

# Benchmarking the Fire Maintenance Industry and towards eMaintenance

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## Abstract

Fire protection systems are only as effective as the quality of care and maintenance the system receives. This paper discusses how maintenance benchmarking enhances the level of care and maintenance for Active Fire Protection systems. In the absence of a maintenance benchmark, industry participants do not have an objective means to measure the quality of maintenance delivered to a particular fire protection installation.

Benchmarking seeks to (a) establish a standard by which all building owners and maintenance contractors may assess one's own performance in terms of safety, quality, productivity and cost; (b) define a quantifiable set of Indices for enforcement authorities to determine compliance of the relevant sections in the Fire Services Act on an objective basis.

Computing System Availability in a web-based environment by Internet-enabling the fire protection system as a means of implementing maintenance benchmarking is highlighted. Internet-enabling the fire protection systems creates a globally supervised network, facilitating the transition from conventional maintenance to electronic maintenance (eMaintenance).

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## 1. Existing challenges faced by the Fire Maintenance Industry.

### 1.1 Level of Service

The fire maintenance industry experienced unprecedented growth over the last several years. This could be attributed in part to new statutory requirements, a greater level of fire safety awareness, and the scarcity of new constructions projects driving more industry players to focus on deriving a more stable and recurring revenue base from the fire maintenance sector.

In an unregulated and highly competitive environment, this rapid growth has developed some unhealthy and potentially dangerous trends. Of greatest concern from the fire-safety perspective is the trend of contractors offering unrealistically low rates in order to secure a maintenance contract. As a result, the level of service and maintenance delivered may deteriorate to an extent that compromises the integrity of the system being maintained, thereby compromising the safety of occupants and property.

Having a set of guidelines and quantifiable benchmarks would level the playing field for all maintenance contractors while providing good value for money and ensuring a high level of service for property owners.

### 1.2 Maintaining Designated Buildings

Introduction of sections 27-36 of the Fire Services Act, 1988 in August 2002 was a positive step towards enhancing the standard of maintenance of fire protection systems. The Act places the responsibility of providing proper maintenance, testing, and operation of the system on the owners and managers of designated buildings. It also empowers the Fire and Rescue Department (Bomba) to take punitive actions against offending parties.

However, in the absence of an objective set of guidelines and benchmarks, issues may arise in the course of implementation due to ambiguity in interpreting the requirements of the Act. For example, property owners are responsible for keeping the fire protection facilities in "good order at all times" as a pre-requisite for annual renewal of the Fire Certificate. It begs the question "How good is good?" Is a single failure discovered during a random inspection by Bomba reason enough for turning down a renewal application? Otherwise, how much allowance should or could be given?

It is therefore timely for Bomba and the industry to define a set of guidelines and benchmark for the benefit of all parties. A well-defined benchmark could be used not only for managing designated buildings but may also serve as a useful standard for owners of non-designated buildings and maintenance contractors in general.

## 2. Fire Maintenance Benchmarking: The concept

The industry generally relies on “Code of Practice” documents as a benchmark against which to measure the work and services rendered. The “Code of Practice for the Installation and Maintenance of Fire protection Equipment” FPAA001-2000 published by the Fire Protection Association of Australia<sup>2</sup> is an example of a comprehensive set of codes adopted by Corporate members of the association. There is also a “Code of Ethics”, a scaled down version of the former designed for individual members<sup>3</sup>. The British Standard BS5839 Pt. 1 has recommendations for maintenance of fire alarm systems. These documents generally provide “best practices” and guidelines to safeguard industry integrity and professionalism.

Benchmarking, on the other hand goes beyond “best practices” and “guidelines”.

Merriam Webster defines **Benchmark** as **(a)** a point of reference from which measurements may be made **(b)** something that serves as a standard by which others may be measured or judged **(c)** a standardized problem or test that serves as a basis for evaluation or comparison.<sup>4</sup>

In the context of this paper, Fire Maintenance Benchmarking involves

- (a) seeking out the best examples of methods, processes, procedures, and products in order to establish a standard by which all building owners and maintenance contractors may assess one’s own performance in terms of safety, quality, productivity and cost;
- (b) defining a quantifiable set of parameters (known as Indices) for Industry players and Bomba (as the enforcement authority) to determine compliance to the relevant sections of the Fire Services Act on an objective basis.

The key is defining applicable Indices and setting corresponding benchmarks acceptable by the Industry and Bomba.

An example of such an index is “Availability”. For example, the Availability<sup>5</sup> of a Fire Alarm system  $A_{fa}$  is defined as:

$$A_{fa} = \frac{X - Y}{X} \times 100\%$$

Where  $X = \text{Committed Availability (hours)}$   
 $Y = \text{outage (hours)}$

Obviously, 100% availability, though desirable, is not practically achievable due to scheduled maintenance, equipment failures and human error. Industry-Bomba consultations should determine an acceptable benchmark.

Similar indices may be defined for other Active Fire Protection systems like Sprinkler system, Hose Reel System, Total Flooding system, etc. An overall System Availability index for the Active Fire protection subsystem could then be computed.

Benchmarking the Fire Maintenance industry is a very large and complex exercise. Each sub system within the entire fire protection system calls for expert knowledge. Since benchmarking covers both managerial and technical aspects, it is also multi-disciplinary in nature.

It is therefore not within the scope of this document to address the various aspects of benchmarking in depth. Rather, it seeks to set the framework for further discussions and inputs from property owners, facility managers, fire specialists, professional bodies and the authorities. It also seeks to demonstrate, by way of examples, how quantifiable indices may be applied to benchmarking maintenance of Active Fire Protection systems.

### 3. Meeting existing challenges by Benchmarking

Generally, critical elements of Active Fire Protection systems are electronically supervised by a control panel. Any system abnormality is detected and annunciated by visual and audible means.

The time between the detection of an abnormality and restoration of the system to its normal working condition is the Outage period. During this period, the system is classified as “unavailable”. System Availability is a direct measure of the percentage of time it is NOT in an “unavailable” condition.

#### Calculating Availability index for a typical Fire Alarm system

$$A_{fa} = \frac{X - Y}{X} \times 100\%$$

Where  $X = \text{Committed Availability (hours)}$   
 $Y = \text{outage (hours)}$

*Committed hours of Availability, X*

In a given year,  $X = 24 \text{ hours a day, } 365 \text{ days a year}$   
 $= 24 \times 365 = 8760 \text{ hours}$

*Outage hours, Y*

This could be due to actual system/equipment failures ( $Y_f$ ) and scheduled maintenance ( $Y_{sm}$ )

$$Y = Y_f + Y_{sm}$$

Outage due to scheduled maintenance would be directly proportional to the number of detectors in the fire alarm system. If over the period of 1 year, every detector in the system has undergone one complete operational test for fault and alarm, and the average time to test each detector (including travel time between detectors) is 30 minutes, the average annual scheduled maintenance outage,

$Y_{sm} = d/2 \text{ hours, where } d = \text{number of detectors.}$

#### Example:

A fire alarm system with 60 detectors experiencing an average of 10 hours outage per month due to system/equipment failure.

$$\begin{aligned} Y_f &= 10 \times 12 = 120 \text{ hours} \\ Y_{sm} &= 60/2 = 30 \text{ hours} \\ Y &= Y_f + Y_{sm} = 150 \text{ hours} \\ A_{fa} &= ((X-Y)/X) \times 100\% \\ &= ((8760-150)/8760) \times 100\% \\ &= 98.3\% \end{aligned}$$

For a large addressable panel with 5 loops and 100 detectors in each loop,

$$\begin{aligned} A_{fa} &= ((8760-370)/8760) \times 100\% \\ &= 95.8\% \end{aligned}$$

For networked systems, the overall  $A_{fa}$  is determined by the mean  $A_{fa}$  of all panels in the network.

Likewise, the overall Active Fire Protection System Availability (A) may be benchmarked as

$$\begin{aligned} A &= (A_{fa} + A_{hr} + A_{sp} + A_{ph} + A_{tf} + \dots) / N \text{ where} \\ A_{hr} &= \text{Availability of Hose Reel system} \\ A_{sp} &= \text{Availability of Sprinkler system} \\ A_{ph} &= \text{Availability of Pressurized Hydrant system} \\ A_{tf} &= \text{Availability of Total Flooding system} \\ N &= \text{Total number of subsystems} \end{aligned}$$

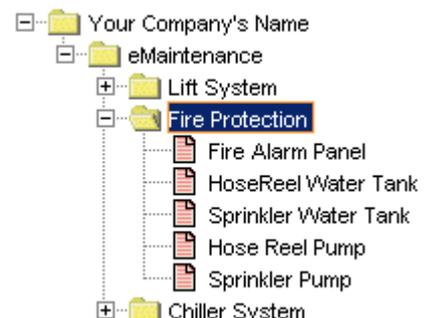


Table 1 below shows availability targets versus hours of outage allowed.

Availability target (%)	Outage allowed (hours / per year)	Average outage (hours / per month)
99.9	8.76	0.7
99.0	87.6	7.3
95.0	438.0	36.5
90.0	876.0	73.0

**Table 1: Availability target and Outage hours**

It may therefore be reasonable to tag a minimum benchmark of  $A_{fa} = 90\%$  for the general industry, a more stringent benchmark of 95% for public-access buildings like hotels, and an even higher benchmark for high risk premises like petrochemical plants. The final benchmark should be determined through Industry-Authorities consultations.

☑ It should be noted that outages due to scheduled maintenance of about 30 hours per year (for an average sized system) accounts for only 0.3% reduction in availability. Hence, except for systems requiring availability targets exceeding 99%, outages due to scheduled maintenance is insignificant and System Availability as calculated above is a very accurate measure of downtime due to equipment or system failures.

Being able to attach a numerical value to the overall System Availability index of a fire protection system has two distinct advantages:

- It is an objective measure of how well a particular fire protection system is maintained
- It is an objective measure of the level of services rendered by the maintenance contractor.

It is evident that benchmarking offers an effective means to overcome the two main challenges currently faced by the Fire Maintenance industry.

#### 4. Other benefits of Fire Maintenance Benchmarking.

Maintenance “best practices” always advocate systematic, detailed and accurate record keeping. It is essential for benchmarking. The following are examples of other useful indices that may also be benchmarked.

<i>Number of False Alarms / month</i>	Indicates vandalism, detector cleanliness, need for calibration, etc
<i>Number of jockey pump runs / month</i>	Indicates leaks, misuse (cleaning cars with hose reel), etc
<i>Number of equipment trips / month</i>	Indicates electrical or mechanical problems, etc

In addition to technical benchmarking discussed above, building owners and maintenance managers also benefit from benchmarking managerial indices like:-

<u><i>Repair Cost (RM)</i></u> <i>Total Maintenance Cost (RM)</i>	Ideally between 15% - 20%. A high index or a positive trend may indicate unnecessary repairs. Should develop a negative trend as the maintenance program shifts from reactive to proactive or condition-based maintenance.
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<u><i>Material Cost (RM)</i></u> <i>Labour Cost (RM)</i>	Index could be trended to detect abnormal variations.
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<u><i>Maintenance Cost (RM)</i></u> <i>Total Maintenance work hours (hours)</i>	Index could be used to benchmark contractor quotations
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## 5. Implementing Fire Maintenance Benchmarking

Critical utilities infrastructure like power, telecommunications, computing networks, servers, etc are rigorously benchmarked with Availability indices. This is possible because relevant system parameters like down times, service disruptions and scheduled maintenance periods, are readily available in real time. It is an integral part of the maintenance management process.

However, Fire Protection systems generally do not have similar built-in capabilities. Dependence on manual recording and calculations to produce reliable System Availability indices over an extended period is not feasible due to inherent weaknesses. Hence, benchmarking Fire Protection systems at the macro level has not been an option, until recent advancements in technology.

Technology is available today to extend this high level of care and maintenance to the Building Facilities Management community in general and the Fire Protection industry in particular. Maintenance management tools employing Embedded Internet technologies and web-based Internet monitoring of Fire Protection systems are able to capture data relating to system failures in real time. This real time data is automatically logged and can be processed into the various indices discussed in the preceding sections.

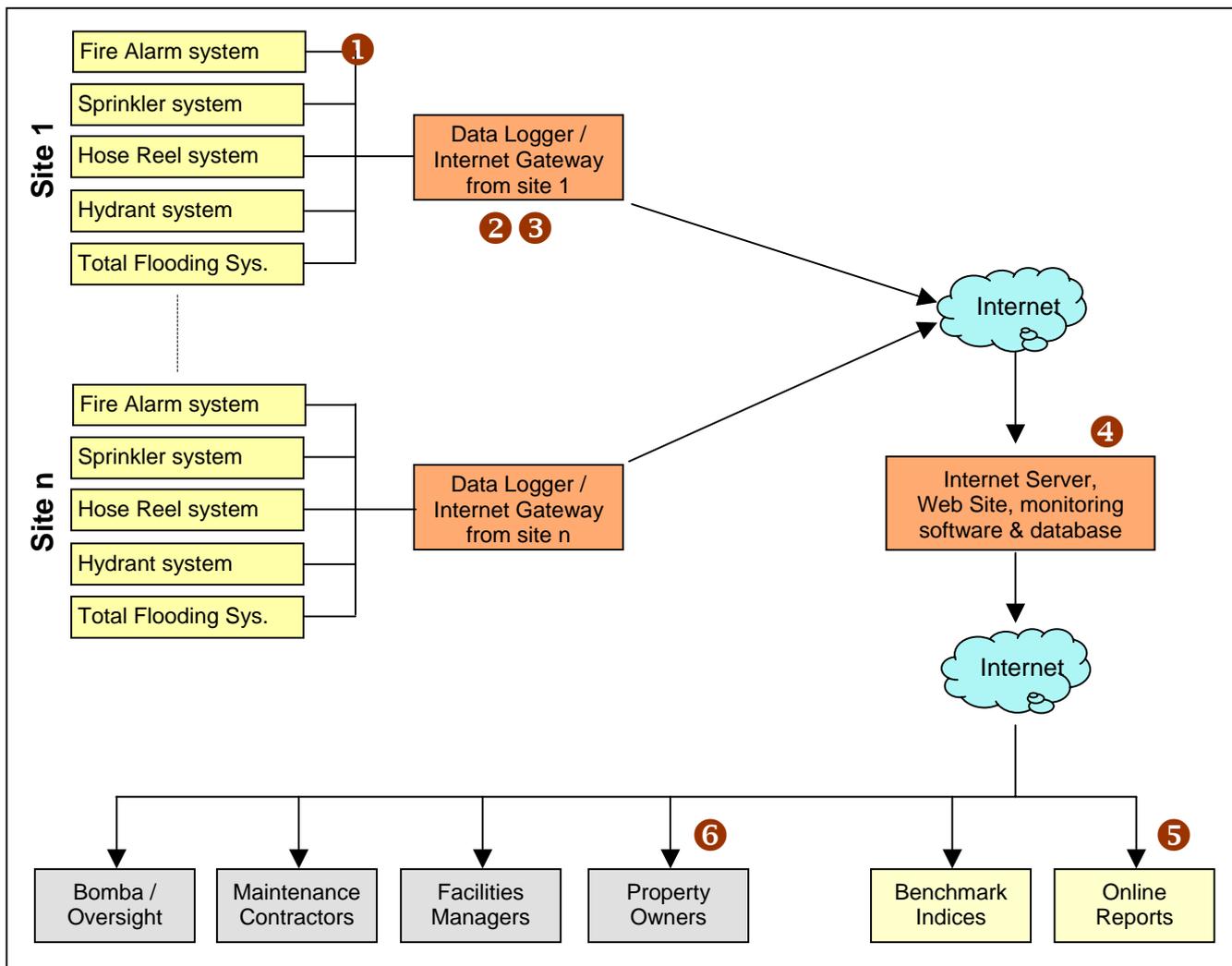
Location : Bilik Kawalan ( 3 Events )		
Event	Channel	Date and Time
Alarm Reset	Fire Alarm Panel	Sun, 4 Jan 2004 06:11:33 PM
Fault Restored	Fire Alarm Panel	Fri, 2 Jan 2004 03:05:58 PM
Trip Restored	Lift Panel	Sun, 4 Jan 2004 06:11:35 PM

Regulating agencies like Bomba, maintenance contractors, facilities managers and property owners having real time access to these crucial indices will be able to benefit as follows: -

- Bomba:** Reliable and objective information to gauge compliance.  
Enhances efficiency and transparency in the renewal of fire certificates.
- Contractors:** Fast, efficient and automatic notification of system failures or abnormalities.  
Objective and efficient mechanism to evaluate Service Level Agreements (SLA) with clients.
- Facilities managers:** Effective benchmarking of maintenance contractors' level of service.
- Property owners:** Automatic recording and benchmarking leaves an audit trail, thereby providing transparency at all levels, from the authorities down to contractors.  
Enjoys a high level of safety and protection.

Figure 1 illustrates how a typical Internet-based Supervisory Control and Data Acquisition (SCADA) system may be deployed to implement Maintenance Benchmarking for Active Fire Protection systems.

- 1 Control panels detect equipment/system faults (e.g. broken cabling, battery failure, electrical tripping, detector malfunction, etc).
- 2 Failure data is picked up by Data Loggers and Embedded Internet Gateways retrofitted to the control panels.
- 3 Failure data is automatically transmitted to an Internet server without any human intervention.
- 4 Data is processed by specialized software and users are alerted of failures through mobile devices.
- 5 Processed data (including Benchmarking indices) are presented to users on any PC with an Internet browser and Internet connection.
- 6 All parties (Bomba, Contractors, Facilities Managers and Property owners) have universal access to the same data in real time.



**Figure 1: Web-based data acquisition for implementing maintenance benchmarking**

Implementation of Fire Maintenance benchmarking can only take off in the industry if it is reliable, easy to deploy and does not pose a financial burden to affected parties. Consider the following factors that facilitate adoption of the benchmarking concept as described above.

- **Embedded Internet technology** eliminates the need to use personal computers and proprietary software to process or transmit data at the site, greatly increasing the reliability of the overall system. The only requirement is to make the Fire Alarm Panel at each site “**Internet-enabled**” by retrofitting a self contained, low cost Embedded Internet Gateway to collect and transmit data over the Internet. Sites using new panels with built-in Gateways may implement benchmarking without any additional hardware.
- Employing a **web-based architecture** eliminates the need for dedicated communication infrastructure to collect, transmit and distribute data. Unlimited number of sites can be served and unlimited number of users supported by using existing public domain infrastructure. This results in a low cost and fast deployment. Web-based Graphical User Interface (GUI) using a standard browser ensures user friendliness and flattens the learning curve. A web-based solution takes the complexities out of an engineering system and makes data available to non-technical users and the management.
- A **Managed Services** model where an Application Service Provider (ASP) hosts the server, server-based application software and database eliminates the need for users to invest in IT hardware and software, set up an IT infrastructure or to allocate IT human resources when implementing Fire Maintenance Benchmarking. This results in low capital expenditure and no IT (software and hardware) maintenance cost.

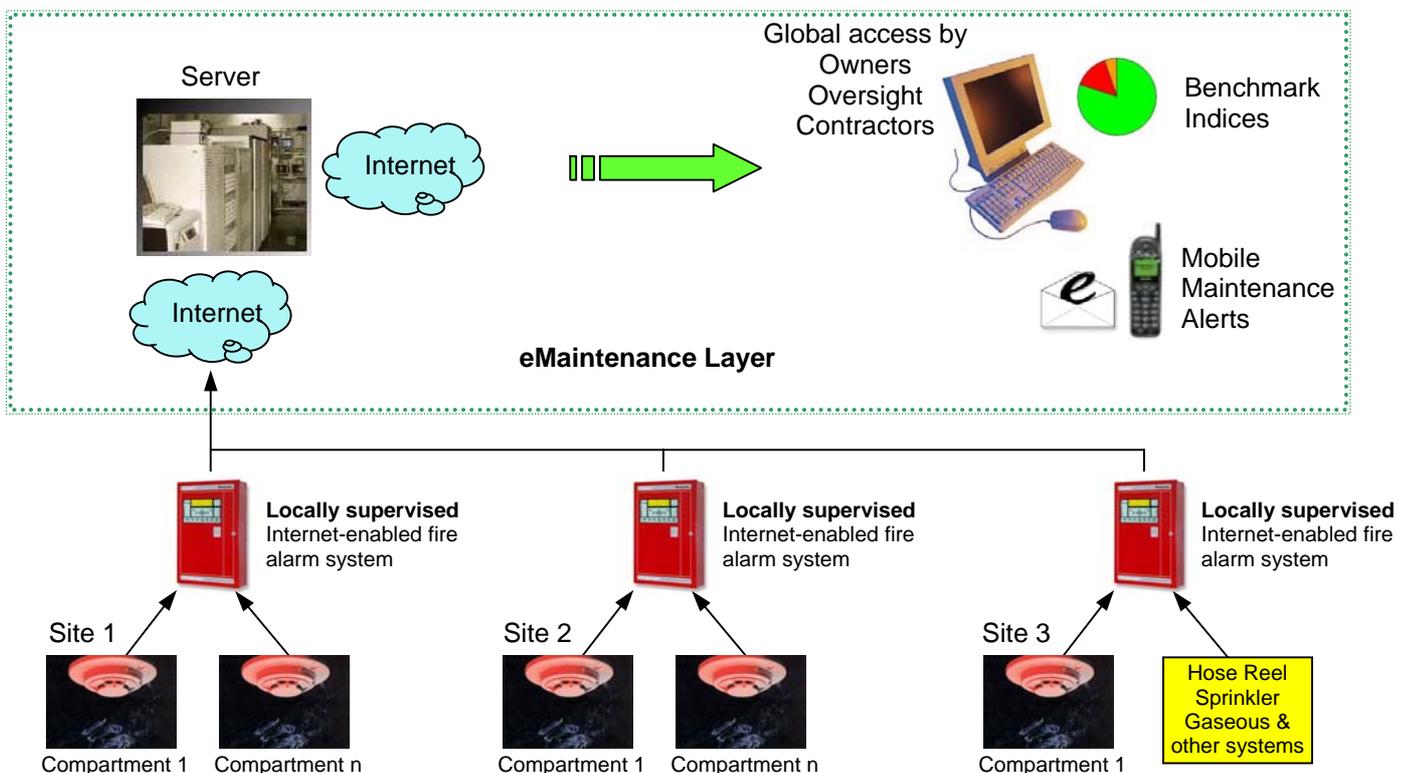
Web-based architecture, embedded Internet technologies and a managed services model collectively brings the cost of implementing fire maintenance benchmarking down to as low as 5% of a typical fire protection system.

## 6. Towards Electronic Maintenance (eMaintenance)

The preceding sections discussed the concepts and merits of computing an Availability Index to benchmark the fire maintenance industry. It has been demonstrated that Internet-enabling the active fire protection systems is a practical means of implementation. Besides benchmarking, another significant benefit of Internet-enabling the fire protection systems is the ability to upgrade the maintenance management from conventional maintenance to electronic maintenance (eMaintenance). eMaintenance is a maintenance management concept whereby maintenance tasks are managed electronically using real-time data obtained from the systems being maintained.

Consider the maintenance requirements of the fire alarm system. Code of Practice BS5839 Pt.1 requires, among other tasks, a daily visual inspection of the fire alarm panel to ensure that the system is in its proper operating condition. It calls for keeping a record of all faults detected. Unfortunately, in many instances this strict maintenance regiment is seldom adhered to. However, when the fire protection systems are Internet-enabled, this process becomes automated, greatly enhancing the level of maintenance because the entire system is now electronically supervised. The following stages of enhancement in fire alarm system design illustrate the natural progression from its most basic to the most advanced form incorporating eMaintenance principles.

- (1) In its most rudimentary form, self-contained smoke detectors are installed in protected areas. These devices are *not* electronically supervised and require periodic manual inspections.
- (2) This basic detection and alarm system is greatly enhanced when self-contained smoke detectors are replaced with wired detectors that are continuously supervised by a control panel. Daily inspections are now required at the control panel level, but not the detector level. This design is the current industry norm.
- (3) Extending the concept of electronic supervision another layer upwards (eMaintenance layer) by treating all control panels as “detectors” will result in a globally supervised fire alarm system. Automatic maintenance alerts, event logging, benchmarking and other key performance indicators are now accessible globally. Since other sub-systems like hose reel, sprinkler and gaseous suppression systems are already supervised by the fire alarm panel, Internet-enabling the fire alarm panel alone provides a globally supervised active fire protection system as shown below.



**Figure 2: eMaintenance layer with globally supervised fire protection system**

## 7. Trends and Conclusions

### 7.1 Trends

As fire protection systems become increasingly sophisticated, corresponding progress in maintenance concepts and technologies are required to keep up with the trend. Recent advancements in embedded Internet and web-based SCADA technologies provide an opportunity for the industry to embrace new approaches to elevate the level of maintenance. With the advent of embedded Internet technologies, the Internet is rapidly becoming the preferred means of machine-to-machine communications due to its inherent reliability and low cost. Fire protection systems can ride on this public infrastructure as well.

### 7.2 Conclusions

- Benchmarking provides an objective and efficient means to measure the level of care and maintenance a fire protection installation receives.
- It provides an objective measure of the performance of maintenance contractors.
- It facilitates efficient enforcement by authorities.
- Internet-enabling the fire protection system using embedded Internet technologies is a practical means of implementing fire maintenance benchmarking.
- Internet-enabling the fire protection system adds an eMaintenance layer over existing active fire protection system architecture resulting in a globally supervised fire protection system, thereby enhancing its overall availability and maintenance efficiency.

## References

<sup>1</sup>Peraturan-peraturan Perkhidmatan Bomba (Perakuan Bomba) 2001 (P.U.(A) 241/2001)

<sup>2</sup>[http://www.fpaa.com.au/code-of-practice/FPAA001\\_June2000\\_.pdf](http://www.fpaa.com.au/code-of-practice/FPAA001_June2000_.pdf)

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<sup>4</sup><http://www.m-w.com/cgi-bin/dictionary?book=Dictionary&va=benchmark>

<sup>5</sup><http://techrepublic.com.com/5100-6314-1060287.html>