship between the building owners, apartment owners; property managers and tenants is frequently discounted, thus exacerbating efforts to reduce the number of false and unwanted fire alarm activations.
- Owners often have to bear either the full or partial costs of false and unwanted fire alarm activations irrespective of whether or not they are directly responsible for them;
- The transient, tenant population is difficult to manage in terms of their part in causing many of the false and unwanted fire alarm activations;
- High level of public ignorance of things that trigger the alarms, what to do when an alarm goes off, the risks associated with fire and the New Zealand Fire Service charges incurred for false fire alarm activations;
- An increasing intolerance of false and unwanted fire alarm activations because of the associated costs and the nuisance factor.

Territorial Local Authorities:

- Often viewed as unable to provide a sufficient level of enforcement of building regulations;
- Little or no formal relationship with the New Zealand Fire Service or the alarm installation industry to prevent installation problems.

New Zealand Fire Service

- Most call-outs are false and unwanted fire alarm activations, tying up and diverting resources;
- Frequently are called in *after* there are problems with the building's fire alarm system, rather than at the planning stage of the building process.

It appears, therefore, that the problems of false and unwanted fire alarm activations cannot been seen in a vacuum but instead has to be viewed in terms of the actions of individuals, groups or organisations within the context of changes in demography, building use and regulatory reforms, as discussed in the following themes. It is important to acknowledge the different responsibilities of individuals in the context of false and unwanted fire alarm activations, as outlined in the causal loop diagram below in Figure 17.

Figure 17: Different Forms of Individual Responsibility in the Context of False & Unwanted Fire Alarm Activations
(Note: Factors that move in the same direction are notated by an **s** or a positive **(+)** sign. Factors which move in opposite direction are notated by an **o** or negative **(–)** sign.)

Tenants' role in false and unwanted fire alarms

As noted earlier, Auckland's residential population has increased substantially because of the huge growth in the number of apartments. As a consequence the residential population is now predominately young, frequently born overseas, and is typically in rental accommodation. The following table (Table 14) based on 2001 census data illustrates this trend.

	Auckland CBD	New Zealand
Medium Age	29	34
Med- Income	$26,500	$18,900
Working	92%	93%
Full-time study	18%	8%
Renting	71%	29%
European	65%	80%
Asian	31%	7%
Maori	6%	15%
Pacific	3%	6%
Couple alone	31%	21%
Flatmates	31%	9%
Living alone	21%	9%
Parent/children	9%	29%
Children	8%	32%

Table 14: Demographic Profile of Apartment Dwellers
Source: Statistics New Zealand, 2005.

Apartment building tenants have been singled out not only because research shows that they are a high risk group in terms of fire death and injury (Mitchell, 2001; Firenze, 2005), but they are also the main perpetrators of false and unwanted fire alarm activations that occur in apartment buildings (NZFS 2004). Interviewees argued that these dramatic changes in Auckland's demography could account in part for the rise of certain types of false and unwanted fire alarm activations. In particular, the three main areas of concern are as follows:

- The tenants' lack of understanding of how building fire/smoke alarm system are activated;
- The rise in the incidence of malicious activations;
- The increasing complacency amongst tenants to evacuate the building.

Interviews with property managers and fire safety officers indicate that it is common for tenants to *inadvertently set off the fire/smoke alarm* when cooking, smoking, showering or tampering with the smoke/fire alarm system. More often than not unwanted fire alarm activations in apartments were a consequence of the incorrect placement of the apartment's sensors (e.g. directly above the stove). In addition, tenants would open the front door to dissipate the smoke or steam only to unwittingly set off the building alarm system. With the Type 5 Alarms recommended for apartment buildings the windows should be opened but not the door to the common area corridor, as this automatically triggers an alarm, notifying the New Zealand Fire Service.

Property managers and fire safety officers interviewed were also perturbed at the rise in the number of incidences of tenants tampering with the smoke/heat sensors, for example, covering the sensors in plastic, disabling the sensor or damaging the sensor (e.g. when using it as a clothes hanger). However, property managers interviewed stated that it was difficult to continuously monitor tenants to ensure that they did not interfere with the smoke/fire alarm system and often the problem was only revealed when the property manager undertook an inspection of the property. Nonetheless, property managers interviewed were endeavoring to combat the problem. For example, some of the building managers had prepared information sheets for the tenants explaining what to do, and penalties for tampering with smoke/heat sensors or activating the alarm unnecessarily. The sheets were partially successful and served as a warning notice for subsequent disciplinary action. However, their effectiveness was limited for two reasons. First, many of the tenants never read the information or had limited English language comprehension and could not understand the information. Secondly, many of the commercial/apartment buildings are on strata title and therefore, new tenants normally deal directly with the unit/apartment owner and have no contact with the building manager. Occupants may move in or out of the building without the manager being informed and the "house rules" explained. The other solution was to evict recidivist offenders, particularly those tenants found tampering with the sensors. Property managers were also installing anti-tampering devices over the fire/smoke sensors as a way of combating the rising number of unwanted fire alarm activations, although interviewees noted that this was a more expensive option.

A reoccurring observation made by the property managers and fire safety officers was that the number of incidences of *malicious tampering* with manual call points and fire extinguishers by tenants and their visitors was increasing. However, as Figure 14 above shows, this trend is not reflected in the New Zealand Fire Service data and in particular, the Auckland CBD data which shows that, overall, the number of malicious activations resulting in false fire alarm activations has remained fairly constant. Nonetheless, there are resource implications, including allocation of personnel as illustrated in Figure 18 causal loop diagram.

The property managers and fire safety officers interviewed cited the following reasons for the increase in malicious alarm activations:

- A rise in the number of redeveloped buildings whereby the purpose of the building has been changed from commercial to residential;

- An increase in the amount of government subsidised inner city accommodation; and
- As a result of an increase in the amount of rental accommodation, there has been the corresponding increase in the population of young, tenant people in the CBD.

The property managers together with fire safety officers were exploring ways to reduce the incidence of malicious activations, such as covering all manual call points, informing tenants of when and how to use fire alarms and extinguishers and taking punitive action against non-compliant tenants.

The third concern was the increasing number of occupiers, particularly young residential tenants, *refusing to evacuate the building* when a fire alarm was activated. For any alarm system to be effective, an individual must have a level of fear of being harmed by a fire. However, Proulx (2000) reports that frequent false and unwanted fire alarm activations reduce the level of fear and the credibility of the alarm system. Concurring with the literature, interviews with occupiers, property managers, and fire safety officers suggest the following reasons for the high level of complacency towards evacuations:

- The high frequency of false and unwanted fire alarm activations ("it's just another false alarm, why bother");
- An attitude of being invincible (associated with young men's behaviour); and
- The lack of knowledge of either what to do in the event of an alarm activation and/or the risks associated with not leaving the building in the case of a possible fire.

Property managers noted, however, that one positive outcome of frequent drills was that inhabitants were becoming well versed in the evacuation procedures, thus ensuring that all parties were compliant under the Health and Safety in Employment Act, 1992.

Figure 18: The NZ Fire Service's Human Resource Implications as a Result of Malicious Fire Alarm

(Note: Factors that move in the same direction are notated by an **s** or a positive **(+)** sign. Factors which move in opposite direction are notated by an **o** or negative **(–)** sign.)

The domination of major players in the alarm industry

The third theme to emerge from the interviews was the overall concern regarding the domination of a few major players in the fire alarm industry and the subsequent lack of competition in the industry. The interviewees believed that having such few service companies contributed to the systemic problems in the industry. In particular, property managers complained that they were:

- receiving a poor level of service;
- being over-charged;
- frequently dealing with incompetent contractors; and
- witnessing an industry that was not doing enough to ensure a high level of compliance with the fire safety regulations.

Below are examples of comments made by the interviewees:

- *"They charge out horrendous bills, and it doesn't matter which fire company you are dealing with…Somebody has opened up one of our riser cupboards and it cost us $250. It has a triangle lock and I have asked them for a key but they will not give me one because they can charge $250 a pop" (Case Study HR#C)*
- *"You've got probably four of them in Auckland [sub-standard monitoring companies]. If we could get rid of four operators out there we could raise the bar" (Case Study HR#B)*
- *"You get two different engineers and may get two different stories there anyway…there are some reputable firms where you know you can get the job done properly, but they might be 50% dearer than the firm down the road that will tell you it's a Type 5 when it is actually a Type 3" (Case Study HR#A)*

The interviewees also commented that choosing a contractor to service their alarm system was primarily based on price and as a consequence smaller operators were not able to compete against the larger and cheaper ones. According to the interviewees, the result was that most of the smaller operators were being forced out of business The other problem identified by the interviewees was that most installers had only a very narrow level of expertise; that is, little or no expertise in installing or maintaining a range of products. The property managers explained that most installers are affiliated to one, frequently large, manufacturer and therefore would only have knowledge of that particular manufacturer's products, which may not suit all building types or situations. To illustrate these complexities of maintaining a high standard of quality and service within the fire safety industry and the different features of the industry, such as education/knowledge of the industry, a causal loop diagram (Figure 19) has been created below.

Figure 19: Alarm Industry & Quality of Service Casual Loops
(Note: Factors that move in the same direction are notated by an **s** or a positive **(+)** sign. Factors which move in opposite direction are notated by an **o** or negative **(–)** sign.)

Interpretation & Application of the Regulations

The fourth reoccurring theme from the interview data was the perception that many people in the construction and installation industry had little or no knowledge of the regulations pertaining to installation of fire alarm systems and that this lack of knowledge contributed to the frequent misinterpretation of the regulations and the resultant sub-standard systems being installed. Viewed from a systems approach, there has to be a high level of confidence in the legislation and the fire alarm system, as illustrated in the causal loop diagram in Figure 20. In particular, interviewees reported that the different parties involved in the building process – namely, the developers, architects, builders and other tradesmen, fire safety engineers, alarm installers and the New Zealand Fire Service officers often had conflicting opinions over the interpretation of the fire safety regulations (see Appendix 1). The confusion over the interpretation of the regulations also created a situation in which there are huge disparities between quotes where the cheaper options were invariably non-compliant or not best practice. As the interviewees noted, the flow-on affects of installing cheaper, sub-standard systems which are not fit for the purpose of the building were: a) frequent and costly false and unwanted fire alarm activations; and b) the necessary and expensive remedial work to install the correct alarm system. As one interviewee from the fire protection industry stated:

> *"Training is a big thing for the industry … even knowing the standards, it says it is a Type 5, yeah, we all know the standard guidelines but it is not a law, it's a guideline. It is all an interpretation. Hence that's why there are lots of buildings out there which, in my opinion, don't comply, which will never comply… …If a system would clearly cost $200,000 with us and you would probably get it for about $160,000… One we did down the bottom of Auckland…We priced it at $75,000 and another company who won did it for $30,000, and it [the system installed] is wrong"* (Case Study HR#B)

Another interviewee also noted:

> *"Someone certifies these things as being compliant and they are clearly not, and there doesn't seem to be any penalties which apply to the person certifying. There is also so much regulation in terms of the fire regs at the moment. There seems to be a bit of confusion out there as to just what's required at any particular time."* (Case Study HR#A)

Not only is there a perceived lack of knowledge of the regulations pertaining to installation of fire alarm systems in the building industry, but the interviewees also believed that there were endemic system failures in the building process. Each interviewee provided many illustrations of incorrect fire alarm systems being installed during the construction process only to have the system replaced after construction at a significant cost. In two of the case studies, HR#A and HR#C, the original building plans had stipulated the correct fire alarm system, but the plans were altered during construction and on final inspection of the completed building, the fault was identified and required to be remedied at a substantial added cost.

In summary, the case study findings have highlighted a number of issues. It is clear that because each party has its own interests (e.g. for developers it is profits while for the New Zealand Fire Service it is preserving life and property), there are inherent tensions between each group. As a consequence of these inherent conflicts of interest, implementing solutions aimed at reducing false and unwanted fire alarm activations will invariably be fraught with difficulties. It is also evident that the actions of some groups, for example apartment tenants, are more likely to cause certain types of false and unwanted fire alarm activations, such as malicious false fire alarms. Moreover, the New Zealand Fire Service recorded descriptions of the causes of false or unwanted fire alarm activations are not always precise and may disguise the underlying cause, for example the recorded reason will be “burnt toast” but the underlying cause is the installation of inappropriate alarm system or incorrectly placed heat/smoke detection sensors. The case study data, therefore, provides more information which will aid policy and strategies to reduce the number of false and unwanted fire alarm activations.

Figure 20: Level of confidence in the legislation and the fire alarm system

4.3 Affinity Testing Results

As noted above, using the Affinity Diagram Method, an analysis of the New Zealand Fire Service's incident description datasets was undertaken to identify the underlying circumstances leading to false and unwanted fire alarm activations. In particular, a random sample of 200 descriptions from the remark field of these datasets was chosen to indicate the most frequent causes of false and unwanted fire alarm activations and categorised in terms of primary and secondary groups, as outlined in Figure 21. Table 14 shows the groupings that emerged. Interestingly poor maintenance of the alarm systems, environmental factors and contractors contributed 57% of the sample of descriptive activations. This result is confirmed by other studies (refer to Bukowski & Reneke, 1999; Davis, 2000; Rodricks, 2000; Gottuk, et al 2000; NEMA, 2002; Liu & Kim, 2003; Freestone, 2004; Ahrens, 2004).

However, it should be noted that as the New Zealand Fire Service categories have and are changing and therefore there may be a few anomalies and overlapping causes. For example, the category "Poor Fit for Purpose" could incorporate environmental factors and accidental human causes. Another example of ambiguity is the category "Maintenance – Building" which could apply to maintenance errors undertaken as part of building renovations or denote an accident during maintenance work on the fire alarm system.

Reason grouping	**Incidence**	**Percentage**
Maintenance - Alarm System	42	21%
Environmental Factors - Internal Occupant Negligence/Inappropriate System	32	16%
Contractors – Non-fire system	20	10%
Contractors - Fire system	20	10%
Human Cause – Accidental	19	9%
Unknown/Not Investigated	19	9%
Environmental Factors - External	10	5%
Maintenance – Building	8	4%
Human Cause – Malicious	8	4%
Poor fit for purpose	7	3%
Random External Factors	6	3%
Good Intent	7	3%
Intentional Tampering with System	6	3%
Total	204[25]	100%

Table 15: Affinity Grouping of False Activations

[25] As some descriptions fell into two categories they have been counted twice, leading to 204 incidences from a sample set of 200.

The exercise, therefore, highlights the difficulties with generic terms and the need to identify clear, meaningful headings in order that the New Zealand Fire Service can target their resources to problem areas. Currently, the New Zealand Fire Service has implemented its preventative strategy of targeting the top 30 buildings in terms of their number of false and unwanted fire alarm activations and the identified groupings in Table 15 will be further adjusted and clarified as the implementation of their strategy continues. The finalised groupings will be presented to the New Zealand Fire Service to assist in the current changes to the data collection groupings.

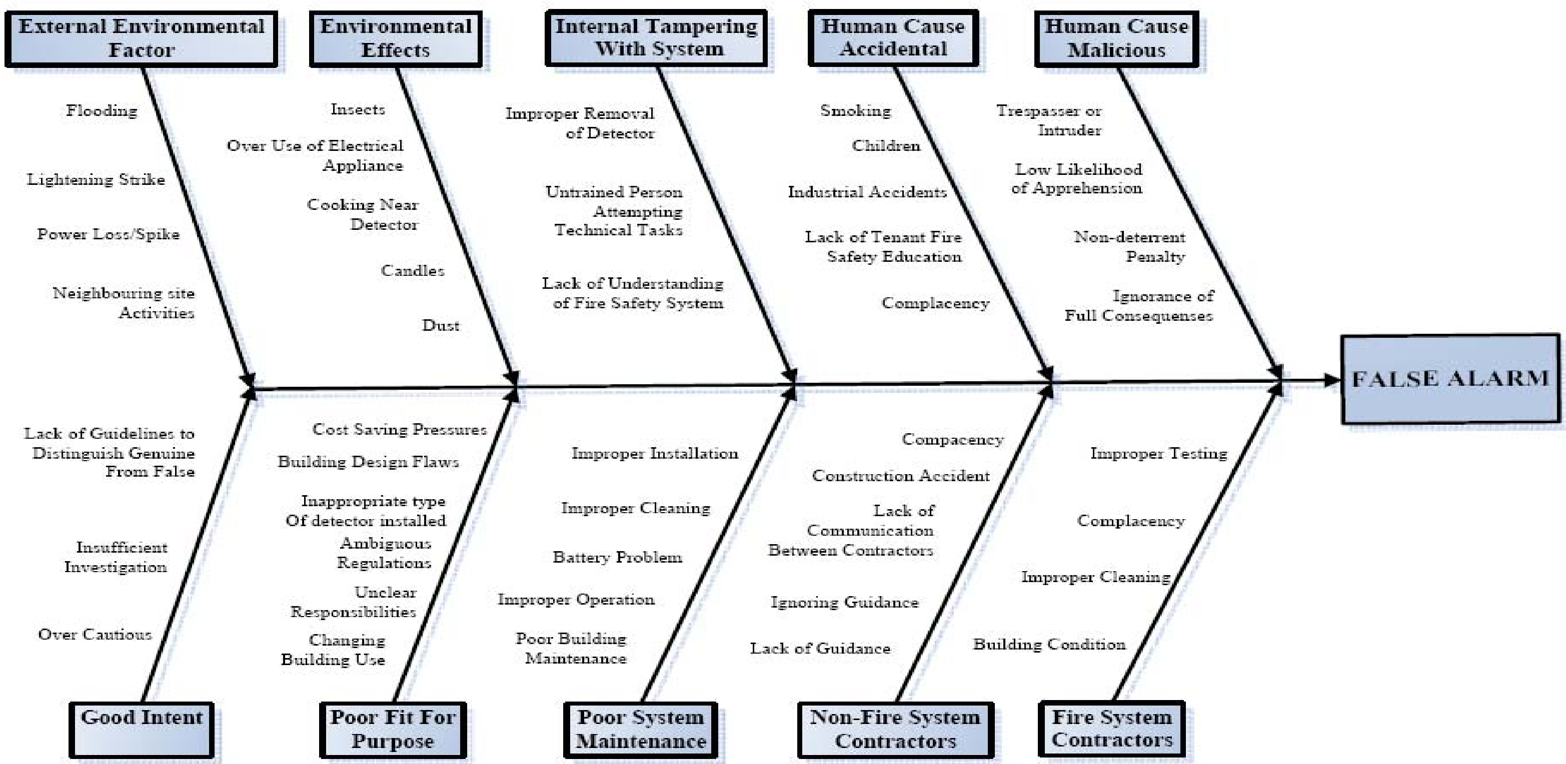
4.4 Excel Spreadsheet

Based on both the case study data and the affinity grouping exercise of false activations, it is possible to construct an Excel spreadsheet. In particular, users can insert individual costs in order to provide an estimate of the total costs of false and unwanted fire alarm activations for a specific building or business. The table below (Table 16) gives examples of some of the items included in the spreadsheet, which can be found in the appendices (refer to Appendix 6).

Lost Revenue	**Additional Costs**	**Repairs and Maintenance**
Unbilled professional hours	Spoilage	Repairs required – short/med/long term
Customers turned away	Wages	Further disruptions

Table 16: Elements of the Cost of False & Unwanted Fire Alarm Activations

Figure 21: The Primary and Secondary Categories of False and Unwanted Fire Alarm Activations



4.5 Statistical Analysis of the NZFS Database

The aims of this section are to address the following:

- To provide a detailed profile of the occurrence of false and unwanted fire alarm activations in Auckland based on quantitative and qualitative data;
- To investigate the conditions (e.g. climatic, time of day, month or year, age of the fire alarm, building usage, etc) that cause false and unwanted fire alarm activations to occur and the frequency with which they occur;
- To identify the industry sectors and types of buildings most prone to false and unwanted fire alarm activations;
- To create graphs and tables illustrating the building type and month prone to unwanted or false fire alarm in Auckland City (2000).

Results of the Analysis

1. **Data sets used**: The data on false and unwanted fire alarm activations received from New Zealand Fire Service was in the form of two datasets – Data Set 1 and Data Set 2. Data Set 1 covered entries from the period January 2000 to December 2003 while Data Set 2 covered 2004, as depicted in Table 17. Efforts were made to reconcile the differences in the fields and definitions, as seen in Table 18.

		Year					
		2000	***2001***	***2002***	***2003***	***2004***	***Grand Total***
Auckland CBD	***False Alarm***	2249	2467	2527	2442	2609	12294
	Genuine Alarm	511	228	177	233	249	1398
	Good Intent Calls	91	23	21	29	26	190
Total		*2851*	*2718*	*2725*	*2704*	*2884*	*13882*
NZ other than Auckland CBD	***False Alarm***	8167	8769	8156	8309	10020	43421
	Genuine Alarm	4097	653	662	649	799	6860
	Good Intent Calls	633	287	260	176	214	1570
Total		*12897*	*9709*	*9078*	*9134*	*11033*	*51851*
Alarm Total		10416	11236	10683	10751	12629	
Grand Total		15748	12427	11803	11838	13917	65733

Table 17: New Zealand Fire Service Data Sets

Year						
	2000	**2001**	**2002**	**2003**	**2004**	**Total**
False Alarm	10416	11236	10683	10751	12629	55715
Genuine Alarm	4608	881	839	882	1048	8258
Good Intent Calls	724	310	281	205	240	1760
Grand Total	15748	12427	11803	11838	13917	65733

Table 18: Activations in the Data Sets 1 & 2

2. **Pattern of activations based on building type, system type and reason:** It was decided to analyse the usable data for patterns of activations based on building type, system type and reason attributed using cross tabulations and other graphical tools. The following graphs outline the patterns of false fire alarm activation and are based on data from the New Zealand Fire Service. As noted above, there were some problems with the New Zealand Fire Service data. In particular, there were numerous data entries missing between 2000 and 2004 and therefore some of the graphs have been based only on data from Data Set 2.

- ***Building Types***
  The two graphs (Figure 22 and Figure 23) below show the number of unwanted or false alarm incidences in Auckland's inner suburbs (Grafton, Parnell, Ponsonby), and the Auckland CBD. Most entries from 2001 to 2003 were "not recorded", and therefore have not been included in the graphs as the picture would have been meaningless. Figures 22 and 23 have been constructed from the 2000 data only. Both Auckland and New Zealand level have similar patterns of false or unwanted fire alarm activations for establishments. Those types of establishments that have the highest false fire alarm incidence recorded are *commercial, retail, manufacturing, storage,* with *residential* establishments in second place and *educational institutions* in third place.

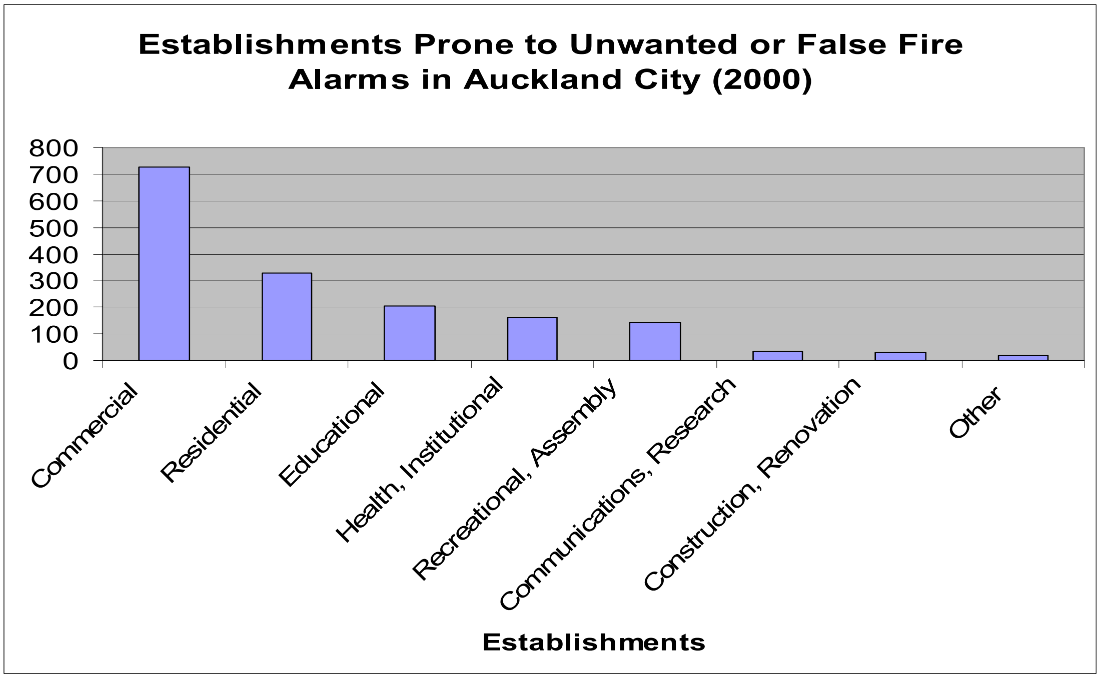


Figure 22: Establishments prone to unwanted or false fire alarms in Auckland City (2000)

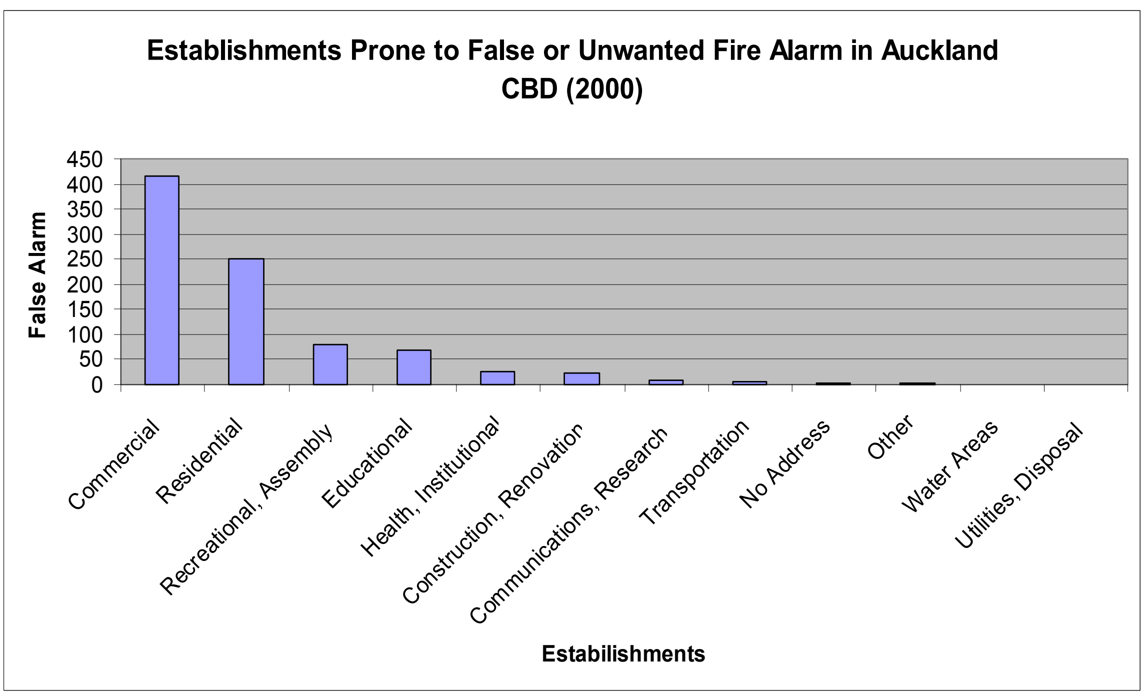


Figure 23: Establishments prone to unwanted or false fire alarms in Auckland CBD (2000)

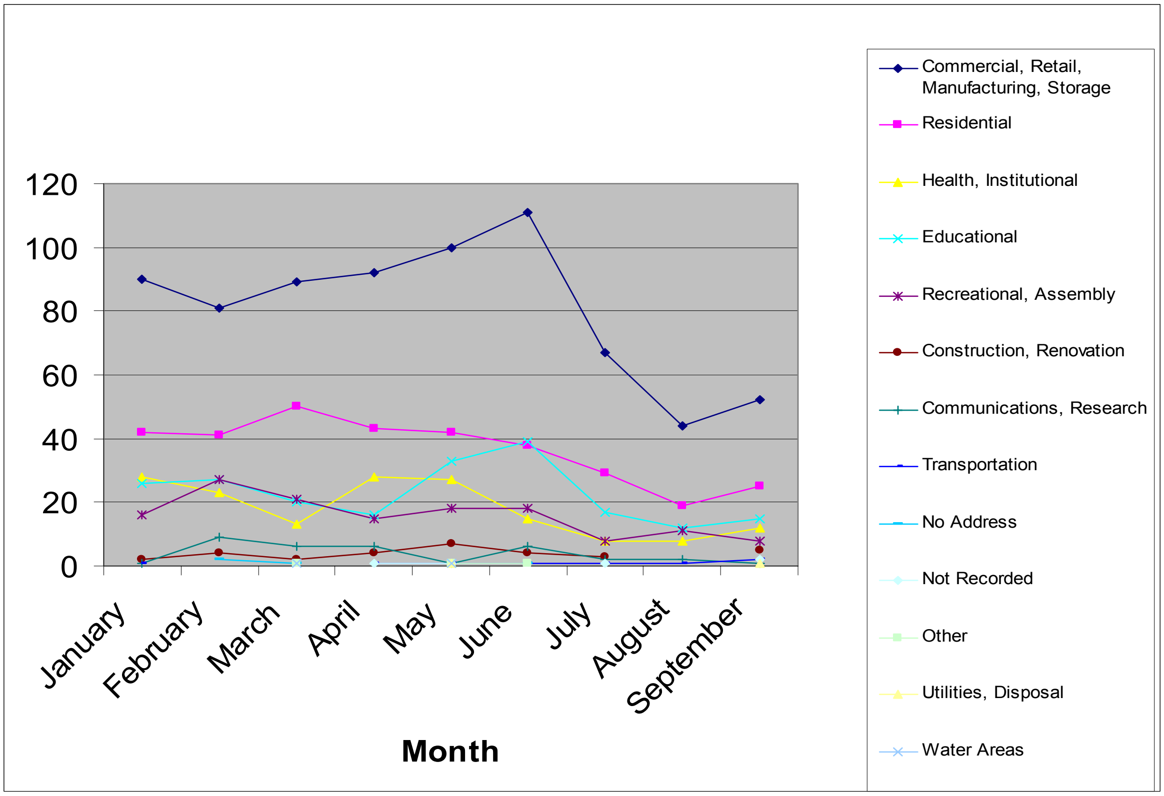


Figure 24: False or Unwanted Fire Alarm Activations by Month & by Establishments

- ***System Types***

The following graphs depict the different types of alarm systems and are based on the New Zealand Fire Service Data Sets 1 and 2.

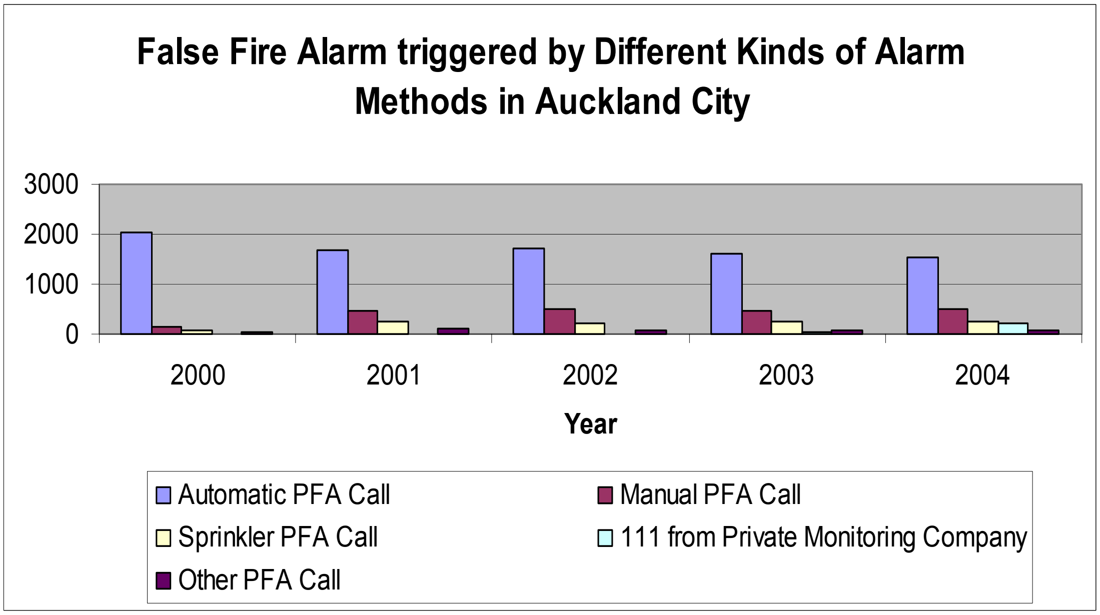


Figure 25: False fire alarm triggered by different kinds of alarm methods in Auckland City

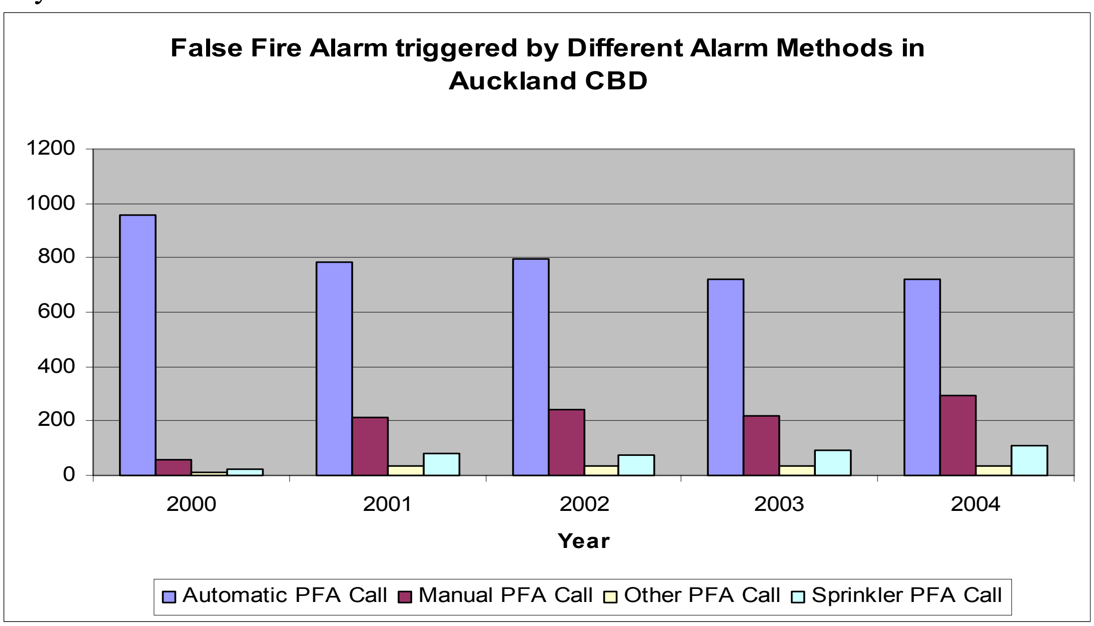


Figure 26: False fire alarm triggered by different alarm methods in Auckland CBD

Most of the false or unwanted alarm activations are triggered by Automatic PFA Call systems. However, in recent years, there has been a downward trend in the number of false alarms triggered by Automatic PFA call systems, while the number of false fire alarm triggered by non-automatic means have increased, thus the overall incidence of false fire alarm has remained fairly static.

- ***Reasons***

The following graphs illustrate the different causes of false and unwanted fire alarm activations. The data is from the New Zealand Fire Service and is based on Data Sets 1 and 2. The following graphs also show that in both the Auckland inner suburbs and Auckland CBD, the main causes of false or unwanted fire alarm are defective and accidental operations. The former can be prevented by better maintenance of the fire alarm system whereas the latter can be prevented by provision of better fire safety education to citizens.

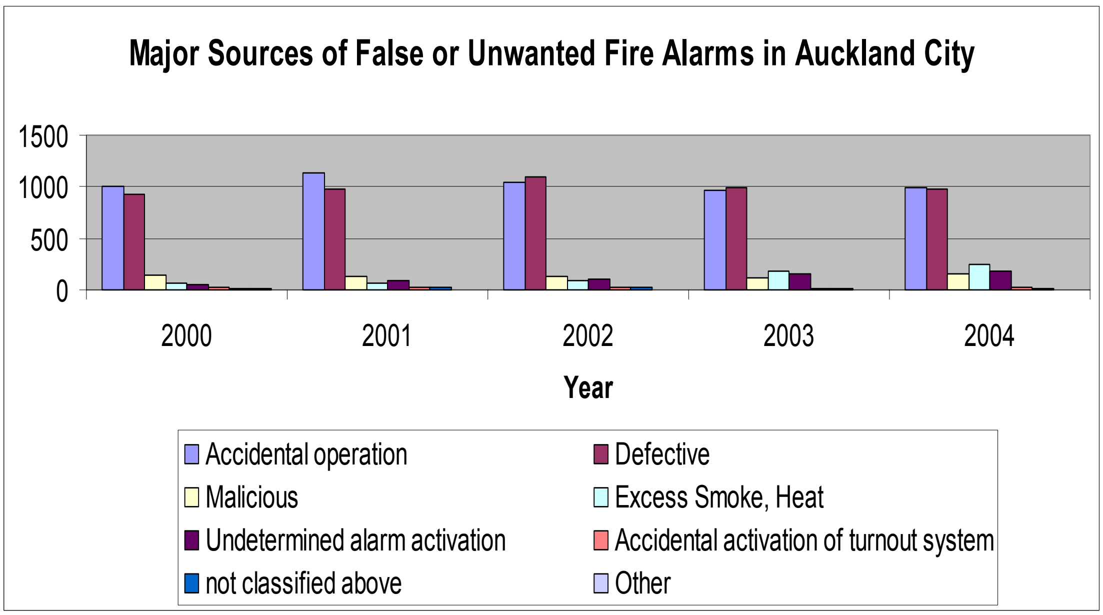


Figure 27: Major sources of false or unwanted fire alarms in Auckland City

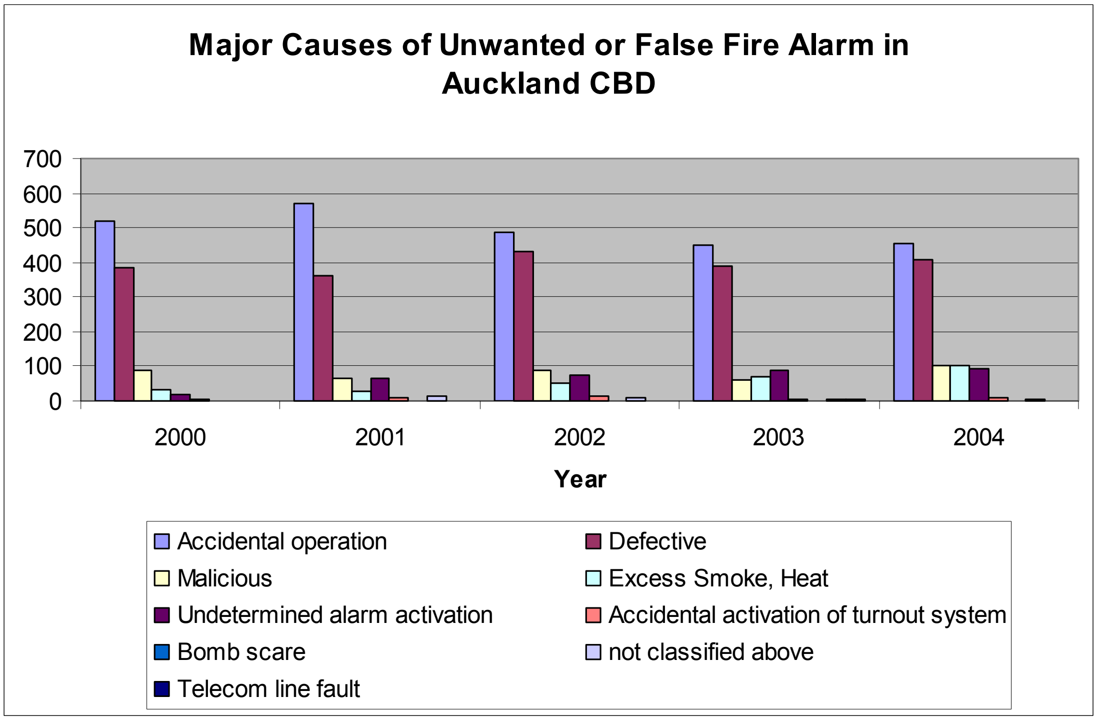


Figure 28: Major sources of false or unwanted fire alarms in Auckland CBD

3. **The number of activations in a day as a time series**: It was decided to analyse the number of activations in a day as a time series to throw some light on the trends and seasonality as well as examine remainder or residual components present in the data. This was done using the STL (Seasonal-Trend decomposition Procedure) software written in R computer language. STL[26] is a filtering procedure for decomposing a time series into trend, seasonal and remainder (residual) components.

   The decomposition in the New Zealand Fire Service example shows that there is an obvious trend in the series, and also some seasonal effect. First, the decomposition procedure can be used to diagnose the stationarity of the series. Second, it can be used as the input data to fill a stationary time series model. The remainder (or residual) is really the remainder after we extract trend and seasonality from the time series data.

   The daily number of false alarm activations has varied from 1 to 26. Of which 6.4 to 7.2 is explained by trend component. Seasonal component accounted for another -4 to +4 of the activations. Thus the remainder still varied from -10 to 15. Note that the scales used in the following diagram are different for the different components.

[26] Cleveland, R.B., Cleveland, W.S., McRae, J.E. and Terpenning, I., 'STL: A Seasonal-Trend Decomposition Procedure Based on Loess', *Journal of Official Statistics*, 6, 1, 1990, pp3-33.

However, it should be noted that the monthly fire alarm data showed stable process behaviour, *except* for August 2000. The reason for this particular month in 2000 being an exception is unclear.

Figure 29: Number of Activations in a Day as a Time Series

Figure 30: Time Series of False or Unwanted Fire Alarm Activations

4. **The different periods (six hourly) of the day**: The hourly false or unwanted fire alarm activations data shown below reveals patterns of variation during the day, suggesting analysis of the data after grouping six-hourly periods of the day.

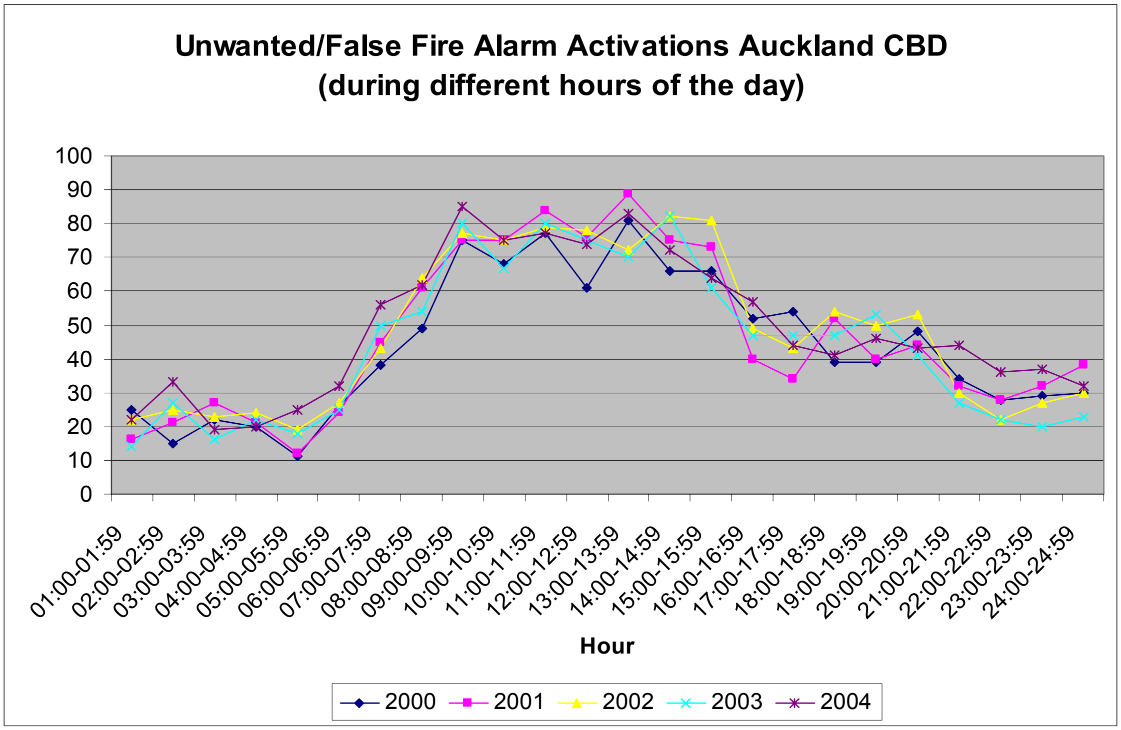


Figure 31: Unwanted/False fire alarm activations in Auckland CBD during different hours of the day

It was decided to analyse the number of activations over the different periods (six hourly) of the day. It is evident that there is a daily pattern of false alarm activation in Auckland CBD and inner suburbs. False or unwanted fire alarm activations occur mostly between 6:00am to 6:00pm. There has also been an increasing trend in the number of occurrences since 2000.

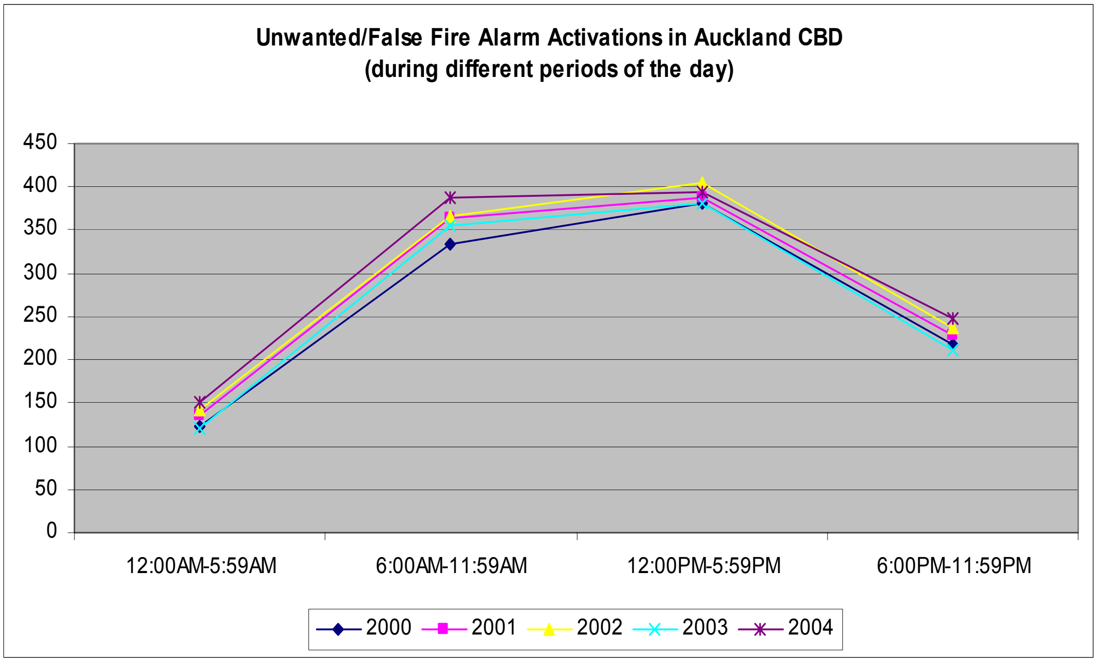


Figure 32: Unwanted/False fire alarm activations in Auckland CBD during different periods of the day

5. To further understand the profile of false or unwanted fire alarm activations, it was decided to answer the following research questions:

   - Does the occurrence of false alarm associate with different periods of a day?
   - Does the occurrence of false alarm associate with different days of a week?
   - Does the occurrence of false alarm associate with different months of a year?
   - What are there interaction effects among the above three factors?

   The following analysis is based on data between 2000 and 2003 from the Data Set 1. The focus here is on the false and unwanted fire alarm activations within the Auckland CBD.

   As expected, the number of false or unwanted fire alarm activations is highly correlated (0.889) with the number of activations (at 1% level of significance). The average period of a false fire alarm activation was the least (7.03) for year 2000 and the most (7.61) for year 2002 and the difference was statistically significant.

   The purpose of the analysis was to compare the unwanted or false fire alarm activation with the different periods of the day, day of week and month of year. The dependent variable is the number of unwanted or false fire alarm activation during any period of the day in Auckland CBD. An attempt was then made to explain the number of false fire alarm activations in a period, using the factors: period of the day, day of the week, and the month, was made using the full factorial analysis of variance (ANOVA) model of the software package, SPSS. This model had an R^2 of 0.657 implying that around 66% of the variation in the number of false fire alarm activations can be explained by these factors.

The output shows that the main effect of the period of the day, day of the week, and the month of the year are all significant (.001) on the activation of a false or unwanted fire alarm in Auckland CBD. Because all the main effects are significant, post-hoc analyses are required. A comparison of marginal means for each effect is necessary.

The three-factor interaction between period, day of the week and month and the interaction between period and month were not statistically significant. Thus by leaving out the above interactions from the model we obtain a revised model with R^2 as 0.588.

ANOVA Table

Dependent Variable: Number of False Fire Alarm Activations in Six-hour Period

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	16874.393(a)	335	50.371	5.597	.000
Intercept	69260.949	1	69260.949	7695.952	.000
Period	10178.016	3	3392.672	376.978	.000
Day of Week	1458.857	6	243.143	27.017	.000
Month	306.776	11	27.889	3.099	.000
Period * Day of Week	1837.277	18	102.071	11.342	.000
Period * Month	340.221	33	10.310	1.146	.264
Day of Week * Month	1174.631	66	17.797	1.978	.000
Period * Day of Week * Month	1434.763	198	7.246	.805	.971
Error	8810.667	979	9.000		
Total	97030.000	1315			
Corrected Total	25685.060	1314			

a R^2= .657

Table 19: ANOVA Table - Dependent Variable: Number of False Fire Alarm Activations in Six-hour Period

The post-hoc analysis suggests that there are significant differences between different periods of day but there may be no difference of false fire alarm activation between period 2 and 3. In addition, the activations of false fire alarms in period 1 are lower than that of period 4.

The post-hoc analysis suggests that the number of false and unwanted fire alarm activations on Fridays in the Auckland CBD is significantly different from those on Mondays and Sundays. The number of activations on Fridays is between 2.5 to 4.3, higher than that on Mondays and between 1 to 2.8 higher than number of activations on Sundays.

Figure 33 below shows that for Mondays and Sundays, the period of the day is also an influential factor on the level of false and unwanted fire alarm activations in the Auckland CBD. On Sundays and Mondays, there are a significantly lower number of false fire alarm activations in all periods of the day, except during *period one* compared to the rest of the week. In contrast Figure 34 shows no interaction between month and period of the day.

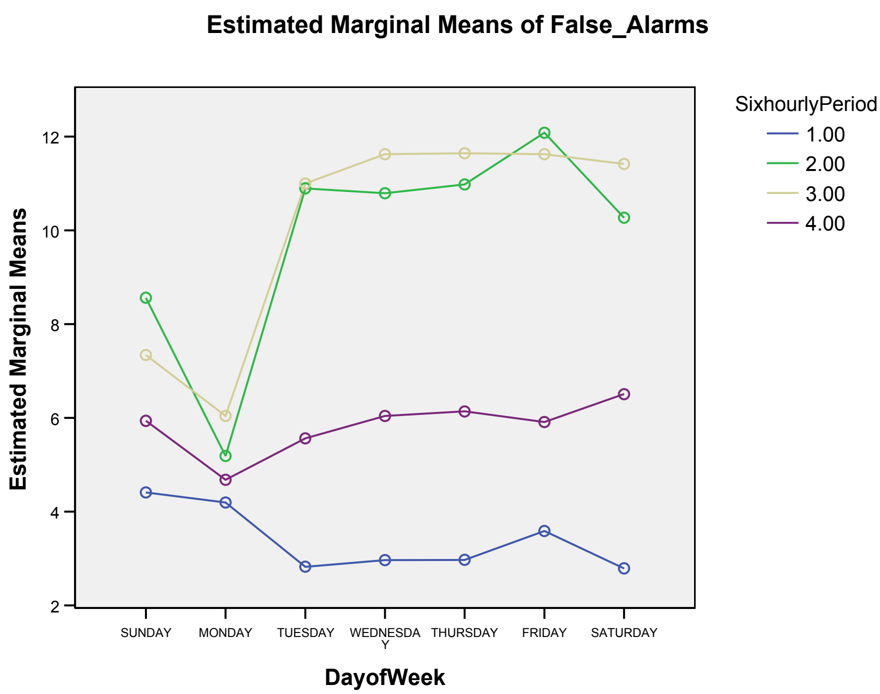


Figure 33: Estimated marginal means of False Alarms by day of week

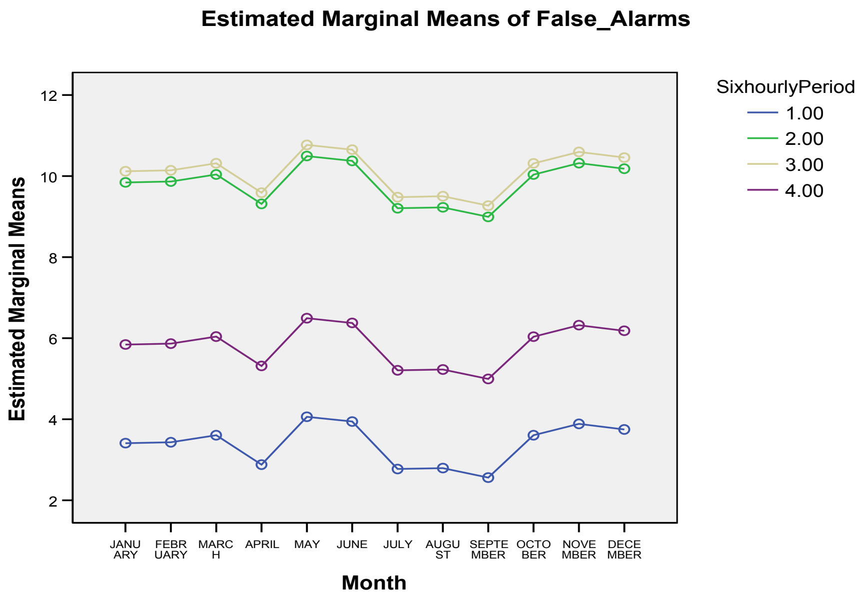


Figure 34: Estimated marginal means of False Alarms by month

Thus all the research questions have been answered in the affirmative. *These finding have operational significance, as this model could be used for allocation of resources depending on the period of the day, day of the week and the month.*

5 Conclusions and Recommendations

It is clear from New Zealand and overseas experiences that the problem of false and unwanted fire alarm activations will never be completely resolved. However, it is also clear that the incidence of such activations in the Auckland CBD is unacceptably high (Auckland has 26% of New Zealand's false and unwanted fire alarm activations even though it only makes up 1.5% of New Zealand's population), and constitutes an enormous waste of resources for the New Zealand Fire Service, businesses and the public. Though the rate of false and unwanted fire alarm activations from automatic alarm systems is reducing, the overall incidence of false alarm activations is increasing. Most investigations of the problem of false and unwanted fire alarm activations have taken an economic approach, rather than a systems approach, and have generated fiscal estimates that are borne by the fire service and tax payers. However, growing overseas evidence argues that producing a singular monetary figure of the costs associated with a nation's total number of false and unwanted fire alarm activations can be counter-productive as it tells us very little about the causes of false and unwanted fire alarm activations and what can be done to reduce the number of activations. Also, it is often impossible to determine exactly how such figures were calculated. Instead there is a growing inclination to apply risk-management and systems approaches in which identifying the systemic causes of false and unwanted fire alarm activations and developing solutions through joint participation of all the parties involved are the preferred outcomes.

Therefore, the central purpose of this study has been to *provide a comprehensive picture of false and unwanted fire alarm activations* within Auckland CBD. In particular, the aims of the project have been to identify the *conditions* or *incidences* that trigger false and unwanted fire alarm activations by analyzing the New Zealand Fire Service database and thus to provide *empirical information* about the key economic and social factors that contribute to these types of alarm activations. In addition, a *spreadsheet* has been developed which will provide users with case-specific estimated costs of their false and unwanted fire alarm activations.

It is also possible to draw a number of conclusions based on the findings.

The first conclusion is that there is *not necessarily only one factor* that contributes to the level of false and unwanted fire alarm activations but a range of different factors that can vary between buildings and fluctuate over time. For example, the age of the building and/or the fire alarm system, the type of building, the type of occupancy (e.g. apartments) and the type of alarm system (i.e. fit-for-the-purpose of the building) as well as the time of day, day of the week and the month are all factors that contribute to false and unwanted fire alarm activations. False or unwanted fire alarm activation can also occur as a result of several interrelated factors. For example, a smoke detector located inappropriately in the kitchen that is activated every time someone burns the cooking.

Although there is not just one factor that contributes to false or unwanted fire alarm activations, some *causal factors are more pronounced*. By analyzing false and unwanted fire alarm activations with different variables, such as the time of day or the building type, it is possible to see *clear patterns* of high or low incidences of alarm activations. Such information can be used as the basis of resource allocation for the New Zealand Fire Service. However, the documentation of reliable and usable data is critical in order to provide an accurate picture of the extent of the problem.

The second conclusion is that type and occurrence of false and unwanted fire alarm activations *are not static*. At a macro level, the Auckland CBD business and residential population has increased substantially and has become more diverse over the past 20 years. There has also been a corresponding increase in the volume of false and unwanted fire alarm activations, as shown by the New Zealand Fire Service data. In addition, New Zealanders have also witnessed major regulatory reforms concerning building and fire safety where the legislation has shifted from being primarily prescriptive to one that relies more on the self-management of regulations and codes. As part of these reforms, the enforcement by territorial local authorities has changed from a public sector model to a private sector model with an emphasis on profit driven objectives and "farmed-out" enforcement. These reforms to the building legislation have not only impacted on the quality of building design and construction, but have also had enormous implications for fire safety, including the installation and maintenance of fire alarm systems.

The third conclusion is that the problem of false and unwanted fire alarm activations *does not take place in a vacuum*. Fire safety is more than just the reactive compliance to the regulations governing smoke detectors and evacuation plans. It is an integral part of the building process and its maintenance as well as public health and safety. Variables such as the type and use of the building, access to resources, the relationship with the fire service and other fire safety/alarm system advisers, are recognised as having an influence on the type of fire alarm system installed and how well it is maintained. Solutions applied to false and unwanted fire alarm activations are meaningless unless they incorporate a network of multiple factors. Therefore, when trying to implement prevention strategies, it is more useful to include *all those involved* in the building and property management industries as well as fire safety engineers, fire alarm installers and more importantly officers from the New Zealand Fire Service *at the planning stage* of construction or redevelopment. Only then will the desired outcomes be achieved.

The forth conclusion is that there are *inherent conflicts of interest* between the different parties involved in fire safety, which, if left unaddressed, will frustrate any attempts to reduce the level of false and unwanted fire alarm activations. Fire safety and the installation of fire alarm systems can be interpreted and explained by applying a conceptual framework that links the different parties – namely the regulatory enforcement agencies (i.e. TLA's and the New Zealand Fire Service), the building developers, owners and occupiers as well as those in the alarm industry. The interview data clearly shows that there are inherent tensions not only between each of the parties but also within each of the groups.

Excellence in fire alarm systems is reliant on the commitment to fire safety from the building developers, owners and occupiers together with a best practice approach from those in the fire alarm industry. Ideally, there should be equilibrium between best practice in the installation and maintenance of the fire alarm systems and the safety behaviour of the occupants, as a lacuna in one area has a compounding effect on the other. Conversely, poor and or inappropriate installation and maintenance of the systems will often coincide with poor fire safety behaviour on the part of the building occupiers.

Finally, a reduction in the number of false and unwanted fire alarm activations could lead to a more efficient and effective New Zealand Fire Service, with reduced response times and more time available to carry out their other duties. Attention to the causes and reduction of false and unwanted fire alarm activations could also have the beneficial effects of increasing the level of reliability and integrity of fire alarm systems, reducing the level of public complacency and minimising the economic and social costs associated with responding to false and unwanted fire alarm activations.

Recommendations

Based on the findings in this study, the following recommendations are proposed:

- It is recommended that the *legislation* covering fire safety be urgently reformed so that it is consistent with *other safety legislation* in terms of the structure (*one* act enforced by *one* authority covering *all* buildings) as well as powers of enforcement. It is recommended that the New Zealand Fire Service be the sole agency responsible for enforcing fire safety regulations and promoting fire safety practices. In particular, it should be *mandatory* for the New Zealand Fire Service be involved in major building and redevelopment work at the *planning stage* of the process and that they be kept fully informed when changes to the design are made. It is also recommended that, where possible, areas of confusion in the legislation be eliminated, for example the confusion over when to install a Type 4 or a Type 5 alarm system.

- It is also recommended that the New Zealand Fire Service, together with those in the alarm industry, continue to *regularly review* the way in which the *alarm activation data* is collected, stored and analysed. The high number of false alarms recorded as "other" or "no reason" diminishes the value of any comparisons that can be made or trends identified. When a false alarm occurs there must be a reason. If the reason does not fit into the currently available definitions then those definitions need to be adjusted. The affinity testing revealed an alternative grouping regime. It is understood that the New Zealand Fire Service is implementing new data collection methods and programmes in 2006, and that the "*reason"* groupings will be changed. It should be noted however that, while this will improve available data and future analysis, it will make precise comparison with past data difficult.

- It is recommended that the fines collected for false or unwanted fire alarm activations are used exclusively for their reduction and to support the proactive efforts by the New Zealand Fire Service to assist the public in installing the correct and appropriate alarm systems.

- It is recommended that the successful New Zealand Fire Service's targeted "Top 30 Buildings" approach to reducing the incidence of false fire alarm activations be replicated to *target the fire alarm industry's poor performers*. This could also provide the Fire Protection Association (NZ) with the impetus to review that way in which registrations are granted and licenses issued or revoked for failure to meet standards.

- It is recommended that those operating in the building and fire safety industries continue to take an active and participative role in reducing the incidence of false and unwanted fire alarm activations. The interview data reveals that there are a number of serious issues which developers, builders, and installers need to address, such as poor construction and service, and lack of fire safety knowledge.

- It is also recommended that those operating in the rental business (landlords/landladies and property mangers) take responsibility for ensuring that there are good fire safety provisions in each tenanted dwelling. In particular, they should ensure that tenants are fully cognisant of the evacuation procedures (as outlined in the regulations) and that each tenant has a basic fire alarm guide in a number of prominent languages.

- Finally, it is recommended that a working group representing the key stakeholders be established to investigate, in the first instance, strategies to reduce the number of false and unwanted fire alarm activations in the Auckland CBD and later, to examine ways of improving fire safety in general.

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Appendix 1

Appendix 2: Types of Fire Safety Precautions

Type 1 Domestic Smoke Alarm System: A stand-alone domestic/residential type automatic smoke detection system with limited coverage that activates automatically in the presence of smoke and is for use only within single household units. This system may be battery powered and has detectors and alerting devices. The system is restricted to a single firecell and does not have a connection to the Fire Service or an indicating unit.	**Type 5 Automatic fire alarm system with modified smoke detection and manual call points:** A variation of the Type 4 and Type 7 alarm systems permitting part of the smoke detection component to comprise only a local alarm. The local alarm system, activated by the presence of smoke, has audible alerting devices to warn only the firecell occupants and the building management, where such management exists.
Type 2 Manual fire alarm system: An alarm system, which is activated only by someone operating a manual call point. It is a single or multiple zone system with an alarm panel providing a zone index diagram and defect warning and suitable for connection to the Fire Service.	**Type 6 Automatic fire sprinkler system with manual call points:** An automatic fire detection, alarm and control system which, when a specified temperature is exceeded in the space, activates the sprinkler head in the affected area and includes alerting devices throughout the building. The system permits alerting devices to be activated manually.
Type 3 Automatic fire alarm system activated by heat detectors and manual call points: A detection and fire alarm system, which activates automatically when a predetermined temperature is exceeded in the space, and can be activated manually at any time.	**Type 7 Automatic fire sprinkler system with smoke detectors and manual call points:** An automatic fire alarm system having the same characteristics as a Type 6 alarm plus an automatic smoke detection system. The fire alarm signal resulting from smoke detection is not required to be directly transmitted to the Fire Service.
Type 4 Automatic fire alarm system activated by smoke detectors and manual call points: A detection and fire alarm system, which activates automatically in the presence of smoke, and can be activated manually at any time.	**Type 8 Voice communication system:** An automatic system with variable tone alerting devices, the facility to deliver voice messages to occupants, and to allow two-way communication between emergency services personnel.

Source: "The Approved Document for NZ Building Code Fire Safety Clauses" 2005.

Appendix 3: Australasian Fire Authorities Council (AFAC) Report

Goal 1 - Enhance Community Safety and Prevention Capability

To create a safer community able to recognise and manage the performance of fire alarm systems

KPI	STRATEGY	TARGET
What do we measure to know if we have achieved it?	How are we going to achieve this?	Level of Performance.
Evaluation of new technology in fire alarm systems and associated equipment and their benefits in minimising unwanted false alarms.	Liaise with fire protection industries on new and current technology that can assist in reducing unwanted false alarms.	Report on the benefits of new/ current technology Nov 2006.
Evaluation of new technology in Alarm Signalling Equipment (ASE).	A report will be submitted on the advancement of ASE technology and how this technology can assist in reducing false alarms. Each committee member will furnish a report if applicable relative to the progress of new ASE technology.	Initial report by Nov 2005. Completed Nov 2006.
The production of a manual on how new technology can assist in reducing unwanted false alarms (for internal and external Stakeholders).	Discussions with fire maintenance/monitoring companies, external fire detection consultancy companies and fire services re relevant information for manual.	Completed March 2007.

Goal 2 - Enhance Operational Service Delivery

To improve the availability of fire crews to actual emergencies

KPI	STRATEGY	TARGET
What do we measure to know if we have achieved it?	How are we going to achieve this?	Level of Performance.
The establishment of false alarm prevention matters in the AFAC's National Training Curriculum.	Enhance the role of Operational Officers capacity to manage false alarm reduction strategies.	Co-ordination of training requirements of each state/NZ. Discussion with AFAC. Assessing current information on strategies/training programs (local/international). Agreement on training programs for inclusion into National Curriculum completed by March 2008.

Key Result Areas (cont)

Goal 3 - Continuous Business Improvement

To promote a culture of continuous improvement of fire alarm systems performance

KPI	STRATEGY	TARGET
What do we measure to know if we have achieved it?	How are we going to achieve this?	Level of Performance.
An on-going evaluation/research (local and international) into false alarm prevention strategies- share information and disseminate where appropriate.	Facilitate research into current unwanted false alarm prevention strategies and if appropriate make recommendations for change.	Ongoing.
	Review emerging issues and ensure procedures/practices are established to minimise unwanted false alarms.	Ongoing.
	Investigate how statistical information can assist in minimising unwanted false alarms.	Report completed by Nov 2006.
Assess how we can influence change through legislation, Codes, Standards or industry guidance.	Discussion and action plan on ARUP/MFB and NZFS false alarm projects. Committee will establish an action plan.	Initial assessment Nov 2005. Completed 2010. Progress reports each meeting.
Evaluate the NZFS/Auckland University false alarm project - disseminate information to Stakeholders.	Work towards a common form of calculating the actual cost to the fire service of false alarms and charging similar types of false alarm activations.	Initial report on findings Nov 2005. Disseminate information to fire services/businesses March 2007. Collate/assess information Nov 2006.

Goal 4 - Contribution to National, State and local Policy agenda

To consistently apply agreed unwanted false alarm strategies across Australasia

KPI	STRATEGY	TARGET
What do we measure to know if we have achieved it?	How are we going to achieve this?	Level of Performance.
Evaluate what false alarm preventions are appropriate and then conduct an assessment of partnership programs that can assist in minimising false alarms.	Establish agreed direction on strategies to reduce unwanted false alarms.	March 2006.
	Develop partnerships with industry stakeholders for the purpose of establishing networks to share information leading to minimising unwanted false alarms.	25% (minimum reduction) in unwanted false alarms by 2010.
	Develop a national web-site for the recording of statistical and prevention information.	Completed by Nov 2006. Statistics ongoing.
	Liaise with other committees and related forums to directly promote unwanted alarm reduction strategies.	Ongoing.
Determine what other committees, groups, forums agencies, and fire services that need to be involved to assist in our aims and objectives.	Committee to implement an action plan co-ordinated through AFAC's Urban Sub Group and other AFAC committees.	Completed by Nov 2006.

Appendix 4: Case Study Questionnaire

x

Entry Code	Interviewed on:
ANZSIC Code	
Business Details	**Interviewee Details**
Name of Business/Building:	Name of Interviewee:
Address:	Position/Status of Interview:
Telephone Number	Telephone Number
Fax:	Fax:
Email:	Email:
Name of Owners/Managers	
Building Details (Current)	**Fire Alarm Details**
Designated use of the building	Type of System(s)
Age of the building	Age of System
Number of floors in the building	Number of Alarm activations over: • Since the construction of the building: • 5 years • 3 years • 1 year
Number of rooms/dwellings in the building	Number of Activations as a result of fire: • Since the construction of the building: • 5 years • 3 years • 1 year
Number of occupiers	Number of Unwanted fire activations • Since the construction of the building: • 5 years • 3 years • 1 year
Number of modifications done to the building	
Type of modifications	
When and what was the most recent modification(s) undertaken?	

Questionnaire

1 What is the nature of your business?

2 How many staff are employed on this premises? ☐ People

3 How long has the business been an occupant of the xxx building?

☐ Months
☐ Years

4 Have any alarm activations originated from your premises?

5 What have been the main causes of fire alarm activations?

6 What has been done to resolve the problem?

7 How many times have you had to evacuate due to a fire alarm activation?

8 How long does it take you to evacuate the building? ☐ Minutes

9 How long does it take to resume normal work after an alarm activation?

☐ Minutes
or ☐ Hours

10 What are your associated inconvenience costs?

	Dollar	Time	Description
Staff			
Lost Sales			

Client

Other

11 How would you rate the level of inconvenience to the business? (please circle)

1	2	3	4	5	6	7
Annoying			Disruptive			Unacceptable

12 What could be done to reduce the number of false fire alarms

Thank you for taking the time to complete this questionnaire

Appendix 5:
Language Data Analysis – Affinity Testing Exercise

External Environmental Factors

1. Plant rm flooded activating smk det on lower lvl
2. Major water leak in rm118 floored thermals
3. Activation as a result of water damage to bldg re: storm
4. Faulty MCP, may have been result of lighting
5. Water in det's due to storm
6. Smk det lvl 9- smk coming in from next bldg
7. Gardener using motorised tool outside, smk det protected area, door/window
8. Activated due to power lost to site
9. Damaged cable due to rats under floor
10. Smoke detector activated by exhaust from jeep

External Factors:

1. Activated due to power lost to site
2. Broken pipe on caustic tank sprayed chemical over thermal det operating
3. Power to bldg switched off by Trustpower, panel went into fire due to low
4. Header tank overflowed in ceiling above rm A10 which caused smk det trigger
5. Possible energy spike
6. Line fault caused multiple f/calls on multiple systems, attended site, not

Internal Tampering with System:

1. Smk det removed from base
2. Manager of restaurant zone 4 removed det thinking it was a domestic ty
3. MCP 1-1 zone1 basement activated smoke detector 9-3 ripped off ceiling
4. MCP in pub operated
5. MCP 1-118 activated snapglaze broken
6. MCP activation on cct O, attended site reset system, placed broken callp

Human Cause Accidental:

1. Zone X smk det's activated due to RT. Police interference
2. Touched brigade test in panel (sent f/call). There is another test switch
3. Water urn left high activated smoke detector
4. Spk in loading bay had been knocked off
5. Forklift hit sprinkler main
6. Det 2/3 activated – suspect patient smoking in room
7. Smoker in bedroom
8. Activated due to patient mistaking the red call point for a door release
9. Callpoint by laundry operated by kids
10. Caused by smk from chainsaw demonstration
11. Smk sensor 5 zone 1 reactivated. School exams in progress, iso'ed sen
12. Suspect students
13. Spk head knocked off
14. Forklift
15. MCP activated by someone trying to open doors, through it was door rel.
16. MCP operated in dark, mistaken for light switch.
17. Forklift working above point, believe this caused activation
18. Pipe and spk head ws hit by a car
19. Kids activated MCP

20. Broken MCP in stairwell 21. Forklift smashes off MCP 22. Person lit paper in stairwell and activated smk det
Genuine/Good Intention: 1. Smk det operated in hallway 2. Spk activated 3. Jammed electric jug 4. Callpoint operated by resident 5. Detector activated, there was smoke in the corrider 6. Possible lightning strike 7. Patient activated smoke detector
Human Cause Malicious: 1. Person lit paper in stairwell & activated smk det 2. MCP grd flr main exit activated maliciously 3. Malicious activation 4. Lvl 3 stairwell centre zone 32 L1 M23 MCP glass broken, maliciously ope 5. Malicious activation of MCP 6. Malicious activation 7. Malicious 8. Two MCP glasses broken by intruder, 2nd one operated, replaced glass
Poor Fit For: 1. Det 7-10 operated possible steam from bathroom 2. Smoke detector in burger king kitchen Z17 operated due to smoke from 3. High temperature in skylight, replaced det to higher temp rating 4. Spk head activated due to excessive heat in bldg 5. Heat det in conservatory corridor activated, 2ND call within 4wks. Carrying 6. Smk det in passge near bathrm tripped due to excessive steam 7. DBA input requires reconfiguring to non-brigade calling
Poor System Maintenance: 1. Faulty contacts 2. Cct function-problem, investigation ongoing 3. Corrosion of wiring termination 4. Faulty MCP, mg love been result of lightening 5. Failure of smk card 6. Corroded det 7. Smk det activated due to contaminated det 8. Gas heaters being cleaned, dust activated smk det 9. Activated due to battery 10. Found thermals corroded 11. Corroded heat det's 12. MCP operated in dark, mistaken for light switch 13. Analogue heat det decided cold room, was actually 63degress 14. Faulty det apartment 13 fault on cct 15. Another call from anti interference valve activation 16. Flat 6 lvl 1 cct 6 operated. Unable to gain access, found faulty plug, repl 17. Activated due to waterleak 18. Activated due to panel fault 19. Leak on pneumatic system

20. Found outside det corroded replaced 4 det's on cct
21. Cable fault
22. Adjust flow switch
23. Water from leaking roof had corroded a det causing a det causing activation of FA
24. Smk sensor activated in main entrance, removed & cleaned, reinstated
25. Smk from emergency light activated smk det. Possibly electrical fault
26. Water leak from drain on floor above
27. Faulty heat detector
28. Smkd et 5b/1 failed
29. Faulty monitored valve
30. Disturbed dust, collected in det chamber caused smk det to activate
31. Water leak
32. Damaged cable to rats under floors
33. System pressure dropped due to worn drain rubber
34. Fluctuating water pressure
35. Loose plug in FA panel
36. Drity smk det
37. System pressure dropped, replaced bottle
38. Dirty detector
39. No cause found, possible leak @ ceiling
40. Some sensor activated level 5 foyer removed, clean and reinstated
41. Shutter 1 dropped, faulty manifold, replaced bottle
42. Wire not connected into responder 7/2 correctly
43. Panel fault
44. EOL heat det badly corroded causing failure
45. Activation result of dirty smk det & flyspray
46. Micro switch in MCP was faulty
47. Dirty smk det
48. Replaced suspect det's & put cct on test
49. Smk det D6 had gone into alarm. Large amount of dust in the chamber

Non-Fire System Contractors:

1. Found contract construction worker carrying out cutting, failed to isolate
2. Vinyl layers set off smk det with fumes from heat guns
3. Smk det had activated in access way, bldg alterations being carried out
4. Workman cutting & grinding creating smk
5. Builders dust activated det
6. Builders working accidentally activated the alarm
7. Gas heaters being cleaned, dust activated smk det
8. Contractor cut through cables
9. Painter set off smk det in passage from spray
10. Builders on grd flr unhooked cct
11. The good old vinyl layers again with their heat torch
12. Bldg alterations in progress, contractors activated system
13. Builders cut cables
14. Workman snapped pipe at thread of fitting, causing spk system to operate
15. Blazing of copper pipe below thermal sensor most likely cause of fire calling
16. Concrete cutter on site, dust set of detector
17. Activated due to electricians cutting formica
18. Smk det main entrance operated due to floor removed people
19. Activated due to repairing air conditioning system
20. Vinyl layer activated smk det

Systems Contractors: 1. Operator error SGD wire removed in error by tech 2. System 3 being pumped up system DBA 1 latched into fire as pressure 3. Activated due to test relay 4. Telecom tech changed batt to LTX caused spk to activate 5. Contractors fixing pipework, water activated det 6. Cleaned dirty smk det 7. Spk fitter failed to isolated DBA properly 8. While testing, battery failed caused spk alarm 9. Adjust flow switch 10. Burnt food extractor fan not working well 11. Tech on site 12. Test timed out before test carried out 13. Contractors accidentally wet a heat det in the detached bldg @ the rear 14. Main stop operated DBA not isolated 15. New alarm tester fail to isolate LTX when doing testing 16. Lvl 1 smk det activated by cleaners spraying chemicals on flr 17. Technician replaced wrong component 18. Tech onsite-reset error 19. Maintenance person opened wrong valve 20. Contractor' grinding concrete
Environmental (Negligent, Cooking etc): 1. Smk activated in office. No visual fault upon arrival. Reset OK 2. A book mite entered an optical smk det causing activation 3. Mike in smk det 4. Operated due to smk from a bbq 5. Smoke machine 6. Smk activated by spray on deodorant 7. Smk from candles set off smk det 8. Sugar dust from machine activated smoke detector 9. Candles on b'day cake operated det's on dance floor 10. Candles lit under smoke detector 11. Smk machine activated det's in lobby 12. Fumes from gas heater activated the smk det 13. Forklift loading foam created dust setting off smk det in zone A 14. Activated by dust 15. Caused by small insect inside det 16. Insect found inside smk det Zone N 1st floor 17. Toast burning in aprt 1E 18. Burnt toast 19. Toaster near kitchen 20. Burnt toaster 21. Smk det in apart 230 operated due to burnt toaster 22. Smk from burnt toast drifted out of kitchen to smk det 23. Burnt toast in kitchen activated smk det in corridor 24. Cooking fumes activated smoke detector 25. Burnt tost in Michael Hill shop 26. Cooking 27. Burnt Cooking 28. Build up of cooking fumes 29. Food odour in stairwell 30. Smk det operated due to cooking

31. Burnt dinner det in hall activated by smk from kitchen

Unknown/Not Investigated:

1. Det termination
2. Unknown-unable to gain access to all areas in zone
3. Not our site at time
4. Lvl 4 zone N smk det operated, cause unknown, left isolated-further investigation
5. Unknown
6. Unknown
7. Unknown
8. Unknown
9. Cause unknown
10. Unknown reason for activation, will followup on Monday
11. No apparent reason for activation, removed det
12. Smk sensor B2 activated. No visual reason for activation upon arrival
13. Det in aprt 21 set off. Cause unknown, no smk
14. Callpoint operated in flat 281, reason unknown
15. No access to zone, isolated
16. Smk activated in office. No visual fault upon arrival. Reset ok
17. Unable to establish cause
18. Checked smk & heat det's, no one in premises @ time. No obvious reason
19. False activation

Appendix 6: Excel Spreadsheet

The Financial Cost
of False and Unwanted Fire Alarm Activations

This spreadsheet is intended as a rough guide to help business tenants, building managers and building owners to quantify the financial cost of false and unwanted fire alarm activations.

	Average time between alarm activation and resumption of business (minutes)				15
	Lost Revenue				
either	Professional billing rate per hour				
	Number of staff	x		=	0
or:	Customers on premises				
	Customers turned away	+			
	Average spend per customer	x		=	0
or:	Average sales per hour			=	0
	Additional Costs				
	Stock wastage or spoilage				
	Machinery shut down and restart costs				
	Average staff wage per hour				
	Number of staff	x		=	0
	Overtime rates paid to meet deadlines				
Total Financial Cost to Business per activation					0
	Costs of Repairs and Maintenance - Short Term				
	New Zealand Fire Service False Alarm Charge				
	Alarm Monitoring company reset charge	+			
	Immediate repair or replacement of components	+		=	0
Total Financial Cost per activation					0
	Average number of activations per year			÷ 12	
	Months until long term solution implemented	x			0
	Costs of Repairs and Maintenance - Medium Term				
	Fire alarm service company temporary solution quote				
	Business disruption during repairs	+		=	
	Costs of Repairs and Maintenance - Long Term				
	Fire alarm service company solution quote				
	Business disruption during repairs	+		=	
Total Expected Financial Cost until problem is resolved					0