STRATEGIC MANAGEMENT INFORMATION IN SUPPORT OF OPERATIONS

EXECUTIVE PLANNING

By Kevin Cuneo
Fire & Rescue Service
of Western Australia
PERTH, W.A.

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ABSTRACT

As fire services embraced new technology there was a requirement to understand the implications on other aspects of service delivery.

The problem the Fire & Rescue Service (FRS) faced was that it lacked appropriate management information to assist it to make informed decisions about its future fire suppression methods and water resourcing requirements.

The purpose of the applied research project was to identify the deficiencies in management information and to develop a suitable list of data it should collect. The research employed historical, descriptive and action research methodologies to identify:

(a) the current water supply infrastructures and practices employed by fire services and upon what principles are they based,

(b) new fire suppression methodologies that are being employed and how do they differ from previous modes,

(c) management information systems required to assist decision-making,

(d) specific information required to assist the FRS to determine the fire suppression methods it will employ and the water infrastructure it will support.

The procedure reviewed past and present fire suppression methods, water supply requirements and management information systems. A workshop identified further fire incident information which needed collecting that would assist decision-making.

The study found that fire services were utilising new technology to suppress fire and they possessed well-developed management information systems. The findings indicated that most of the change was driven from a technical perspective. Because of the significant implications, management needed to consider all aspects of any developments. From the findings it was recommended that prior to the FRS introducing new technology, it should

(a) collect additional information outside its Incident Reporting system about its mode of operations and water resourcing requirements, (b) consider the wider implications technology changes will have on its whole operations when determining which option to take, (c) monitor and regularly review new fire suppression research and development outcomes, and (d) upgrade the presentation format of regular reports.

TABLE OF CONTENTS

INTRODUCTION

Over the last decade the Fire & Rescue Service (FRS) has been debating whether there needs to be significant changes made to its water supply infrastructure which support its fire suppression efforts or whether the status quo should remain. The discussions have centred particularly around its hydrants of which there are some 47,000 within gazetted fire districts across the state. Other aspects which have been discussed include vehicle design and hose requirements for delivery as well as supply purposes. With the establishment of the Fire and Emergency Services Authority (FESA) encompassing the Bush Fire Service, the reticulation and hydrant systems within their jurisdiction will further impact on the decision-making process.

Closely aligned to the issue of water supply infrastructure are the methodologies used by fire services to suppress fires. Because water is widely used as a major suppressant agent, these two issues are closely linked (Friedman, 1997). With new suppressant agents, improvements in pump, equipment and vehicle design, methods in fire suppression are changing to accommodate these enhancements. Many of these improvements come from technological advances and are driven from that angle without consideration of a number of other factors which require management decisions.

Fire services nationally have proceeded to introduce a whole raft of changes into their service. Some of the improvements included are designed to accommodate class A foam systems and changes to delivery and supply of hose lines. The changes have occurred in comparative isolation of other fire services in the country.

Decision-making in relation to all aspects of an organisation’s operations relies on valuable information and it is therefore essential a fire service gathers relevant data to support that process.

The problem faced by the FRS is that it is debating a number of related issues and it lacks appropriate management information which would enable it to make informed decisions about not only its water resource infrastructure but also which fire suppression technology it should employ.

The purpose of the research project is to identify deficiencies in the services management information system which is inhibiting management to make informed decisions about its fire suppression strategies and in turn its infrastructure which would support the methods selected.

A historical research methodology was selected to carry out the research into the relationship between the systems employed today to that of the original design features. The literature reviewed also looked at the fire suppression methods used previously as compared to the new technologies emerging today. Descriptive and action research was also selected to carry out the study and develop a list of information which needed to be collected outside of the current incident reporting system. A literary review of management and leadership publications was conducted to ascertain the current view of management information structures and the types of information required to support decision-making. The research questions included in the study were as follows:

1. What are the current water supply infrastructures and practices employed by fire services and upon what principles are they based?
2. What new fire suppression methodologies are being employed by fire services and how do they differ from previous modes?
3. What management information systems do fire services require to assist strategic and operational decision-making and how should they be designed?

BACKGROUND AND SIGNIFICANCE

Requirements placed upon developers and public utilities to provide water resources and hydrant systems have not progressed significantly for many years in Western Australia. When the current Fire Brigades Act was written in 1942, certain requirements were placed upon the fire service relating to the maintenance and ownership of fire hydrants. Although the legislation has been amended a number of times, the section dealing with the provision of fire hydrants was last changed in 1951 (Fire Brigades Act, 1942).

The significance of water supply systems and hydrants for the FRS cannot be understated. Legislation currently requires the FRS to own the fire hydrants in gazetted districts and to maintain them in effective order (Fire Brigades Act, 1942). Accordingly, the fire service maintains the infrastructure which equates to 47,000 hydrants with a current asset value of 25 million dollars. (Western Australian Fire Brigades Board [WAFBB] Annual Report, 1997). This is an enormous asset which requires regular maintenance and as far as hydrants are concerned, replacement.

With the integration of the Bush Fire Service and Fire & Rescue Service into one organisation, the asset base and value will rise significantly further adding the cost of maintenance and replacement.

Because of the significance of water in suppressing fires (Friedman, 1997) and the recognised importance of having an infrastructure which supports community protection, there is a need to maintain a system of supply for some aspects of operations. However, although water is required in most cases the methods utilised by fire services to suppress fires has improved significantly with the advent of new technologies and techniques (Colletti, 1998).

The high flow rates required particularly in combating residential compartment fires has shifted towards employing techniques such as high pressure hose reels, smaller hose lines with constant flow, variable pattern branches, and now foam additives.

When a service looks at one aspect, such as whether class A foam should be introduced through compressed air foam systems, there are a number of issues which also arise and technological adaptations the fire service needs to investigate. Issues such as vehicle design, training, standard operating procedures, environmental and water supply requirements need addressing. Another aspect which needs to be taken into account is the changing demographics of the community. Urban growth in the major cities and towns throughout the State has had a profound effect on the fire problem in the urban/rural interface. The role of fire service has also seen notable variations. Today's fire services are multi-functional organisations carrying out a number of suppression, Hazmat, rescue, and community service roles. Through this evolution, little change has been made to the infrastructure which sits behind its operations.

Importantly, in support of its strategies and operational aspects is sound information on which decisions can be made. Fire services work in a very intricate field carrying out a wide range of functions. There needs to be reliable and up-to-date information which enables managers to make decisions based on this information (Robbins & Mukerji, 1990). Further, by researching trends a more informed view will be available so that management can make a range of decisions which could ultimately effect numerous aspects of its business.

This work aims to build on the material of the applied strategic planning model of the executive planning module of the Executive Fire Officer Program, in particular to analyse, plan and integrate implementation plans within the organisation in a symptomatic and organized way.

Executive planning emphasises the internal and external influences which are constantly placing greater demands on fire service management. Furthermore, greater accountability for the delivery of a service to the public requires managers to establish information systems in order to capture, accurately report on, and reflect the achievements of a service.

LITERATURE REVIEW

Water still remains one of the major fire suppression means utilised by fire services throughout the world. Apart from its low cost, relative availability and other outstanding properties of non toxicity and non flammability, according to Friedman (1997) "water is superior to any other liquid for fire fighting the majority of fires" (p. 1-94).

The importance of water resources for fire fighting has long been recognised by fire services and government legislators. In New Zealand (NZ), the fire service is required to specify its water requirements for fire fighting, (New Zealand Fire Service [NZFS], 1992). While the Manual of Firemanship (1987) states the Fire Services Act 1947 of the United Kingdom (UK) requires "a fire authority to take reasonable measures" for the adequate supply of water for use at fires (p.69). As recent as 1997, sufficient supplies of water for fire fighting was seen by the WAFBB as a necessity. In their Annual Report to Parliament they stated that adequate water resources were "critical in preventing loss of life as well as limiting property and environmental damage" (W.A.F.B.B., 1997, p. 15).

Water Mains Infrastructure

Typically, in developed countries fire services have access to water supplies through reticulated mains, well designed to provide water for fire fighting as well as domestic needs (Schultz, 1997). This dual role influences the design, and particularly the flow rates of the system, and even the location of standpipes or hydrants from which a fire service can draw supplies. Linder (1997) also identified different hazards and future community growth as a consideration when designing a system. He saw that fire flow rates in the United States of America (USA) were based upon a number of methods, with the Insurance Service Office (ISO) methodology "the most comprehensive and widely recommended" (p. 6-67,6-68). However, Grimwood (1994b) of the UK saw that the "American formulas provide over estimates of actual fire ground requirements". He makes a comparison when outlining his formula with that of the formula for estimating water flow rates for fire fighting which Royer and Nelson of Iowa State University developed (p. 30).

In Western Australia, the fire service sets a water flow rate out of a hydrant at 1500 litres per minute in residential areas and 6,000 litres per minute in industrial or commercial areas (WAFBB, 1993). The rate of flow was established a number of years ago and includes domestic and fire flow requirements. A survey concluded in 1993 that in selected residential suburbs of the Greater Metropolitan Perth, the minimum flow rates in some areas were not being achieved. Likewise in 1992, the NZFS reviewed their fire flow rates and published new standards. Now, the New South Wales Fire Brigade is considering adopting new standards of flow rates of 600 litres per minute in areas where Class 1 dwellings (residential) will be constructed (I.D. MacDougall, Person Communication, June 5, 1998).

Schultz (1997) recommends pipes should not be less than 150 mm in diameter on reticulated mains for fire service use. However, many water authorities install smaller systems in residential areas in countries such as the United Kingdom, New Zealand and Australia. Some older systems have 75 mm pipes, but commonly, the minimum 100 mm pipe sizes make up the distribution system today (Grimwood, 1992; WAFBB, 1993).

Fire Hydrants

Fire hydrants are the means whereby fire services obtain their water supplies for fire fighting. It is upon the water distribution system that the fire hydrants are installed. According to Schultz (1997) hydrant location spacing is determined by the fire flow demands of ISO or other formulas and "at present there is no universally accepted method". Generally, however, spacing should not exceed 245 metres and in closely built up areas, 150 metres (p. 6-41). A survey of Australian and United Kingdom hydrant spacing found that there was no consistency in spacing of hydrants evident between fire services, although none exceeded the 245 metre apart distance (R. Hinch, Personal Communication, May 31, 1995).

Hydrant design has been perfected to suit the local conditions, particularly in areas where very low temperatures are recorded (Schultz, 1997). In Western Australia, both below ground and pillar hydrant designs can be found installed today, even though they were largely perfected early this century. Improved versions of the original design below ground ball type hydrants can still be found in the areas first settled in the city. Similar conditions are recorded in the Goldfield City of Kalgoorlie.

Fire Suppression Using Water

Fire Services have been using water without any foams or wetting agents for the majority of their fire suppression efforts since fire services began operating. According to Friedman (1997) apart from sprays from automatic sprinkler systems, the most common way of applying water is by "a solid stream or spray from a hose" to extinguish burning solids (p. 1-94). It wasn't until the indirect method of fire attack in ship compartments was developed by the United States Marine Corp during World War II that according to Grimwood (1992) fire suppression shifted to any degree from the older method of straight water streams aimed at the base of the fires to different procedures. The procedure developed by the US Marine Corp involved applying water to hot compartment services which in turn rapidly changed the water into steam. The practice particularly suited the European method of fire attack and gained popularity where fire services favoured smaller self contained fire appliances which could operate with reduced water capacity.

The NZFS adopted the fire attack method in the 1960s as its main attack tactic for all but larger fires where low pressure deliveries are used (B. Jones, Personal Communication, August 4, 1998). Australian services use similar methods of fire suppression as other services throughout the developed world. They typically use straight and spray nozzle streams as well as high pressure hose reels with the capacity to produce water fogs (Thornton, 1997). The fog method of fire attack started to lose popularity in the USA because of health and safety issues which were largely overcome with the introduction of medium diameter hose lines that delivered the desired amount of water through a solid stream fire attack method from safe distances and without disturbing ventilation methods (Grimwood, 1992).

The lower pressure delivery method requires larger quantities of water to put onto a fire the required water flows are typically obtained from water mains and delivered through fire service pumps for added suppression power. On the other hand, high pressure water delivery through hose reels has a much lower flow rate and therefore for compartmentalised dwelling fires water carried on the appliance has been found to be ideal. (Grimwood, 1994a). While Kokkala (1996) concluded that for the same extinguishment times water application rates were three or four times higher for solid streams than that compared with fog.

Foams

An emergency trend is the use of class A foams by urban fire services for structural fire suppression. Foams on the other hand have been used reasonably extensively by rural and land management agencies for a number of years. Stern and Routley (1996) found that the State of Texas commenced using foaming additives in the 1970s for wildland fire situations and following further development still use this method extensively today. Their research also found that class A foams were firstly evaluated in the 1930s with results showing "class A foams could suppress fires more efficiently than plain water in most cases" (p. 3, 4).

According to Weider, Smith and Brakhage (1996) the technology has only been fully developed recently. This was backed up by Colletti (1998) who found that the current class A foams were developed in the 1980s. The new foams contain the surfacant properties of detergents, chemicals to improve penetration and other additives to improve the foam's mechanical properties. The new mixtures required low mixture rates between 0.1 to 1 percent compared with other concentrates (Colletti, 1992).

Many benefits have been derived from using class A foams according to Stern and Routley (1996). These include:

- faster knockdown and extinguishment
- quicker overhaul time
- less damage to property
- reduced firefighter fatigue
- reduced water supply requirements.

Class A foams can be delivered by two main methodologies. In the nozzle aspirated system, the water and foam is mixed by a proportioning device on the discharge side of the pump. The foam water solution is aerated at the branch, usually through a branch designed to aspirate.

In compressed air foam systems (CAFS), the foam and water are also mixed on the discharge side of the pump. However, compressed air is then introduced into the water/foam solution thereby aerating the solution prior to its delivery to the branch. In CAFS, smooth bore branches can be utilised (Stern & Routley, 1996).

Jones (1995) reported in the tests that Fairfax County (VA) Fire & Rescue Department did with the US Army Tank Automotive Command at Fort Belvoir (VA), that there were several advantages CAFS had over plain water. It was found that class A foams penetrate deep seated fires due to their water surface tension breaking properties, the foam solution had greater penetration, and overhaul was safer because crews could do the task from a more remote position. Additionally Colletti (1993) found that CAFS systems reduced temperature faster than plain water and foam/water solutions. An added advantage identified by Carringer (1995) of class A foams was that the aerated foam clings to, and blankets fuels as well as insulating exposures from the radiant heat.

Water Mist Technology

Another method of initial fire attack being promoted throughout Europe, the USA, Asia and Australia is the impulse fire extinguishing technology. Its principle extinguishing method is similar to the high pressure hose reel concept, except it uses compressed air to expel small amounts of water at pressures of 25 bar from an impulse gun (Victorian Urban Fire Brigades' Association, 1998). According to the manufacturers, the very fine droplets of water (2 to 200 microns) are injected at high velocity from the impulse gun directly into the seat of the fire, whereby the small droplets rapidly cool the burning material. The high velocity of the water stream enables greater penetration while the conversion of water into steam reduces the heat of the fire to below its ignition temperature. The technology can be employed in a number of ways from backpack to appliance mounted configurations (Wilkey, 1992). The portable backpack mode of operation is reportedly useful in buildings, congested streets and alleyways where response times are delayed because of traffic congestion and limited access.

Small amounts of water are required to make an initial attack as well as control compartmented and other outdoor fires. It was reported in the Victorian Urban Fire Brigades' Association newspaper, *Fireman* (1998) that only "seven litres of water" were required to extinguish a fully involved passenger car fire (p. 15). Conversely, the systems are generally limited to first strike action and rely on the response from other fire personnel with the more traditional fire suppression equipment to, in some cases, fully extinguish the fire as well as carry out large overhauls. Apart from manufacturers' literature there is little recorded research on this new technology.

Management Information

According to Daft (1995) "information is the life blood of organisations because information feeds decision-making" regarding every aspect of an organisation's business. Organisations need to collect and provide information for management (p. 299). Likewise, fire departments are required to provide information to prove their cases for budget allocations as well as problem solving and program development. Gone are the days where the Fire Chief, with years of experience could use his professional opinion only and not base decisions on sound facts (Delgardo, 1993).

Both small and large fire departments are presented with similar decision-making requirements and therefore require typical information. However, it is not necessary for fire departments to collect management information in the same manner. The information can be collected either manually or in a computer database.

Computer databases do however, provide computer power which enables fire departments more quickly to compile and analyse data than the manual system. Because of today's business environment being very competitive with ever increasing demands on levels of service by the community, fire services need effective management. The computer-based management information system is one of the ways to increase productivity with fewer resources (Harvey, 1997).

Hodgetts (1990) saw that even though information systems had the "primary goal" of "providing managers with data necessary for making decisions", information systems had to be developed to meet the different decision-making requirements of each organisation. He also saw that managers faced a major problem with information overload, recognising that too much information doesn't necessarily assist the decision-making process (p. 344, 345).

According to Harvey (1997) there is no universal or one best method to manage information systems. However, the success of the information system depended on how it was "organised and managed" (p. 10-45). Daft (1995) also noted that the way information systems were designed was equally as important. Managers firstly needed to understand the difference between data and information. He sees data as "tangible" and includes such things as numbers, words and times, whereas the data only becomes information once understanding of the numbers, etc has taken place. He concludes information systems should provide managers with information and not data.

Because information is required by managers to make decisions, Hodgetts (1990) also saw that management information systems needed to be tailored to suit the requirements of each level of management and function being performed. To overcome some of the design features, it is imperative for managers to be involved in the design and participate in the system development.

While Keen (1995) identified that in the developing stages of management information systems (MIS), the "MIS staff rarely understood the business, and few business executives understood MIS" (p. 17).

Because organisations and fire services use information to make decisions regarding a number of functions, information systems needed to be designed so that information can be utilised from one area to another. Keen (1995) outlined a data base management system (DBMS) which allows the integration of data from one function to be shared and integrated with data from another function. The system design enabled sub sets of data to be developed which make up the organisation's total data base. According to Harvey (1997) there are two ways system integration can be accomplished. One is the way business functions are packaged. For example, a computer aided despatch data base may be designed so it could be expanded to include human resources and incident reporting data. The other method is for the corporate database to be made up of a number of or groups of databases. In this way the information is obtained from a number of functional areas.

Although most fire services management information systems support a variety of functions such as budget and finance, personnel, fleet management and fire prevention, it is the computer aided despatch (CAD) and incident reporting systems which is orientated towards a fire service's emergency operations. Usually, CAD and incident reporting systems are linked.

The National Fire Incident Reporting System (NFIRS) was established in the 1970s according to Delgardo (1993) and its success has not been on the number of systems installed throughout the USA, but whether or not NFIRS turned out to be the storage of "important and useful source of information" (p. 48).

Information regarding individual incidents according to Schaenman (1997) is for both the individual fire service and "the broader fire protection community" (p. 11-12). Furthermore, aggregated data of fire services across states and countries can be more useful as it enables assessment of effective programs. It is however, difficult to predict all the information that is likely to be required to assist in the decision-making process and therefore, data bases need to be designed so that information can be gathered relatively easily and reliably, and adjusted to include new requirements. Uniformity is a necessity when fire departments wish to compare data across a broader spectrum of the fire protection community. This is accomplished in the USA through the National Fire Protection Association 901 Standard and in Australia through the Australian Incident Reporting System (AIRS).

Importantly, information collected for uniformity and for the wider fire protection community needs to be collected for the benefit of the local fire service. Without any relevance to the local service, according to Schaenman (1997) the "motivation and commitment to quality and completeness may diminish, with a result of reduction in the usefulness of the data" (p. 11-12).

There are two ways in which a fire service can specify the data it requires to be collected and stored. The first way is to define the information required and then determine the best method of collecting it, or alternatively utilise readily available information sources and ascertain how that information can be obtained (ICMA, 1998). Usually, fire services collect their own data from a range of operational sources and utilise information collected by other non fire specific agencies. For data from outside sources to be useful it must be organised in such a format that the data can be manipulated and read easily.

Because most senior executives either do not have the time or the skills to analyse details, spreadsheets or tables, the information should be produced in such a way that it can be easily read and clearly understood. Common methods used can be simply generated by most computer systems in the graphic or tabular form so that the statistical data can be interpreted. Because computer systems are very powerful they can generate useful charts quickly and presented either on an overhead screen or printed out for individuals to scan (ICMA 1998).

Although MIS are designed to provide information regarding an array of activities and the information suffices those requirements, there is still a need for fire services to occasionally study specific aspects of the organisation's operations. According to Kroenke (1992) "decision support systems are created to solve particular problems on an ad-hoc processing basis" (p. 55).

PROCEDURES

The desired outcome of the research paper was to identify information deficiencies in the FRS Management Information System which were inhibiting the decision-making process in relation to which fire suppression methods it should employ, and the resourcing infrastructure implications. It stands to reason that with a greater understanding of the technical nature of fire suppression and public infrastructure, management can utilise that information to make more informed decisions regarding other aspects of its operations.

Historical research was conducted in the literature review to ascertain the relationship between the current public utilities and fire suppression methods employed by fire services to that of early emergency service agencies. The purpose was to gain an understanding of how the past methods and designs have influenced engineering practices in the 1990's. The literature review concentrated on material published in fire service journals and publications. Also, historical research of FRS records and papers written by the Water Corporation of Western Australia was undertaken to ascertain the origins of the West Australian utilities structure and engineering principles. The historical research provided background as to why certain equipment, benefits, and utilities were designed in such a fashion.

The research was additionally descriptive in that it described the current status of the management information, water supply infrastructure and fire fighting methods. Lastly, action research, through a workshop consisting of a cross section of technical and operational staff, was used to identify decision-making information deficiencies. From this, recommendations were made and a process outlined to gather further information which would overcome the current decision-making shortfalls. The information required to be gathered is documented in Appendix A.

Due to the recent changes in technology, a number of fire services have been looking into their operations. The NZFS commissioned the engineering department of Canterbury University in Christchurch, New Zealand, to carry out studies for them. The writer obtained a yet unpublished copy of the work done by the head of department, Dr Fleischmann who is currently doing a comparative investigation of the extinguishing effectiveness of high pressure fog, high pressure fog with class A foam, and compressed air foams in fully developed domestic compartment fires. Apart from the information gathered from his unpublished work, a seminar was held recently at the FRS and the NZFS assisted in providing information for the research.

The literature review concentrated on determining the origins of water system design and infrastructure. From there fire service publications were researched so that an historical approach could be documented on the way in which fire suppression methods evolved. These perspectives were significant as considerable discussion has taken place recently within the FRS whether it should design its fire appliances to include class A foam injection mechanisms and compressed air foam systems. The service has been relying mainly on technical data and the research was important to identify any other resource implications and managerial issues. As a consequence of the research, a contemporary vie w of management information systems required, and a view of what data should be collected, has been formed. Furthermore, this perspective was significant as the technical capabilities were driving decision-making whereas issues such as cost, strategic objectives, time management, staffing levels, and resource allocations were not being considered.

The research project was limited to documentation readily available from Australasia, the USA and the UK. A great deal of literature regarding impulse technology was unable to be found. Therefore research carried out by other than manufacturers and articles written in *Fireman* (1998) and *Helicopter World* (1998) was the only material reviewed.

Additionally, most documented information on class A foams was researched from the USA and recent work carried out in Australia by the Country Fire Authority (Thornton, 1997). The work of Dr Fleischmann from Canterbury University in New Zealand will be useful once published. Further information regarding the United Kingdom and European experience, particularly Sweden would be helpful, as their current fire suppression methods appear to be not consistent with that of USA (Grimwood 1992).

RESULTS

Following research into contemporary water resource requirements, fire suppression methodologies, as well as Management Information Systems which support decision-making, a list of additional incident information requiring collection was developed. It is outlined in Appendix A.

The following research questions were also answered:

1. What are the current water supply infrastructures and practices employed by fire services and upon what principles are they based?

Most infrastructures established to supply water for domestic use are also designed to accommodate fire service requirements. Separate domestic and fire service reticulation systems can be found in certain countries particularly where water supplies in the domestic main cannot support major fire fighting water requirements (Manual of Firemanship, 1987; Schultz, 1997).

Hydraulic calculations, which still are of some relevance today to calculate water stream requirements, stem from the “extensive investigation” work done by John R Freeman in the 1880’s and William Jackson in 1893. The work included determining standard fire streams and hose sizes (Bugbee, 1987, p. 12). From the earlier studies, today’s fire flow rates were developed and are reflected in a number of formulas (Myer, 1993; Schultz, 1997).

Water main sizes are also recommended to accommodate flow rates for fire fighting. In Australia, the UK and NZ, the minimum diameter of 100 mm is found in most residential reticulation systems, although some of the older areas have 75 mm mains. In the USA mains less than 150 mm in diameter are not recommended for fire service use (Grimwood, 1992; Schultz, 1997).

To achieve better delivery into hydrants the ideal system would be where all mains are inter connected in a series of loops so that there are no dead ends (Manual of Firemanship, 1987; Schultz, 1997).

To enable fire services to draw water from the distribution system, hydrants are provided on the mains. Hydrants can either be below ground or above ground in the case of pillar hydrants. The spacing between fire hydrants depends on the fire flow rate near the identified risk to adequately suppress a fire. Shultz (1997) saw that the location of hydrants varied according to need:

> there is no universally accepted method for establishing fire flows for other than fixed extinguishing systems, spacing of hydrants should not exceed 245 metres between hydrants. In close built areas 150 metres or less between hydrants is more realistic. Hydrants should be located as close to the street intersection as possible, with intermediate hydrants along the street to meet the area requirements (p. 6-41).

Furthermore, hydrants should not be placed arbitrarily at set distances apart, but positioned to satisfy fire flow demands. The spacing of hydrants differs in countries with the UK setting arbitrary distances of 90 and 180 metres apart, whereas investigations have found that Australian Fire Services do not have a common standard (Linder, 1997; Manual of Firemanship, 1987; R. Hinch Personal Communication, May 31, 1995).

There are several formulas for estimating fire flow requirements in which to extinguish fires (Grimwood, 1992; Myer, 1993; Schultz, 1997). Two formulas commonly used in the USA are the Royer/Nelson and National Fire Academy formulas.

There is quite a disparity between these two formulas which led Grimwood (1992) to conclude “in my own experience, I find both of these fire flow formulas provide over estimates! Of the two, the Royer/Nelson theory is closest to the real fire requirements”. There are also several variables which affect the amount of water required to extinguish a fire. These include the fire load found within a structure, as well as the skills of the firefighter making the attack on a fire (p. 86).

2. What new fire suppression methodologies are being employed by fire services and how do they differ from previous modes?

In an endeavour to improve the effectiveness of water as an extinguishing agent, work commenced over fifty years ago on the development of water surfacant agents. These surfacants improve the penetrating capabilities of water by reducing its surface tension. The surfacants were produced to be applicable for the different fire classifications but in general are grouped into “either wetting agents or foaming agents” (Thornton 1997, p. 14). It was found there is a difference between the two groups. Wetting agents have the capability to improve the water’s ability to spread and penetrate, while foaming agents are true foaming concentrates with the ability to produce bubbles which can cling to surfaces (Carringer, 1995; Colletti, 1992).

<u>Class A Foams</u>

Synthetic detergent surfacants such as class A foam technology has advanced recently with the new types first appearing in the 1980s (Colletti, 1998, Weider et al., 1996). Research found that class A foams have the ability to penetrate class A fuels, cling to surfaces, reflect radiated heat, enable water to spread like a wetting agent, exclude oxygen, as well as retaining its heat absorption properties (Thornton 1997).

With the recognition that fires can be controlled and extinguished more effectively when additives, and in particular class A foams are introduced, a number of fire services are now using class A foam technology (Grimwood, 1992; Jones, 1995; Stern and Routley, 1996; Thornton, 1997). The foam fire fighting methodology was originally developed for bush and wildland fire fighting. Since those early days, the literature identified considerable development had occurred. This culminated in the development of CAFS. This method combines the good attributes of the aspirated class A foam, but introduces compressed air into the systems which has the ability to "convert 90% of the water to foam" (Thornton 1997, p. 16). It was found the key features of the compressed air foam systems were that for both the wildland and structure fire suppression situations, very low water supplies are required to extinguish fires and the heat of a fire is reduced quicker using CAFS. (Colletti, 1993, 1998).

Water Fogs

Another form of fire suppression which, although not new, continues to be utilised throughout the developed world, is the fog attack fire fighting method. Although it was found that its popularity in the USA is waning, this fire fighting method is still used extensively throughout the UK, Europe and Australasia. The benefits identified of using this type of fire fighting technology over solid streams is that consequential loss caused through water damage to property is reduced, there is a reduction in demands on firefighters, and the amount of water required to bring a fire under control is also greatly reduced. (Grimwood, 1992).

Fire fogging systems were identified as being also used in rural and wildland fire fighting. Similar advantages such as easy handling of long lengths of hose, reduced firefighter fatigue, as well as greater water suppression efficiency were found as with fighting fires with fog systems (Turnbull, 1996).

Solid Streams

The solid stream or low pressure spray differs from the fog or high pressure spray method because of the higher volume of water output and pressures to energise the water. Solid streams have their applications, particularly in defensive fire suppression modes, when an offensive attack is made directly into the base of the fire or if a fire is reaching a point where full involvement may occur. The striking and penetration power of straight streams coupled with the ability to attack a fire from a safer distance were also seen as the suppression methods main advantages. (Grimwood, 1992; Thornton, 1997).

Water Mists

Although inbuilt water mist systems in structures have been available for some time, portable water mist systems, called impulse fire extinguishing technology, has been recently developed in Germany. The technology uses compressed air to expel small amounts of water at high velocity into a fire. Because fine water spray is expelled as such high velocity, the water stream has greater penetrating power than the high pressure fog extinguishing medium delivered via a high pressure hose reel.

From the limited literature, it appears the technology has application in wildland fire fighting as well as structure fire suppression. It is applicable also for exterior high rise fire fighting via the use of helicopters as a platform (Victoria Urban Fire Brigades' Association, 1998; Wilkey, 1998).

The difference between this technology and other forms of fire extinguishment is that the water is expelled at very high velocity by compressed air. Although there is little information published on the fire suppression methodology, manufacturers marketing material shows that water additives, such as class A foam, can be introduced into the fire stream. The biggest advantage is that very small amounts of water are required to bring fires under control (Victoria Urban Fire Brigades' Association, 1998).

3. What Management Information Systems do fire services require to assist strategic and operational decision-making and how should they be designed?

It was found that fire services, like other organisations, rely on information to make decisions, either at the strategic or operational level. They also are required to provide information to external bodies, as well as to other divisions within the service (Daft, 1995; Delgardo, 1993; Hodgetts, 1990). The size of an organisation is also not a predictor of the type of information that is required or collected. Neither is whether the MIS is manual or computer based (Harvey, 1997; Robbins & Mukerji, 1990). However, computer based systems do give organisations the ability to access and assess information much quicker than the manual mode (Daft, 1995; Harvey, 1997; Keen, 1995; Robbins & Mukerji, 1990;).

Decision-making is not necessarily dependant on the quantity of the material. Quality also needs to be considered. The information needs to be "relevant, accurate, complete, reliable and timely" (Robbins & Mukerji, 1995, p. 387).

An important aspect of any MIS is the way in which it was designed according to the research. There is a significant difference between what is data and what is information. Running in parallel with this is that a system needs to be tailored to meet the individual the needs of each level of management within the organisation (Daft, 1995; Harvey, 1997; Keen, 1995; Hodgetts, 1990).

Another aspect of a MIS is that they need to be designed in such a manner that information collected in one functional area can be accessed and used for decision-making in another functional area (Harvey, 1997; Keen, 1995).

It is also not possible for an organisation or fire service when establishing its MIS "to routinely collect all the data items that are likely to be needed by all types of potential data users in the future" (Schaenman, 1997, p. 11-12). Ad-hoc specific information is required at times to solve particular problems (Kroenke, 1992). Therefore it was seen that systems should be designed to enable locally collected data to be added when the need arises. This allows for uniform data required to be collected, with the ability of the system to obtain further specific new information for short periods. Once the specific use of that information is completed, an organisation should cease collecting the data (Schaenman, 1997).

The AIRS data base provides comprehensive information about fire protection issues in Australia. It collates data collected on a national basis and accommodates individual agencies who wish to collect further information for their own requirements. The information outlined in Appendix A, which is additional to the AIRS data, should assist the FRS in its decision-making.

DISCUSSION

The results of the study indicate the FRS's infrastructure, which supports its fire suppression strategies, compares with the findings of the research. It was found that the substantial resources fire services have in place reflect the recommendations of the Literature Review, although there are differences between continents and countries in their application (Grimwood, 1992; R. Hinch, Personal Communication, May 31, 1995). Information systems which support decision-making about all aspects of fire service strategies and operational matters reflect the results of the research.

Common throughout the material is that most infrastructures are based upon work done by the noted researchers Freeman & Jackson and that the principles which were developed still form the basis of public water supply and fire suppression equipment today. (Schultz 1997).

What was evident was that the water supply design has greater capacity in the USA, particularly in residential areas compared to that of other countries that form a part of the study (Manual of Firemanship, 1987; Schultz, 1997). It appears that the Australasian designers have followed the UK water main and hydrant spacing formula even though systems around Australia and New Zealand are similar but not exactly the same (R. Hinch, Personal Communication, May 31, 1995). Apart from this, it is universally accepted communities need a well planned water supply system and a guaranteed fire flow supply for fire fighting even though there are a number of different accepted fire flow calculation methods (Grimwood, 1992; Schultz, 1997). Even though research has been documented on other fire suppression methods, the high volume, low pressure spray/solid stream nozzles, are still used widely today. The use of high pressure fog to extinguish fires compares with the research and this method is still widely used by fire services in Australia as one means of fire attack in structure fires. Although there are certain advantages in this method of fire attack, there are also negative aspects identified. Due to these, fire services, in particular in the USA, are reverting to the more traditional method of high water flows at low pressures for principally extinguishing class A fires (Grimwood 1992). Class A foams are now emerging as a method of fire attack since the foaming additives technology has improved (Weider, et al., 1996). The performance of the extinguishing medium being further improved with the advent of compressed air foam systems. (Colletti, 1993).

Little research has been documented on impulse fire extinguishing technology which appears to be emerging as a new method of fire suppression. The advantage of such technology is that very small amounts of water that are required to control and suppress a fire.

In relation to MIS, fire departments are required to collect and analyse information like any other business organisation. It doesn't particularly matter whether the fire department is small or large, similar information is required for decision-making (Delgardo, 1993).

One of the major findings was that the MIS provided information for managers to make decisions. Therefore managers needed to be involved in the design and system development (Hodgetts, 1990; Keen, 1995). MIS needed to also be integrated across functions within a fire service.

Fire Services are relatively unique in that they have MIS which support emergency operations. The FRS has a CAD system and incident reporting system and it collects information complying with the AIRS which was based upon NFIRS of the USA. Even though AIRS is comprehensive, there are information gaps which were identified. An ad-hoc reporting systems needed to be created to provide specific information and then disbanded once the usefulness of the information has passed (Kroenke, 1992).

Having identified that fire suppression techniques have not only changed over the last few years, but there are emerging new technologies that will have significant impacts on the organisation, the service needs to look closely at a whole range of other issues. Implications such as the design of fire apparatus equipment, standard operating procedures, and training staff need to be considered. It is clear from the research that water mains and hydrant systems of today were mainly a product of work done in the last century and even though valid for high flow/low pressure fire streams, technology has moved on. Because most of the new fire fighting methods have significantly reduced water requirements for the suppression effort, changes to water mains and, in particular, hydrant location and design, would need to be seriously considered.

Another important implication that the research has highlighted is that even though the FRS has a well developed MIS, management needs to have greater ownership and be more involved in reviewing the information at all levels. Furthermore, the information from the database is difficult to retrieve and is not presented in a user-friendly manner.

The study has highlighted deficiencies management must address. More information is required to support the need for current water supply infrastructure and suppression methods, and management needs to take greater involvement in determining its information requirements. The additional information requirements are supported by the FRS research and findings and should assist the debate where the Fire & Rescue Service should be heading.

RECOMMENDATIONS

Policies regarding fire protection are achieved through the aggregation of processed information from a whole range of services within a local community, state and nation. Decision-making is based upon information that a fire service elects and uses to understand the effect their service is having upon fire protection within the community. Information is also a good source in order to raise community awareness of fire protection issues.

One of the most widely used methods to gather valuable information about fire protection is the computerised aided dispatch and the fire incident reporting system. Being a relatively isolated fire department within Australia it is beneficial for the FRS to gather information about a range of operations of the service and compare it with the national experience. Without this valuable information quality decision-making may be hindered. Regardless of the technology employed to collect this information for objective decision-making it must be presented in such a way that managers can interpret the data.

By instituting changes to the management information system it demonstrates clearly that the organisation has a culture, firstly of making decisions based upon good information and secondly it sets a tone for people within the organisation and other stakeholders that the strategic and other operational aspects of community protection is based upon logical decision-making. Given that the FRS does not have enough information to support making changes to the fire suppression methods or its water supply infrastructure, the following is recommended:

1. Cease introducing class A foams into the service until an integrated action plan is developed. The considerable work already being done on the technical aspects of the benefits of class A foams, should be documented and added to any other relevant information that is being collated.

2. The full impact of the introduction of new fire fighting methods should be investigated so that there is a clear understanding by management of the implications of any improvements. From there, management can make informed decisions about the future direction of its fire suppression activities.
3. The FRS should collect the additional incident report information outside of its AIRS database. This information is required to assist decision-making about its operations in line with the recommendations made by the workshop (Attachment A). To communicate the purpose of collecting the additional data and to assist the officers doing the reporting, training by regional managers should occur.
4. The small team that has been having ongoing discussions with the Water Corporation about water flow rates, hydrant design as well as maintenance costs, should form part of the interagency working party that is looking into new fire suppression activities. This will ensure that there is a cross-fertilisation of information, and the public utilities should reflect the requirement of the community as well as taking into account the new fire service delivery directions.
5. Management should monitor and be involved more in the work done by the working party, and in that process, identify and analyse factors, other than technical issues which impact upon the service. For example, a cost benefit analysis should be undertaken, which compares the cost of the changes against the savings made if the infrastructure and equipment changes.
6. Lastly, the presentation of data from the incident reporting system needs to be upgraded so that the information is in a more readable format for managers to decipher.

With improved management information for decision-making, the community, will benefit from any improved fire protection measures, and the fire service will also be seen as more professional and accountable. Other factors such as the cost to the fire service as well as the other operational aspects will be clearly seen to be analysed. Additionally, decisions would be based upon not only the technical aspects but also managerial issues.

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Appendix A

Additional Fire Suppression Information

Incident Number____________Date_______________Reporting Officer__________________

1. Type of Fire:
Structure ❑ Bush ❑ Vehicle ❑ Other ❑

2. If fire was in a structure:
   a. was it fought initially from the: Interior ❑ Exterior ❑
   b. the suppression effort was: Offensive ❑ Defensive ❑

3. Technique used to initially attack fire:
   a. Direct (eg. base of fire) ❑
   b. Indirect (eg. overhead or hot surfaces) ❑

4. How was water applied:

a. high pressure hose reel fog	> 15 bar	❑
b. hose reel	< 15 bar	❑
c. 40mm hose – spray pattern	< 10 bar	❑
d. 40mm hose – straight stream	< 10 bar	❑
e. other ________________________		

5. Estimated water used:
   a. to bring fire under control and suppression __________litres
   b. overhaul litres

6. Was the tank supply adequate to suppress fire:
   a. yes ❑ no ❑
   b. if not, other means of supply: hydrant ❑ another appliance ❑ other……

7. Was a hydrant used to:
   a. connect into tank filler to maintain supply for fire suppression ❑
   b. fill the tank just in case ❑
   c. fill the tank after fire extinguishment ❑
   d. only used for supply during overhaul ❑

8. How far was the nearest hydrant from the fire ________metres

9. If the water tank had a larger capacity:
   a. would its contents have been adequate to suppress the fire yes ❑ no ❑
   b. if so, how much more would have been required _____________ litres