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Review and Analysis on Benchmarking

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Table Of Contents

1. OBJECTTIVES AND SCOPE

1.1 Introduction on SOH Project

The Sydney Opera House Facilities Management Exemplar Project (SOH FM Exemplar Project) aims to develop innovative research on facility management (FM) with the focus on asset maintenance. The project utilises the Sydney Opera House (SOH), one of most unique buildings in Australia, to research and create innovative FM strategies and models that will have a direct beneficial role for the Australian facilities management industry as well as the economy as a whole.

The procurement, benchmarking and digitisation are crucial in improving the performance of FM. The procurement develops strategic plan and deployment framework enabling products, services, etc. meet objectives of performance, economic, environment, etc. Benchmarking is a technology used to compare practice and assess performance against the competitors recognised as industry leaders who achieve most successful activities in the field. Digitisation develops digitized FM modelling that facilitates the integration and automation of facility management. The project carries out the research on all the three areas as well as the relationship between them. It aims to develop an integrated approach for the improvement of FM performance.

A further description of the three research areas carried out in this project is as follows:

The procurement research aims to develop a performance-based procurement framework. Service requirements are defined in terms of performance objectives. Performance assessment and decision making strategies are developed.

The benchmarking research aims to develop an asset maintenance benchmarking system that comprises performance measures, methods and procedures, which enables the company/organisation to identify areas of success and where improvement is needed.

The digital modelling research aims to develop a digital FM model based on the 3D digital building models to assist in the integration and automation of facility management.

This report presents an initial research on benchmarking.

1.2 Benchmarking Research

The following objectives on the benchmarking research will be achieved through the development of the project:

- Review benchmarking in facility management with the focus on the asset maintenance. Identify key issues and methodologies through the analysis of SOH cases and best practices.
- Develop an asset maintenance benchmarking system for both in general for the FM community and adoption by SOH. Benchmark a set of key areas which are most valuable for benchmarking and where the improvement of maintenance performance is needed.
- Deliver recommendations on implementation of best practice on asset maintenance required by SOH.

1.3 Deliverable from this Report

This report presents the first deliverable of the benchmarking research. It reviews and identifies key issues and methodologies on benchmarking, as well as provides a comparative analysis of SOH cases and best practices. The structure of the report is as follows.

Section 2 presents a review of benchmarking in facility management.

> Section 2.1 reviews the applications and approaches of performance assessment and analyses on how a performance assessment framework, based on the balanced scored approach, may be developed to support the benchmarking.
>
> Section 2.2 reviews the benchmarking process. Steps of the benchmarking process based on Camp (1989) are analysed.
>
> Section 2.3 reviews the benchmarking system and some key issues.

Section 3 provides an analysis of the benchmarking system.

> Section 3.1 presents some key issues for maintenance benchmarking and a suggested list of the basic measurements for starting.
>
> Section 3.2 discusses the generation of appropriate queries for benchmarking and establishment of an assessment and classification framework.
>
> Section 3.3 analyses the data structures in the benchmarking system. The internal and external data structures in the benchmarking system are defined. It is followed by a comparative analysis of the SOH cases and best practices. Recommendations on how the data structures are improved are presented.
>
> Section 3.4 reviews the management of benchmark process and provides an analysis of the benchmarking process based on the SOH cases.

Section 4 introduces the management of the information on maintenance.

> Section 4.1 analyses the information of building, assets and services based on the SOH cases.
>
> Section 4.2 discusses the approaches of collection of information based on the SOH cases.
>
> Section 4.3 provides a summary of the information management on maintenance.

Section 5 provides recommendations on an integrated information model for supporting benchmarking and facility management.

> Section 5.1 introduces an integrated information environment.
>
> Section 5.2 analyses the information environment of SOH FM.
>
> Section 5.3 recommends an integrated information model for supporting benchmarking and FM.

2. A REVIEW OF BENCHMARKING IN FACILITY MANAGEMENT

This review begins with section 2.1 which highlights the application and trends of performance assessment, provide a guide to developing and managing performance assessments and a performance assessment framework, the concepts underpinning the framework, and its limitations. This is followed by a review and guide on the benchmarking process, and its performance outcomes in section 2.2, and a brief explanation on the importance and key components of a benchmarking system in section 2.3. The key components will be further elaborated in section 3.

2.1 Performance Assessment

2.1.1 Introduction

Performance assessment may be defined as the direct, systematic observation of an actual performance and the rating of that performance according to previously established performance criteria (NCREL, 2005); the purpose of which is to achieve continuous improvement (Hill, 2000). This can be achieved through benchmarking. It enables organizations to enhance their performance (Ramirex, Alarcon and Knights, 2004) by comparing performances between different organizations or different units within an organization that undertake similar goods and processes (Garnett and Pickrell, 2000), so that best practices may be identified, adapted and implemented to improve performances. Irrespective of organizations' business functions, benchmarking if correctly applied, ensures that organizations are able to gain the competitive edge necessary in today's business world. This includes facilities management as it is well-suited to benchmarking (Mainelli, 2005).

2.1.2 Approaches of Performance Assessment

Traditionally, performance assessments are primarily financially-based (Bracketz and Kenley, 2002) involving the measurement of performance via financial indicators (Amaratunga, Baldry and Sarshar, 2000). It is dominated by cost and volume. Cost is in relation to the amount of money spent on the service or commodity, for example, capital expenditure, lease income, total revenue and expenditure. Volume is in relation to a numerical measurement of output, the area or volume of space or buildings covered or the number of items produced for the money spent, for example, OccupancyCost/m^2, RefurbishmentCost/m^2, m^2/person, hours the facility utilized (Heavisides, 2001; Brackertz and Kenley, 2002). These 'traditional' criteria, though providing good data, only paint half the picture of the facilities' performance. This is because the traditional methods of measuring results do not incorporate the valuation of an organization's intangible and intellectual assets, such as high quality products and services, motivated and skilled employees, responsive and robust internal processes, and satisfied and loyal customers. It is also particularly limiting when the organization's strategic aims goes beyond bottom line performance and increasing shareholder value (Brackertz and Kenley, 2002).

There is a general consensus that financial indicators alone are now inadequate (Merchant, 1985; Neely, 1999; Otley, 2000) as a measure of competitiveness or guide for future performances of facilities (Amaratunga, Baldry and Sarshar, 2000). It is therefore pertinent that business performances are measured considering two broadly-based perspectives: financial and operational (non-financial) (Brackertz and Kenley, 2002). Financial measures provide the results of action already taken while operational measures complement the financial measures and drive future financial performance. A combination of these measures will provide organizations with performance assessments that are able to measure performance from a broader, more ‘balanced’ and comprehensive perspective.

A form of assessment which has recently been dominant in performance assessment literature and adopted in practice is that of the Balanced Scorecard Approach (Kaplan & Norton, 1992; Kaplan & Norton, 1993; Kaplan and Norton, 1996). This approach, first developed by Kaplan and Norton in 1992, recognised that many businesses had measurement processes that were incomplete due to an over reliance on traditional financial measures.

Heavisides (2001) also supported the above notion by highlighting that, for the field of facilities management, the Balanced Scorecard is a means of combining the outcomes of performance measurement (indicators) as an overall performance matrix which contributing organizations can use as a benchmarking guide or framework to determine the scope of their overall facilities management performance. For instance, a performance assessment framework may combine commonly known ‘harder’ parameters such staff costs, operating costs, energy costs, area of buildings used or cleaned, telecommunication costs with ‘softer’ parameters such as customer assessment of service, staff assessment of service, attitude and/or responsiveness of service departments, cleanliness of facility, continual service improvement, attitude and responsiveness of contractors etc.

2.1.3 Performance Assessment Framework based on the Balanced Scorecard Approach

This section presents how a performance assessment framework (PAF) based on the Balanced Scorecard Approach (BSC) may be developed (Chan, Lin and Northcott, 2002).

2.1.3.1 Purpose of the Performance Assessment Framework

The Performance Assessment Framework (PAF) is useful in assessing how well an organization was or is delivering its services and to enhance its accountability to its stakeholders. Also, the purpose of the framework is to improve an organization’s performance by focusing on more comprehensive views of performance, rather than simply on “bottom-line figures” that focused primarily on the financial aspects of organizations in the past. Overall, the PAF is meant to serve as a measurement system and a strategic management system to link organizational strategies with operational activities, such as the management of facilities, to improve performance.

2.1.3.2 Developing the Performance Assessment Framework

(1) Establishing the dimensions of the PAF and the design structure for the BSC application

The dimensions of the Performance Assessment Framework are established by considering the needs of all the different stakeholders, outcome and process measures, as well as long and short-term targets (Kaplan and Norton, 1996). All the information provided by the stakeholders would be collected in a centralised database which may be linked to the organization’s asset register which helps reduce duplication of data since existing information about the facilities are linked to the new set of data. The dimensions should reflect the organization’s vision and strategy from which the objectives and measures of the scorecard are derived.

By evaluating the facility for each of the dimensions, these dimensions provide the framework for the scorecard. It is pertinent to note that while Kaplan and Norton recommend viewing organizational performance from four dimensions: customer, internal processes, financial and innovation, the NHS PAF has instituted six dimensions: health improvement, fair access, effective delivery of appropriate healthcare, efficiency, patient/carer experience, health outcomes of NHS care. There may be one or a few main dimensions supported by other dimensions. The aims of these dimensions must also be established in conjunction with the dimensions. Table 1 presents a design structure of the BSC application while Table 2 shows an example of how a balanced scorecard for facilities management may be drawn up based on Kaplan and Norton's four BSC dimensions. (Amaratunga, Baldry and Sarshar, 2000).

Table 1: A design structure of the BSC application.

o	Objectives:	States how a strategy will be made operational. The objectives form the building blocks for the overall strategy of the organization.
o	Measures:	A quantifiable measure (performance metric) that will reflect progress against an objective. The measures communicate the specific behaviour required to achieve the objective and become the actionable statement of how the strategic objective will be accomplished.
o	Targets:	A quantifiable goal for each measure. The set of targets becomes the overall goals of the organization. Targets create opportunity to succeed, help the organization monitor progress towards strategic goals, and communicate expectations.
o	Cause-and-effect:	Objectives are related to one another through cause-and-effect relationships.
o	Strategy Initiatives:	Action programmes that drive strategic performance. These are the activities that will be focused on to ensure attainment of strategic results. Initiatives should be aligned with the strategy on the BSC.

Table 2: An example of a BSC for facilities management.

Dimensions	**Factors under each dimension**	**Aims of organization**
Customer	o Customer satisfaction on quality of service o Customer complaints o Range of service offered o Reaction to customers' needs	To reflect the overarching aim of the organization to provide customers with services that they would expect of a first-class performing arts centre.
Internal Processes	o Service excellence o Technological capability o Understanding of customers o Employees' competence o Process efficiency o Staff development	To recognise that for the organization to provide our customers with first-class service, we have to ensure that we are up-to-date with technology, understand our customers' expectations, and that our employees are well-trained to respond to our customers.
Financial	o Management expectations o Financial growth o Cost reduction o Productivity improvement o Asset utilisation o Management of working capital	To increase revenue and reduce operational expenses by not just looking at financial measures only, but by ensuring all other dimensions (i.e. non-financial) have been improved upon. The financial measures will then take care of themselves.
Learning and Growth	o Technology leadership o Continuous service improvement o Upgrade of staff competencies	To recognise the need for continual improvement and to create value for stakeholders by looking at issues such as improving competency of employees, and having an information system and procedures capable of supporting the Performance Assessment Framework.

(2) Establishing a set of performance indicators

Kaplan and Norton (1996) note that a cause and effect relationship between process and outcome measures is a necessary element of any BSC framework. The NHS PAF assumes that a cause and effect relationship exist between aspects of health service and health improvement indicators. For instance, in a performing arts facility, an example could be ‘aspects of service delivery’’ (i.e. process measures) and ‘customer service improvement’ indicators (i.e. outcome measures). In other words, a set of Performance Indicators are developed, based on the key aims and objectives, to support the dimensions. These indicators should direct and support the organization in meeting their organizational targets and objectives set out in their business strategy.

(3) Establishing a PAF based on a BSC approach

Kaplan and Norton (1996) recommended that the application of the BSC should be modified/transformed to suit the particular context of the non-profit and government organizations. Since then, the BSC has been applied successfully in diverse industries such as hotel, IT, engineering and construction, chemical, converter of flexible materials, telecommunications, and banking (Amaratunga, Baldry and Sarshar, 2000), and of late, its application in the health services, in particular the National Health Services (U.K.). Evidence suggests that BSC offers a medium to deliver a strategic vision while providing an evaluation system at the same time. Some of the concepts of the BSC on which the PAF is underpinned are introduced in the following sections.

2.1.3.3 Balanced Scorecard Approach (BSC) that Underpin the PAF

(1) BSC supports a multi-dimensional framework

- Considers the performance driving factors and outcome objectives.
- Identifies the long-term objectives of the stakeholders.
- Identifies key processes that promote the delivery of long-term objectives. In line with the key processes, measure and report the outcomes and outputs achieved for the resources invested.
- Incorporate dimensions of activity that relates to the organization’s primary priorities.

(2) BSC supports a multi-stakeholder approach

The BSC identifies and incorporates the needs of all other stakeholders, such as customer’s satisfaction, employee’s satisfaction, instead of just profit-oriented issues such as increasing shareholders’ wealth. For instance, there could be one or a few main ‘outcome’ dimensions, such as customer service improvement, which reflect the needs of patrons and visitors of a performance facility; and to achieve these main objectives, several further dimensions of performance measurements are developed to reflect the needs of other stakeholders.

Furthermore, a PAF based on the BSC approach does not just consider the needs of different internal and external stakeholders, but also includes outcome, output and process indicators as well as financial and non-financial measures. According to Chang, Lin and Northcott (2002), though a PAF may be unique to the organization for which it is developed, it is still consistent with the concept of the BSC. However, it is necessary to note that the PAF differs from the BSC by having the needs of different stakeholders spread across the different performance dimensions instead of having each particular dimension representing the interests of a particular stakeholder group.

(3) BSC as a strategic measurement tool

According to Kaplan and Norton (1996), it is important for the BSC to be designed to link the outcome and process measures in a cause and effect relationship in order to maximise the benefit of BSC as a Strategic Measurement Tool. Also, the BSC complements financial measures of past performance with measures of the drivers of future performance, and enhance systematic strategic reviews. It helps in obtaining feedback to learn about the improved strategy, to test and gain feedback on, and update the organization's strategy while putting strategy and vision at the centre; whereas current financial and non-financial measures are only used for control and feedback of short-term operations at a corporate level.

(4) BSC as a strategic management tool

It is necessary, within the PAF, to link the performance indicators to the organization's strategic priorities set up in their business strategy/framework (i.e. supporting business alignment), and summarise the disparate elements of an organization's competitive agenda in one management report. Also, the BSC assists in clarifying and gaining consensus about vision and strategy, and motivates staff to make the organization's vision happen and not just a measure of performance. By focusing on the efforts of people, throughout the organization, it works towards achieving strategic objectives and converts the organization's strategy into a comprehensive set of performance and action measures that provides the basis for a strategic measurement and management system.

(5) BSC as part of an information system for all employees

BSC emphasizes that performance measures must be part of the information system for employees at all levels of the organization. It is balanced between objective, easily quantified, outcome measures and subjective, somewhat judgemental, performance drivers of the outcome measures. In other words, it communicates strategic objectives, performance measures and drivers at all levels of the organization.

(6) Cause and effect relationships

An important aspect of BSC, when establishing appropriate performance indicators, is the need to establish identifiable cause and effect relationships. By evaluating the relevant factors in each segment of the BSC which may have an impact on the financial aim, the appropriate measures can be identified and the alignment of actions to the specific goals can be facilitated, e.g. outcome measures need performance drivers to indicate how the outcomes are to be achieved.

2.1.3.4 Limitation of the Framework

It is difficult to develop a PAF that is able to entirely encompass all the dimensions that an organization is concerned with. For instance, the 'number of complaints' may be used to measure 'improvement in customer satisfaction'. However, improving customer satisfaction is not only about reducing number of complaints. It is also about trying to meet the expectations of customers. Such 'invisible' outcomes are sometimes difficult to quantify.

It is difficult to develop performance indicators that can perfectly or/and accurately reflect the issue to be benchmarked.

The use of multi-dimensional performance measurement systems may not be really balanced and integrated. This is because pressure from one particular stakeholder group may drive down other stakeholders' interests, especially when the different groups' interests are not consistent. For instance, too heavy a focus on efficiency to achieve value for money may be an obstacle to achieving better quality facilities in order to improve customer satisfaction.

It is difficult to decide how much weight should be placed on each dimension that is established.

Although organizations may be encouraged to use the PAF based on the BSC approach, the managers on the ground or the operations personnel may not understand the concept underlying the PAF. Furthermore, each department, managers or operations personnel may have different local priorities and variations.

It is important that organizations have well-developed information systems which can collect performance data and provide timely performance information to different ‘audiences’ more quickly- in other words, an information system that can support the PAF.

2.2 Benchmarking Process

According to Brewer (2003) of the Cooperative Centre for Construction Innovation (CRC CI), ‘benchmarking is more than measuring performance. Its purpose is to improve performance by comparing different organizations to identify relative strengths and weaknesses. By systematically comparing the processes used by different organizations, benchmarking helps each organization involved in a benchmarking study to identify ways of improving performance.’

However, benchmarking is often dependent on the individual or organization carrying out the process. This is because the benchmarking process seeks to understand what is already done and to obtain objective evidence or information about the level of performance a company should be pursuing. The final goal is to develop an action plan to close the gap between the poor and strong performers. The benchmarking process has to be externally focused, measurement based, information intensive, objective and action gathering.

A study of benchmarking literature indicates that the key process steps in benchmarking are not significantly different from each other. For instance, Finnigan (1996) lists the key process steps in benchmarking as establishing the study plan, conducting the study, analysis of data, internalising results and closing gap with the competition, which includes integrating, action and implementing plans and monitoring progress. On the other hand, Codling (1998) lists them as planning, analysis, action and implementation while Camp (1989) lists the key process steps as planning, analysis, integration, action and maturity. A review of the benchmarking process is presented in the following sections.

2.2.1 Planning

2.2.1.1 Identifying What is to be Benchmarked

The critical success factor of organizations as well as the determinants and drivers of these factors must be the focus of benchmarking comparisons.

2.2.1.2 Forming the Benchmarking Team

The team may be an intact work group, a functional team of individuals from different divisions or locations or cross-functional teams. It develops a plan that includes the designation of team members’ roles and responsibilities, project milestones and a realistic completion date.

2.2.1.3 Defining the Process to be Benchmarked

In order to increase the effectiveness of the benchmarking study, members of the team must prioritise the areas of interest. The team should define work processes to be benchmarked and define the measures of performance to monitor progress. A 1991 International

Benchmarking Clearinghouse study found that thorough understanding of the benchmarking process to be the strongest factor to a successful benchmarking study.

2.2.1.4 Determining Data Collection Methods

Data collection methods may include telephone interviews, surveys, focus groups, site visits, and documentary material. A combination of methods that best meets the needs of the study would most often be productive. The data collection method should be geared towards understanding the factors which enable best practice performance and not only deriving quantifiable goals and targets.

2.2.1.5 Pitfalls

The most common pitfall encountered is the choice of processes for benchmarking. These chosen processes may not be critical to the success of the company or they may lack focus on what the company strategically thinks is important. Furthermore, choosing too many processes to benchmark makes the project unmanageable. Inappropriate measures should not be established. This may result in wrongly defining a company's performance as superior and thus emulating practices that are not value adding. Sweeney (1994) finds that many of these firms lack appropriate performance measures, i.e. key performance indicators, to develop superior performance.

Choosing wrong people to be on the benchmarking team is also a barrier to success. They may not be directly involved in the processes studied and this would not have knowledge to perform benchmarking. Some may also lack the internal credibility, communication skills or motivation to carry out the benchmarking task.

Even with good planning and preparation, conducting a superficial or limited search for benchmarking partners can hamper the success of benchmarking. Sometimes, the wrong partners would be chosen or there may be difficulty getting partners as they might be unwilling to share competitive or proprietary information with competitors or unauthorised personnel.

Improper data gathering methods impedes the success of benchmarking as well. A common mistake during collection is that organizations tend to focus on benchmarking measures rather than the process itself. The problem with this is that even if the organization hits the performance target, it wouldn't know how to do it again (DeToro, 1995). There is also a tendency for benchmarkers to deviate from the original plan by focusing on another process that seems more attractive but not critical to the organization. Ease of access does not necessarily lead to useful information if the process under investigation is ignored (Zairi, 1994).

2.2.2 Analysis

2.2.2.1 Identifying Current Performance Gaps

After sorting and normalising the data, identify the gap in performance levels between an organization and its benchmarking partners, and establish the causes for the disparity.

2.2.2.2 Project Future Performance Levels

This step involves identifying improvement opportunities and setting improvement targets.

2.2.2.3 Pitfalls

Collecting the data without analysing or checking for quality and a poor documentation of the processes makes it difficult to develop implementation plans. Lack of understanding of the data sources can cause comparison errors. Thus, much time has to be spent collecting data.

2.2.3 Integration and Action

2.2.3.1 Communicating Benchmarking Findings and Gain Acceptance

Findings must be clearly and convincingly demonstrated as being correct and based on substantive data.

2.2.3.2 Establishing Functional Goals

Convert benchmarking findings into a statement of operational principles which is then inculcated into an organization's culture, technology and human resources.

2.2.3.3 Developing and Implementing Action Plans and Monitor Progress

Findings and operational principles from the benchmarking study must be converted into specific implementation actions. At the same time, systems for periodic measurement and assessment of achievements must be put in place.

2.2.3.4 Recalibrating Benchmarks

Benchmarking findings must constantly be updated since the external practices are constantly changing. There is, therefore, a need for an ongoing report mechanism.

2.2.3.5 Pitfalls

Failure to plan for implementation is a pitfall. A common mistake is to imitate best practices without tailoring it to the corporate fabric. Lifting a process from a company and transplanting it directly into another company without change would not work because of differing cultures, locations, and organizational structures.

Employee resistance is a potential obstacle in implementing changes. This may be attributed to employees' lack of understanding of benchmarking objectives and benefits or where findings from benchmarking are not communicated to them. Unrealistic targets from benchmarking make employees reluctant to accept and implement changes. Companies may have neglected both intrinsic and extrinsic motivations that are very important change facilitators.

A benchmarking step most often left out by most organizations in the benchmarking process is to inspect its results. Failure to inspect, ask questions or check for progress in implementing changes and securing results will signal everyone that benchmarking is not highly valued.

2.2.4 Maturity

An organization achieves maturity when they incorporate best practices in all their business practices to ensure superiority. The true test of success of benchmarking is when employees realise that the search for best practices is an ongoing part of the job which must be repeated as part of the unending quest for continuous improvement.

Complacency is a significant pitfall in benchmarking. Once a process has been improved, it is easy to lose interest in that aspect of business and focus on something different. Benchmarking should not be short-term but rather an on-going process that is constantly a self-initiated facet of an organization's strategic planning.

2.3 Benchmarking System

2.3.1 Introduction of Benchmarking System

A benchmarking system allows a comparison of costs and techniques with those of similar businesses, bringing to light the better ways of doing things that exist, and the application of best practices that can help to improve organizational performance. To develop a quality benchmarking system, it is pertinent consider its key components espoused in the following section.

2.3.2 Key Components

First, it is necessary to identify the sources of information, the use, and the quality of the data (Camp, 1989). Whilst it is important to collect and compile information, it is crucial to ensure the reliability and homogeneity of measurements, and anonymity of the information contributed by each participating organization. For purposes of this research, the sources of information will be the Sydney Opera House and other comparative facilities such as iconic buildings and in particular, performance centres. Subsequently, a comparative analysis will be made of the information derived from the facilities to preliminarily elicit relevant information, so as to help further define the investigation, make it more focused, and pinpoint information of highest priority (Camp, 1989). This will be elaborated in sections 4.1 and 4.2.

Second, it is necessary to understand the primary function of a quality benchmarking system, which is: to help identify best practices and generate improvement opportunities for the participating organizations. Hence, the benchmarking system must be capable of identifying the position of the participating organization in relation to its group of peers, i.e. participating organizations. This is done by developing an appropriate assessment and classification framework that enables the generation of queries amongst participating organizations. This is elaborated in section 3.2.

Third, in order to effectively perform benchmarking, it is crucial to understand the processes involved. For instance, in order for an organization to raise the level of customer satisfaction that a customer derives from the consumption of a service, it is important that the processes involved are fully understood. It is then essential to map these processes (McCabe, 2001) by developing an assessment and classification framework for the data structure and a process management methodology for the benchmarking system. This is elaborated in sections 3.3 and 3.4.

3. ANALYSIS OF BENCHMARKING SYSTEM

This section provides an analysis on the benchmarking system for asset maintenance. Section 3.1 identifies areas for maintenenace benchmarking. This is followed by the demonmstration of some benchmarking methods, where section 3.2 discusses the generation of appropriate queries and estabilsiment of assessment and classification framework, section 3.3 analyses data structures in the benchmarking system, and the management of the benchmark process is elaborated in section 3.4. A comparative analysis of the SOH cases and best practics is carried out alone with the demonstration of the benchmarking methods.

3.1 Identification for Maintenance Benchmarking

Asset maintenance is an appropriate field for benchmarking, however there are many differences in different organizations. Some key issues for consideration when identifying areas for maintenance benchmarking are listed as follows:

- Identify type of facility;
- Establish a common standard for comparison;
- Identify levels of performance objectives and types of tasks;
- Choose a set of areas that are most valuable for benchmarking and where the improvement of maintenance performance is needed by the organisation.

The following presents a list of areas for measurement, comparison and improvement in asset maintenance from R.S. Means Company (1996):

- Annual maintenance budget;
- Number of facility employees;
- Square footage per employee;
- Number of maintenance employees;
- Ratio of maintenance workers to total facility employment;
- Budget for outsourced (contracted) services;
- Elements of work that are contracted;
- Status of maintenance and repair records;
- Status of maintenance supply records;
- Hours expended on monitoring and inspecting equipment;
- Scheduled vs. actual labour-hours required to complete predictive and preventive maintenance tasks.
- Ratio of planned to preventive and emergency maintenance and repair tasks, in terms of quantity and cost;
- Ratio of repair vs. preventive maintenance;
- Breakdown of maintenance tasks by specialty, and use of in-house vs. contracted services for each;

- Definition of trad responsibilities;
- Labour-hours expended on standard repair tasks;
- Administrative labour cost;
- Cost of worker tools;
- Cost of vehicles;
- Utility costs per square foot;
- Trash removal costs/revenue from recycling;
- Maintenance life and safety equipment, alarms, signage and exist doors;
- etc.

These areas for benchmarking can be catalogued into:

- Cost and budget management
- Operational management
- Quality management
- Information management
- Business process management
- Service performance goals

Based on an initial discussion of the project group, a small set of areas for measurements is suggested for applying to the SOH benchmarking. These will be further expanded along with the development of the project. A list of suggested basic measurements is presented as follows.

- Size (area both enclosed and surrounding);
- Running cost / meter square (based on a list of operational areas that are to be included, refer to BOMA, Chart of Accounts);
- Energy cost, $/m2.yr normalized by basic electricity tariff, etc.;
- Maintenance costs/yr for statutory compliance (both performance spaces and overall);
- Maintenance costs/yr for planned maintenance (both performance spaces and overall);
- Maintenance costs/yr for unplanned maintenance (both performance spaces and overall) ;
- Deferred maintenance: estimated replacement cost.

3.2 Query Generation

3.2.1 Assessment and Classification Framework

Queries are the questions, which are to be answered in a benchmark system to identify the position of the benchmarked object or organisation in a value and structure system in comparison to its group of peers. The appropriateness of a query is determined by the objective of the benchmark project, the missions and goals of the benchmarking organisation and the situation in which the project takes place.

The following sections discuss several aspects of the generation of appropriate benchmark queries. It is the objective of this discussion to establish an assessment and classification framework for the discussion of the ‘SOH Cases’ in section 3.2.2 and the ‘Comparative Analysis’ in section 3.2.3.

3.2.1.1 Benchmark Types

Stoy and Kytzia (Massheder and Finch, 1998; Stoy and Kytzia, 2005) differentiate 5 benchmark types and query groups for benchmarking in the real estate industry. The benchmark types ‘time benchmarks’ and ‘qualitative performance benchmarks’ were added in the following table to the ones named by Stoy and Kytzia (2005):

Table 3: Benchmark types.

monetary benchmarks	e.g.: How much money does it cost?
physical benchmarks	e.g.: How much energy/goods does it use?
time benchmarks	e.g.: How much time does it take?
productivity benchmarks	e.g.: How many percent of the potential output is actually generated?
building efficiency benchmarks	e.g.: How effective is the floor area used?
capacity benchmarks	e.g.: How much area is used for one workplace?
qualitative performance benchmarks	e.g.: How satisfying is the service providers performance?

3.2.1.2 Property or Behaviour Benchmarks

Another way to group benchmark queries is to differentiate the quality of data the system is based on. A benchmark system can be based on static object or organisation properties (e.g. calculated energy demand; planned cost) or on dynamic behaviour (e.g. measured energy consumption; actual cost). The first group requires a set of theoretically realistic boundary conditions and calculation procedures and second group requires expensive calculation to eliminate the object or organisations individual boundary conditions and to make the measurement comparable in the group of peers.

Table 4: Property or behaviour benchmarks

property benchmarks (theoretical demand)	e.g.: How much energy would this building need under defined conditions? (projected; calculated and reproducible)
behaviour benchmarks (actual consumption)	e.g.: How much energy did this building use under real conditions? (measured, contains operation, climate and occupants behaviour)

3.2.1.3 Benchmarking Partners

Three main types of benchmarks projects are differentiated according to the benchmark data source (Massheder and Finch, 1998).

Internal benchmarking collects the data from different departments and locations within the benchmarking organisation. It tries to adjust the performance of similar processes and objects to the best performance in the organisation. Internal benchmarking introduces internal bias into the process. It enables good accessibility of the benchmark data. It can be performed on basis of the organisation's internal data format and structure.

Competitive benchmarking collects the data from core-business competitors. It tries to adjust the performance to the best practice in the group of benchmark partners. Competitive benchmarking allows drawing knowledge from outside the own organisation. A problem of competitive benchmarking is to find a group of peer, which is willing to participate and to deliver comparable benchmark data in an agreed on data format and structure.

Functional benchmarking looks for best practice to provide a function to the organisation. Here it is not important that benchmark partners work in the same core business, but that the benchmarked object or process is comparable. A problem of functional benchmarking is to assess the comparability of benchmarked objects and processes (eliminate the influence of the core business) and to find benchmark partners, who are willing to provide the benchmark data in an agreed on format and structure.

Table 5: Benchmarking types and partners

internal benchmarking	e.g.: How does this department perform compared to the others departments in my organisation?
competitive benchmarking	e.g.: How does my organisation perform compared with other organisations in my industry (competitors)?
functional benchmarking	e.g. How good does my organisation perform this process compared to other organisations, which perform a similar process?

3.2.1.4 Object and Process Classification

Objects and processes in the benchmark process are classified to allow the generation of meaningful answers to benchmark queries, which can be analysed to inform strategic decision-making within the organisation of the benchmarking organisation.

The data structures are designed in a way that each element does only belong to one and only one of its classes on the same data structure level. Data structures order their elements normally in levels. The upper levels comprise the elements of the lower levels, so that each element of the lower level is a member of one and only one higher level (tree structure). Different data structures are overlayed to each other to generate the specific answers to the benchmark queries.

The classification of the objects and processes in a benchmark process can follow the internal organisational structure of the benchmarking organisation or an external structure, agreed on by the benchmark partners or in the domain. Competitive and functional benchmarking requires the adoption of a data type structure, which is assumable different to organisational data structure used by each of the benchmark partners.

Table 6: Internal and external data structures

internal data structure	e.g.: building A, building B; executive office, manager's office
external data structure	e.g.: school, theatre; office space, storage space
overlayed internal and external data structure	e.g.: office space in building B

3.2.1.5 Reference Data (Drivers)

The benchmark data has to be normalized to be comparable with data collected by benchmark partners. To normalize the data the values can either be related to data which is characteristic for the benchmarked organisation (core business) or which is characteristic for the benchmarked process or object.

Object and process characteristic reference values can be used in internal, competitive and functional benchmark projects. They do not relate the benchmarks to the core business, but to appropriate values (drives), which are correlated with the performance measures (e.g. found by regression analysis).

Organisation characteristic reference values can be used in competitive and internal benchmark projects, in which similar processes and objects under similar conditions are benchmarked. This allows a performance assessment related to the core business activities (e.g. business alignment).

Table 7: Reference data

object and process characteristic reference values	e.g.: How much does it cost to clean $1m^2$ office space?
organisation characteristic reference values	e.g.: How much service cost does this department have related to it's turn-over?

3.2.1.6 Comparability of Data

The benchmark data structure has to be based on common concepts for the objects and processes and agreed on data definitions. System borders, boundary conditions, measuring techniques and units have to be defined to ensure comparability in the benchmark population. Also the duration of measurements, report times, the processing of the data after measurement (e.g. averaging, normalizing) and the reaction to exceptional measurements has to follow an agreed on procedure in the benchmark project.

The measurement techniques have to be designed in a way that they provide comparable results. Objective measurement techniques are independent from the subject, who takes the measurement, and from the situation, in which the measurement takes place.

3.2.1.7 Assessment and Classification Framework

The following matrix summarizes the assessment and classification framework and identifies possible, necessary and impossible combinations between benchmark systems and data structure characteristics. The matrix identifies on which databases queries can be answered and processes and objects can be benchmarked.

Table 9: A matrix of an assessment and classification framework

	internal data structure	external data structure	overlayed internal and external data structure	object and process charact-eristic values	organisa-tion charact-eristic values
monetary benchmarks	x	x	x	x	x
physical benchmarks	x	x	x	x	x
time benchmarks	x	x	x	x	x
productivity benchmarks	x	x	x	x	x
building efficiency benchmarks	x	x	x	x	x
capacity benchmarks	x	x	x	x	x
qualitative performance benchmarks	x	x	x	x	x
property benchmarks	x	x	x	x	x
behaviour benchmarks	x	x	x	x	x
internal benchmarking	x	x	x	x	x
competitive benchmarking	-	x	x	x	x
functional benchmarking	-	x	x	+	-

x possible combination + required combination - impossible combination

3.2.2 SOH Cases

According to the available document (SOH 2005), Sydney Opera House uses behaviour measures for qualitative performance controlling by internal benchmarking. It uses an internal data structure and organisation characteristic reference values. The applied data definition and measurement procedure has subjective characteristic.

The SOH benchmark system is, according to the introduced framework, currently not designed to answer queries in competitive or functional benchmarking projects.

3.2.2.1 Benchmarks Types

SOH does qualitative performance benchmarking. It rates the building fabric quality (BFI) and the building presentation quality (BPI) on a scale from 1% (low quality) to 100% (high quality).

The BFI is determined for each element in each room, while the BPI is determined for each room assessing three aspects of building presentation: Overall Impression, Cleanliness and Tidiness. The BFI rates the object quality and the BPI rates the service quality by looking at the process outcome.

3.2.2.2 Property or Behaviour Benchmarks

The SOH benchmarking system benchmarks the measured performance against an internal projected target value of currently 80%. Two values are given for the BPI in the report. A target value of 80% and a benchmark value of 90%, it is not clear if the benchmark value is a measured or a projected value.

3.2.2.3 Benchmarking Partners

The SOH benchmarking system does currently not use external benchmark data and process analysis to improve performance. The benchmarking system must therefore be classified as internal benchmarking.

3.2.2.4 Object and Process Classification

The SOH benchmark system uses a mixed hierarchical geographical and object data structure. The levels of the data hierarchy are general applicable (could be used for other objects), while the formulation of the data elements and their names are specific for Sydney Opera House. The purpose of a geographical data structure is to identify a specific element by its location, not to group elements into object or process classes. The query, which can be asked on this basis, is: How do the elements in this area perform?

Further the SOH benchmark system looks at the performance to assess quality under the aspects of building fabric and building presentation (overall impression, tidiness, cleanliness).

3.2.2.5 Comparability of Data

The SOH benchmarking system is currently not designed to generate data, comparable with other organisations. Also internal comparability is not ensured by the used scoring system. The BPI and BFI are both measured in regular intervals with a simple scoring structure. For the reports the BPI is determined on a weekly basis and the BFI on a quarterly basis by inspections by one representative of SOH and the service provider.

The scoring structure allows a subjective assessment a subjective assessment. The result is likely to depend on the persons, who perform the inspection. It might also change over time, in case the same person performs it.

3.2.3 Discussion and Comparative Review

First single aspects of the framework are discussed, and then publications and query systems are reviewed in this section.

3.2.3.1 Property or Behaviour Benchmarks

It is currently discussed if the energy passport for buildings, which will be introduced in the European Union in 2006 as a method to benchmark a building against the building stock, will use a demand or consumption based value to indicate the heating energy required (Wallerang, 2005). The consumption based would have the advantage that it could be conceived from the energy bill, while demand oriented would need extensive expert calculation. On the other hand the first would not only reflect the quality of the building, but would contain the influence of climate, occupants' behaviours and other operational conditions.

3.2.3.2 Benchmarking Partners

Massheder and Finch (1998) rank the types of benchmark projects in terms of the advantage they can offer to an organisation. The benchmarking type, which offers the most benefit, is on the top of the list:

1. Functional best practices - world class
2. Functional best practices - own country
3. Industry best practice - including non-competitors
4. Competitors best practices
5. Internal best practices

3.2.3.3 Object and Process Classification

This subject will be discussed in the following section 3.3 on 'Data Structure'.

3.2.3.4 FMA Publications (Andersen 1999)

FMA presents benchmark data for the Australian facility management industry (Andersen 1999) for office, education, health and industry buildings. It provides the statistic distribution of costs related to square meter and to full-time equivalent employee in the benchmark population.

The report claims to provide the data for the same service categories as the UK based Centre for Facility Management (CFM Benchmark Report 97) and the USA based International Facilities Management Association (Benchmarks III). Thereby it provides *monetary benchmarks* for communication services, utility services, maintenance service and miscellaneous services. The database is able to support *functional benchmarking.*

The weak point of this publication is the *comparability of data*. The used categories and units are not defined sufficiently and no reference for the definition is given. Tables and diagrams are labelled insufficiently. No analysis of best practise examples is provided.

3.2.3.5 VDI Guidelines (VDI 1994; VDI 1998; VDI 1999)

The Verein Deutscher Ingeneure (VDI Association of German Engineers) issues a series of guidelines with characteristic values for consumption of heating and electricity (VDI 3807 Part2) and of water (VDI 3807 Part3) in buildings. The guidelines give values for several building types and provide an extensive building type structure (incl. Opera Houses, see later in this document).

It provides physical benchmarks for functional benchmarking with statistically evaluated consumption values:

heating energy consumption	kWh/m^2a
electricity consumption	kWh/m^2a
water consumption	m^3/m^2

The method of data generation is precisely described in the guidelines (VDI 1994; VDI 1998; VDI 1999) and the statistic basis and the data sources are given, it is integrated in a system of guidelines, widely used (obligatory) in the German construction and facility management industry.

No analysis of best practise examples is provided.

The recent editions of the VDI guidelines are available in English language.

3.2.3.6 APQC Metrics

The American Performance & Quality Center gives a list with metrics for facility management benchmarking. It contains meters to assess the cost effectiveness, space allocation, process efficiency and cycle times.

Most of the meters are property management internal, a few allow the assessment of the process quality in relation to the core business (e.g. business alignment). Examples are marked with a cross in Table 10.

Table 10: Examples of metrics for facility management benchmarking.

Cost Effectiveness	Property Management (PM) operation cost per gross s.f.
	Property Management cost per building occupant
	Janitorial cost per gross s.f.
	Water cost per gross s.f.
	Electricity cost per gross s.f.
	Property Management cost as percentage of revenue (in $thousands)
	Labour cost per property management FTE
	Repairs/maintenance cost as a % of total PM cost
	Janitorial services as a % of total PM cost
	Utilities cost as a % of total PM cost
	Parking space maintenance cost as a % of total PM cost
	Furniture acquisition & disposal cost as a % total PM cost

Space Allocation	Office s.f. as a % of total gross s.f. Parking s.f. as a % of total gross s.f. Warehouse s.f. as a % of total gross s.f. Training and conference room s.f. as a % of total PM cost Manufacturing s.f. as a % of total gross s.f. Usable s.f. (i.e., vacant space) as a % of total gross s.f. Unassigned s.f. (i.e. vacant space) as a % of total gross s.f.
Process Efficiency	Preventive maintenance hours as a % of total maintenance hours Work orders per repairs FTE per day Billable work orders as a % of total work orders Mission critical (non-routine) work orders as a % of total work orders Customer specific work orders as a % of total work orders Revenue per work order Occupancy rate Water consumption (per 1000) per gross s.f. Electric kilowatt hours per gross s.f. Gas consumption (per million cubic feet) per gross s.f.
Cycle Time	Average turnaround time for routine service requests (in hours)

3.3 Data Structure

3.3.1 Assessment and Classification Framework

The data structures in the benchmark system provide a map in which the position of organisations, objects or processes, which is benchmarked, can be localised. This localisation is used to identify a single object or to group of adjacent objects into classes.

The benchmark data structures can be used to identify the geographical, the organisational, the economic and the operational position of a benchmarked object, process or organisation. Some benchmark systems, mainly for qualitative performance benchmarking, structure the evaluation system itself.

Data structures for benchmarking are normally organised in tree structures, in which the higher-level entities summarize the lower-level entities and the lower-level entities differentiate the higher-level entities.

A data structure can be internal and organisation specific to the support the individual needs of the organisation (e.g. business alignment) or it can be based on common concepts in the group of peer or in the domain (external). In the ideal case the internal data structure is designed as an extension of an external data structure. In this case the internal data structure builds the individual lower-level entities and the external data structure provides the link to the outer world.

External data structures are referred to as ‘data type structures’ internal structures are referred to as ‘data structures’ in the following discussion.

The following text will use the term BE (benchmark entities) to paraphrase organisation, processes as well as objects which can be benchmarked, see Tables 11, 12 and 13.

Table 11: Common Type Structures (external data structure).

Object Type Structure	BEs are structured into Object Types when the relations to object families are used to group the benchmark population. e.g.: 'radiators', 'convectors' are members of the object type 'heat delivery systems' 'office rooms', 'corridors' are members of the object type 'room'
Cost Type Structure	BEs are structured into Cost Types when the relations to cost groups are used to group the benchmark population. e.g.: 'cost' can be structured into 'capital-bound-costs', 'demand-bound-costs', 'operation-bound-costs', 'other costs'
Function Type Structure	BEs are structured into Function Types when the relations to functional or process groups are used to group the benchmark population. e.g.: 'maintenance' involves 'inspection', 'cleaning', 'repairing'
Property Type Structure	BEs are structured into Property Types when a property is used to group the benchmark population. This property can be static or a dynamic e.g.: area groups (compare only offices >15m^2) Star Rating (compare only buildings with a high rating) position (compare everything above sea level)
Aspect Type Structure	A evaluation system is structured into aspects types, when an overall rating is calculated on basis of lower-level ratings, which describe several dimensions or ways to look at a BE. In case of Aspects Structure Types not only the structure has to be defined, but also the procedure (weighting system, etc.) to summarize lower-level ratings to conceive a higher-level rating. e.g.: overall comfort is a composite of various comfort measures overall impression is a composite of tidiness, cleanliness, etc.

Table 12: Organisation Specific Data Structure (internal data structure)

Geographical Data Structure	The geometrical data structure identifies the spatial location of a BE. e.g.: Bottom-Up-Query: Where is this object? Top-Down-Query: Which objects are at this location?
Organisational Data Structure	The organisational data structure identifies to which organisational group this BE belongs to, respectively which organisational group it serves. e.g.: Bottom-Up-Query: Which organisational group does this object serve? Top-Down-Query: Which objects serve the 'accounting department'?
Process Data Structure	The process data structure identifies which process this BE performs, respectively which process it serves. e.g.: Bottom-Up-Query: Which process does this object serve? Top-Down-Query: Which sub-processes serve the 'cleaning' process?
Functional Data Structure	The functional data structure identifies, which function this BE fulfils, respectively which function it supports. e.g.: Bottom-Up-Query: To which functional group does this object belong? Top-Down-Query: Which objects support the function 'security'?
Accounting Data Structure	The accounting data structure identifies on which account expenses are booked. e.g.: Bottom-Up-Query: On which account are expenses for this object booked? Top-Down-Query: Which expenses are booked on this account?
Aspect Data Structure	Aspect data structures are related to aspect type structures, which are described earlier in this document. Aspect data structures represent organisation specific aspects and evaluation systems. Bottom-Up-Query: Under which aspect is this performance rated? Top-Down-Query: Which performance ratings build the overall rating?

Table 13: Additional Systems to Structure the Data.

Spatial Structure	can be absolute (external coordinate system) or object related (internal coordinate system) relative height to the sea level 10m north of point A
Temporal Structure	can be absolute (external) or object related (internal) from 8pm to 10pm, 5. March 2004 2 hours duration 5 min after beginning

3.3.2 SOH Cases

Sydney Opera House currently uses a geographical data structure, which is combined with an object type structure on the lower levels (Room Types, Elements), to identify the location of the objects and the objects themselves. The combination of geographical and object type structure might result in inefficient data access, when queries like ‘Compare the condition of all doors’ are asked as all geographic locations must be visited to answer this query.

Level 1: Building and Site	geographical
Level 2: Storey Setting	geographical
Level 3: Location Zone	geographical
Level 4: Functional Space	geographical / object type
Level 5: Room Type	object type
Level 6: Room	object type
Level 7: Place	geographical
Level 8: Element Code	object type
Level 9: Sub Element Code	object type

Figure 1. Sydney Opera House data structure.

The aspects under which the assets are assessed are parallel and are not organised in a hierarchical tree structure. The vision statement and the corporate objective of Sydney Opera House are given in the strategic asset maintenance plan (Singh and Wimalaratne, 2002), these objective could be used as a root for the assessment model for facility management, currently they are not formally linked, Figure 2.

It can be assumed that more data structures do exist in the SOH organisation and facility-benchmarking department, but are currently not integrated into the benchmark system.

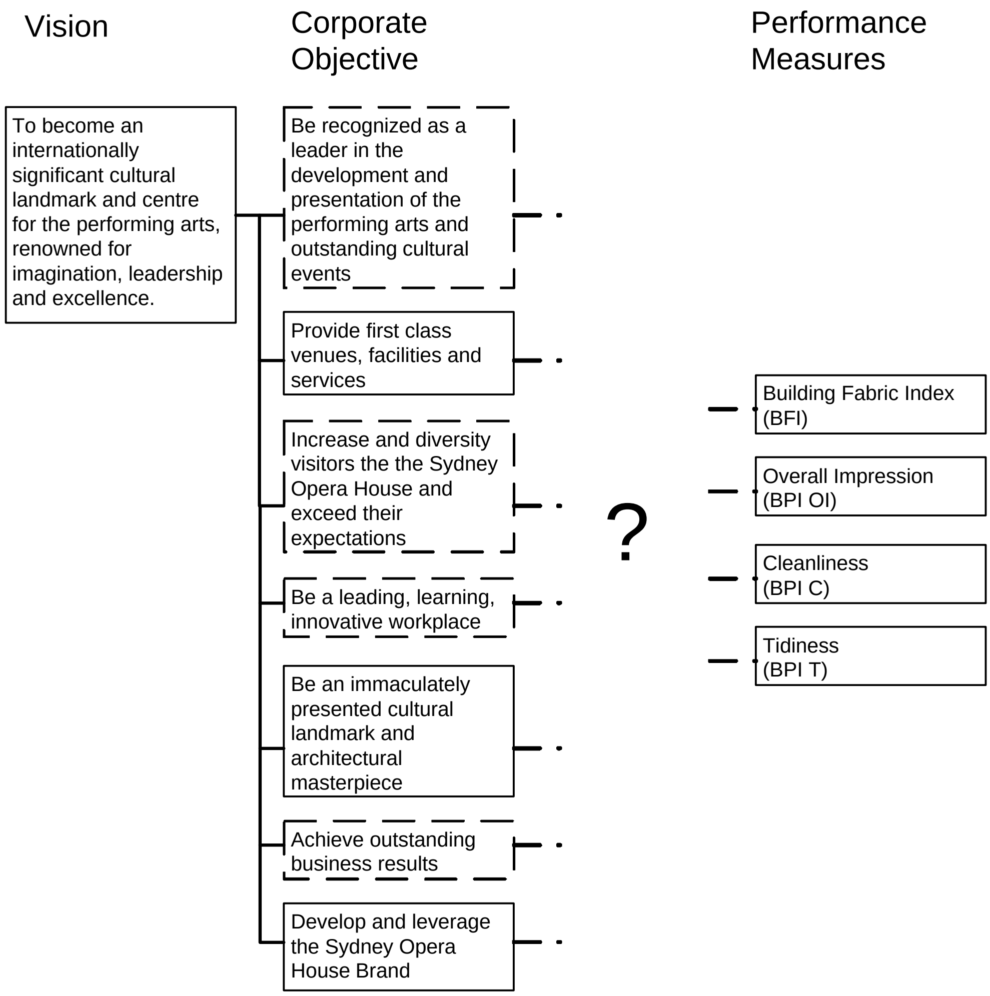

Figure 2. Assessment model for facility management.

3.3.3 Best Practices and Applications

The term best practice for a data structure in a benchmarking process does not refer to a specific absolute best way to organize the data. Best practice can be a very flat data structure, when many, perhaps unqualified, participants are involved, to reduce difficulties in the data collection process. Or it can be a very sophisticated and detailed data structure, when detailed analysis is required and data of high quality can be collected. The design of the data structure depends on the demand of the benchmarking organisation and benchmarking project.

No matter which level of detail the data structure has, it is important that it is defined precisely. A common problem of comparative data analysis is for example that reference values are not used in a uniform way due to ignorance or sometimes to manipulate the result. The data structure has to answer questions like: Does m^2 comprise the circulation area and service area? Another problem arises, when classifications are not described sufficiently.

The following sections will address some issues in this regard:

3.3.3.1 Area Types

DIN 277 (1998) lists different area types in buildings, the guideline structures the areas and defines how they are to be measured. VDI 3807 (1994) uses this framework to calculate consumption values for heating and electricity. It also gives a table to estimate the percentages of the various area types dependent on the building type.

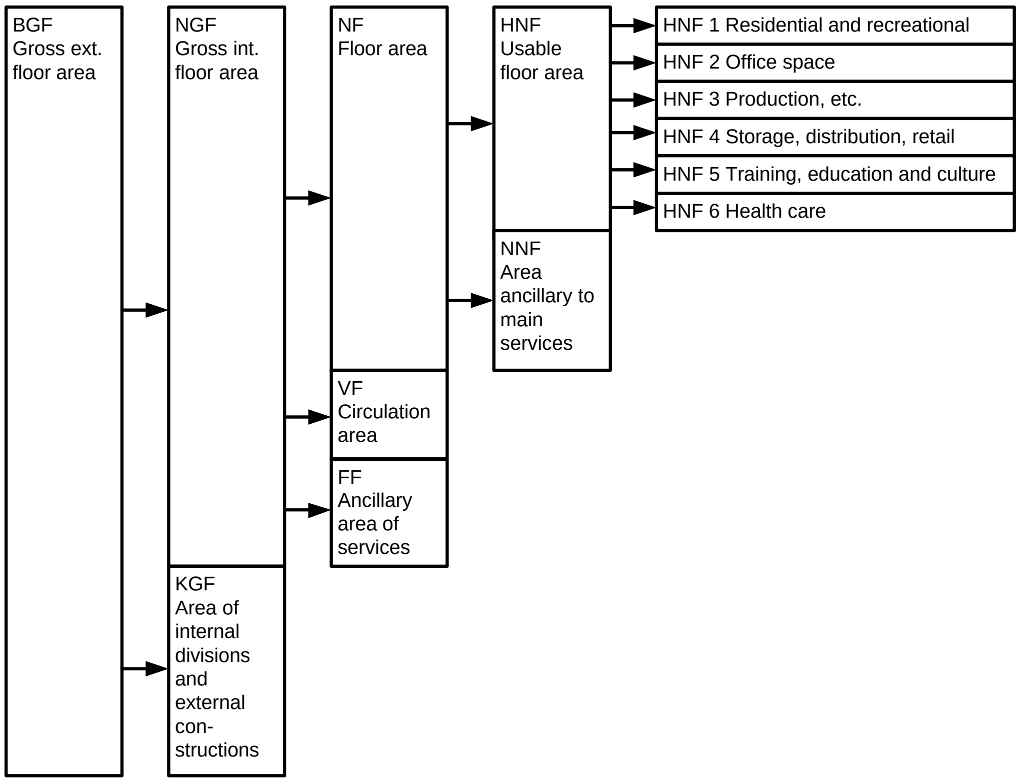

Figure 3. Area structure (DIN 277).

3.3.3.2 Building Types

VDI 3807 Part 2 provides a detailed breakdown of the building classification catalogue issued by ARGE-Bau (a professional organisation in the German construction industry). VDI 3807 is available in English.

building code	**building type**
…	…
9131	Libraries
9132	Public Libraries
9140	Buildings for performance
9141	Cinemas, Theatre buildings
9142	Opera Houses
9144	Large halls, municipal auditoriums
9145	Casinos
9146	Leisure centres
9147	Open-air theatres
9150	Community houses
…	…

Figure 4. Example for the building classification catalogue (VDI 3807, Blatt2).
(Note: the complete catalogue has 10 Pages with building types.)

The Australian Bureau of statistics uses a building type structure, which is not as complete, the ‘ABS functional classification of buildings – functional classification of building structure’ (ABS 2003) for its statistics.

3.3.3.3 Object Types

DIN 276 provides a list with object types, which was originally developed for cost estimation and cost calculation in the procurement process for buildings. It is widely used in the German construction and real estate industry. Among others for benchmarking building and maintenance cost. Company internal applications add more digits to the cost group code to subdivide the object types.

The advantage of DIN 276 is that extensive databases and software on its basis exist.

DIN 277 gives advice how to link DIN277 and DIN276 to conceive benchmarks.

cost group	object type
...	**...**
420	**Heating Supply Utilities**
421	Heat Generation Systems
422	Heat Distribution Systems
423	**...**
...	**...**
430	**Ventilation Utilities**
431	Ventilation Systems
432	Ventilation Systems with Air Conditioning Functions
433	Ventilation Systems with Full Air Conditioning
434	Ventilation Systems for Process Air
435	Cooling Equipment
439	Other Ventilation Systems
440	**Electric Utilities**
441	**...**
...	**...**

Figure 5. Example for the object classification catalogue (DIN 276).
(Note: the complete catalogue has 10 Pages.)

3.3.3.4 Process Types

GEFMA 200 provides a list of process types in a similar style as DIN 276 provides the object types to extend the cost framework for the construction of building into the operation phase (see also cost types). It is suggested to combine DIN 276 and GEFMA 200 to conceive a code for a process, which is performed on an object:

For example,

223.421 Inspection of Heat Generation Systems

224.433 Maintenance of Ventilation Systems with Full Air Conditioning

cost group	process type
…	…
220	Operation of Building Service Equipment
221	Commissioning
222	Operating
223	Inspection
224	Maintain
...	...
228	Document
480	Moving and Relocation Management
481	…
…	…
630	Contract Management
631	Lease Contracts
632	Energy Supply Contracts
633	…
…	…

Figure 6. Example for the object classification catalogue (GEFMA 200).
(Note: the complete catalogue has 10 Pages.)

The American Productivity & Quality Centre (APQC) issued a process classification framework (PCF) as a “high-level, industry-neutral enterprise model that allows organisations to see their activities from a cross-industry process viewpoint” (functional benchmarking). The section, which would contain facility management processes ‘Acquire, Construct, and Mange Property’ seems not to provide the depth needed for facility management benchmarking.

...

9.0 Acquire, Construct, and Manage Property

- 9.1 Property design and construction
  - 9.1.1 Develop facility strategy
  - 9.1.2 Develop and construct sites
  - 9.1.3 Plan facility
    - 9.1.3.1 Design facility
    - 9.1.3.2 Analyze budget
    - 9.1.3.3 Select property
    - 9.1.3.4 Negotiate terms
    - 9.1.3.5 Manage construction/building
    - 9.1.3.6 Dispose of old facility
  - 9.1.4 Provide workspace and assets
    - 9.1.4.1 Acquire workspace and assets
    - 9.1.4.2 Change fit/form/function of workspace and assets
- 9.2 Maintain workplace and assets
  - 9.2.1 Move people and assets
    - 9.2.1.1 Relocate people
    - 9.2.1.2 Relocate material and tools
  - 9.2.2 Repair workplace and assets
  - 9.2.3 Provide preventative maintenance for workplace and assets
  - 9.2.4 Manage security
- 9.3 Dispose of workspace and assets
  - 9.3.1 Dispose of equipment
  - 9.3.2 Dispose of workspace
- 9.4 Manage physical risk
- 9.5 Manage capital asset

...

Figure 7. Example form Process Classification Framework (PCF) (APQC 2004).

3.3.3.5 Cost Group

GEFMA 200 gives a cost structure for facility management. It comprises the areas covered in DIN 276 and GEFMA 200:

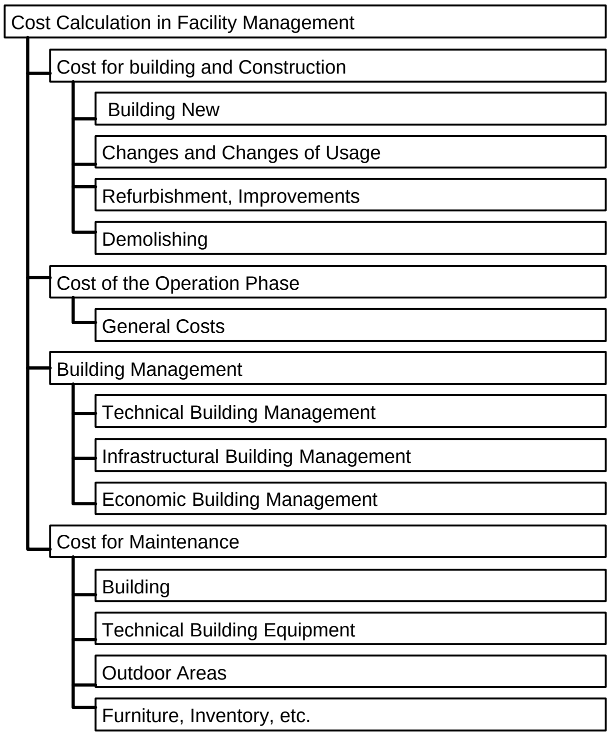

Figure 8. Cost Calculation Structure (GEFMA 200).

VDI 2067 structures the cost for the calculation of efficiency of building installation to allow full cost calculation:

Capital-bound-costs	e.g. investment, replacement
Demand-bound-costs	e.g. energy costs
Operation-bound-costs	e.g. operation, cleaning and maintenance
Other costs	e.g. insurance, taxes, fees.

Figure 9. Cost Calculation Structure (VDI 2067)

3.3.3.6 IFC Model

The CADD/GIS Technology Center (2004) provides an information model, on which the US American effort to develop an IFC model for facility management will be based on. It comprises a geographical data structure and structures for asset, environmental, work, financial, public safety, organisation and information security management. The effort has it origins in the US army and several of the used types use army terminology.

3.3.4 Recommendations

The design of a data structure for benchmarking should be based on the analysis of the questions, which are to be answered, considering the objective of the benchmark process, the missions and goals of the benchmarking organisation and the situation in which the project takes place. It should also consider the availability of resources to generate the data and the availability of data from benchmark partners.

The data structure should be able to link the organisation specific structure on the lower levels to external data structures on the higher level to enable the integration of the data model into competitive and functional benchmarking projects. This also allows using the database to assess the development of the organisation, when the lower levels of the data structure are adjusted to new needs in the organisation.

It should be avoided to use different data types in one data structure (as done in the SOH structure: geographical data and object type), as this constrains the application of the database to the cases it was designed for or might require redundant data structures for new application cases. Redundancy of data structures should be avoided.

The data structure should be reviewed, when the objectives of the benchmark project the structure of the benchmarked organisation or the performance levels change.

SOH should design its data structure in a way that it is able to support functional benchmarking, as it seems to be very difficult to find partners for competitive benchmarking and as internal benchmarking only provides limited benefit.

3.4 Process Management

3.4.1 Management of the Benchmark Process

As a management technique ‘benchmarking’ is a systematic process to assess and to develop the performance of one object, process or organisation by comparison with the performance of similar objects, processes or organisations. Objects, processes and organisations are analysed and superior features are adopted.

The benchmark process is structured according to Camp (1989) into the steps: planning, analysis, integration and action.

Additional to the performance of the single benchmark steps the integration of the benchmark process into the organisation’s management is a measure for the maturity of the benchmark process. The American Productivity & Quality Center (2001) describes a systematic framework to assess the maturity of the benchmark imitative with the objective to understand the initiative current state and to find opportunities for improvements.

The framework (APQC, 2001) is given in the following table. The maturity of the benchmark process implementation increases from the left to the right of the table. Each row represents a key element of the process. Unfortunately the source gives only descriptions of the levels for key element 1, Table 14.

Table 14: A framework by APQC (2001).

	Level 1	**Level 2**	**Level 3**	**Level 4**	**Level 5**
1. Knowledge management/ sharing	Which of the following descriptions defines your organisation's orientation towards learning?				
	Internal financial focus, with short-term focus that reacts to problems	Sees need for external focus to learn	Sets goals for knowledge sharing	Learning is a corporate value	Knowledge sharing is a corporate value
2. Benchmarking	Which of the following descriptions best defines your organisation's orientation towards improving?				
	low maturity				*high maturity*
3. Focal point	How are benchmarking activities and/or inquiries handled within your organisation?				
	low maturity				*high maturity*
4. Benchmarking process	Which of the following best describes the benchmarking process in your organisation?				
	low maturity				*high maturity*
5. Improvement enablers	Which of the following best describes the improvement enablers in place in your organisation?				
	low maturity				*high maturity*
6. Capture storage	Which of the following best describes your organisation's approach for capturing and storing best practices information?				
	low maturity				*high maturity*
7. Sharing dissemination	Which of the following best describes your organisation's approach for sharing and disseminating best practices information?				
	low maturity				*high maturity*
8. Incentives	Which of the following best describes your organisation's approach for encouraging the sharing of best practices information?				
	low maturity				*high maturity*
9. Analysis	Which of the following best describes your organisation's approach for encouraging the sharing of best practices information?				
	low maturity				*high maturity*
10. Documentation	How are business impacts that result from benchmarking projects documented within your organisation?				
	low maturity				*high maturity*
11. Financial impact	How would you describe the financial impact resulting from benchmarking projects?				
	low maturity				*high maturity*

Management of the benchmarking process has to ensure that the process is performed systematically and that each of the steps is defined and delivers the necessary outcome to support the following step.

3.4.2 SOH Cases

3.4.2.1 Planning – Identify what is to be benchmarked

The measures used by SOH are qualitative and targeted on the short term controlling, adjustment and direction of services (day-to-day operation) to secure a high quality performance.

The measures are takes for different locations in the building. The locations are identified in a hierarchical data structure.

The benchmark process is currently not designed to disclose management deficits and waste of resources. The benchmark measures are not formally linked to the corporate objectives of SOH.

3.4.2.2 Planning – Identify comparative companies

SOH does not use comparative organisations as benchmark peers. It determines the development of its own performance over time and compares the measured performance with a target value.

3.4.2.3 Planning – Determine data collection methods and collect data

The BPI and BFI are both measured regularly with a simple scoring structure. For the reports the BPI is determined on a weekly basis and the BFI on a quarterly basis by inspection by a representative of SOH and the service provider.

3.4.2.4 Analysis – Determine current performance "gap"

This step is currently not performed systematically in the SOH benchmarking process. The potential of looking at other organisations is not utilized.

3.4.2.5 Analysis – Project future performance levels

The SOH benchmarking system uses fixed target values for BPI and BFI. Additional it formulates deadlines (for cleaning), which might be associated with business alignment issues.

3.4.2.6 Integration – Communicate benchmark findings and gain acceptance

The SOH benchmarking system uses a one-sheet report style with additional diagram pages. The report seems to be targeted at the service providers and the FM staff.

3.4.2.7 Integration – Establish functional goals

The SOH benchmarking system looks at only SOH performance. The functional goals are not systematically based on best practice, but on the situation of the own object. The benchmark is defined as a "desirable standard that should be achieved given sufficient resources and access".

3.4.2.8 Action – Develop action plans

Operative actions are described in the reports. The SOH benchmark system differentiates between 'immediate' and 'planned' actions. Strategic actions are not described in the available reports.

3.4.2.9 Action – Implement specific action and monitor progress

The weekly respectively quarterly measurement of BPI and BFI serves as a monitoring procedure in the SOH benchmarking process. The procedure and the report style secure the usefulness of the data for monitoring and controlling.

3.4.2.10 Action – Recalibrate benchmarks

No systematic recalibration process is described in the documents for the SOH benchmarking process.

4 ANALYSIS OF INFORMAITON ON MAINTENANCE

4.1 Information of Building, Asset and Service

Building services are usually a major factor that affects the overall project in terms of its design, cost and management. Despite the importance of building services as part of the daily building operation needs, they are both cost centres and space users. Different building services may require spaces up to 30% of the total building volume, and the combination of essential services could reach 27% of the total building cost (Parlour, 2000).

Benchmarking is a process which requires an over all understanding about different aspects and details of the building and its spaces. Towards this end, acquiring the information about the building facilities, assets and services, is the first step and therefore needs to have some initial techniques range from asset registration and building surveys to more sophisticated methods such as establishing a Building Information Modelling (BIM) system, and automatically data collection and monitoring process.

Building information, assets and services have been identified by Sydney Opera House Management System (SOHMS). In the following section, an overview of SOH general building information, assets and services is presented and listed.

4.1.1 SOH Cases

4.1.1.1 Information of Building and Assets

According to Bromilow (1992), building information for facilities management purposes should be gathered to the most detailed level. Individual items of equipments, fittings, fabrics, and the like need to be recognised by FM personnel who should record the state of each individual item (Condition), what each of them comprises (Content), where it can be found (Location), and when an action should be done to it (Action Scheduling). When there are large numbers of individual properties recorded, it is clear that executive levels of management need the information to be aggregated into successively large groups which cover whole building assets, services, and land/site. A tree-structure suggested by Bromilow et al (1986) to aggregate building information, is an example of information aggregation that could be also used as a model in which information about SOH can be included. The importance of the structure could be recognised as an apparent information hierarchy for recording performance data.

While recording information about every individual space and item in a building is relevant to most organisations for benchmarking purposes, Sydney Opera House cases have different directions since it is a performing centre where gathering data about performing spaces and the associated services is more likely to be relevant. The SOH data structure, developed by SOH BPI and BFI (2004) as a software development scheme, is built upon a 9 level hierarchy which identifies the general framework to locate any given item or element in the SOH. The framework is structured in the order in Table 15.

Table 15: A General Framework to Locate Items or Elements in the SOH.

Level 1	Building & Site
Level 2	Story Setting
Level 3	Location Zone
Level 4	Functional Space
Level 5	Room Type
Level 6	Room
Level 7	Place
Level 8	Element Code
Level 9	Sub-Element Code

For example, to identify a stair case in a certain location, the system will look to it in the following hierarchy beginning at the big scale, i.e. the building and site level, to the small details of the element, i.e. the parent level, then the sub-details if available, i.e. the sub element level.

Sydney Opera House's current software development model that shows the hierarchy of tracking down a piece of data about an element is diagrammed in Figure 1.

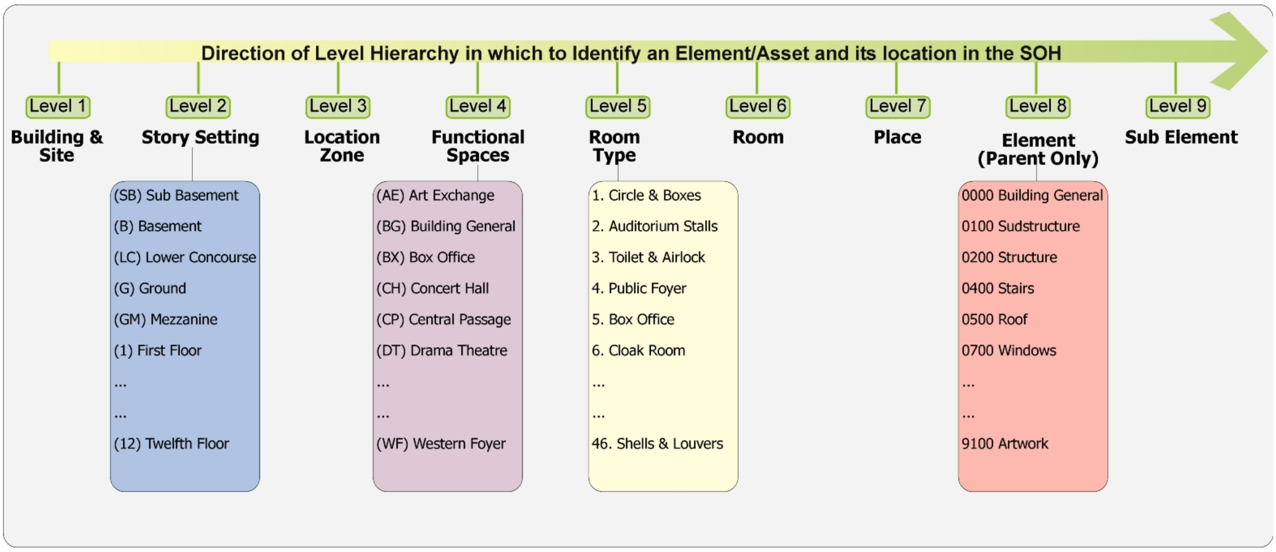

Figure 10. Hierarchy model from SOH BFI & BPI (2004).

There are four detailed subdivisions of the level hierarchy model in which the asset/element could be identified more accurately:

- *Story Setting*: defines vertical story break-ups of the SOH which divide the hight of the building into 17 levels from under-water to the top of the house shells.
- *Functional Spaces*: a level that is categorising the SOH into 16 major zones which activities/functions usually take place in.
- *Room Type*: SOH comprises a total of 800 rooms that are divided into 46 main categories for managing the spaces more accurately. These categories are partially shown in Figure 1.

- *Elements (Parent Headers Only)*: there are a total of 301 defined elements in the SOH, 36 of which are defined as Parent heading for aggregation purposes.

On the other hand, Asset Technologies Pacific has worked out Strategic Asset Maintenance Plan (SAMP) for the SOH. Their scheme (SAMP, 2002), for assets maintenance hierarchy, identifies the asset according to its Location, Sub-location, Elements, Sub-elements and Assets Type respectively and gives a code to the area where the asset is located. It is less complicated and shown in Figure 2.

Figure 11. Hierarchy model from SOH SAMP (2002).

The difference between the two models is that the hierarchy model from SOH BFI & BPI (Figure 1) has the potential of a more logical level hierarchy and details that could extensively be used for three purposes: (1) data collection, (2) Reporting and (3) Maintenance.

Nevertheless, the hierarchy model from SOH SAMP (2002) has initiated a database for a maintenance plan of the current registered elements, sub-elements and assets, for a period up to year 2027. In the database, there are 25 locations, 104 sub-locations, 70 elements, 311 sub-elements and 546 current registered assets.

4.1.1.2 Information of Services

Aggregation of building service information is an important factor that may contribute in structuring and recording performance data of a building. Bromilow (1992) recommended that drawing the building service information in a tree-structure diagram could support decision making in executive and facilities management levels by capturing the overall view of building service components. Main services at the SOH are categorised into 9 headings as listed below:

- HVAC Services (Mechanical Environmental Control)
- Electrical Reticulated Services
- Lighting
- Building Monitoring & Control System
- Fire Services
- Security & Surveillance Systems
- Transportation Services
- Stage Machinery Services
- Communication Services

The tree-structure suggested by Bromilow et al (1986) could be used as an example for the SOH cases to aggregate different building service data according to SOH SAMP (2002). The structure appears in Figure 3.

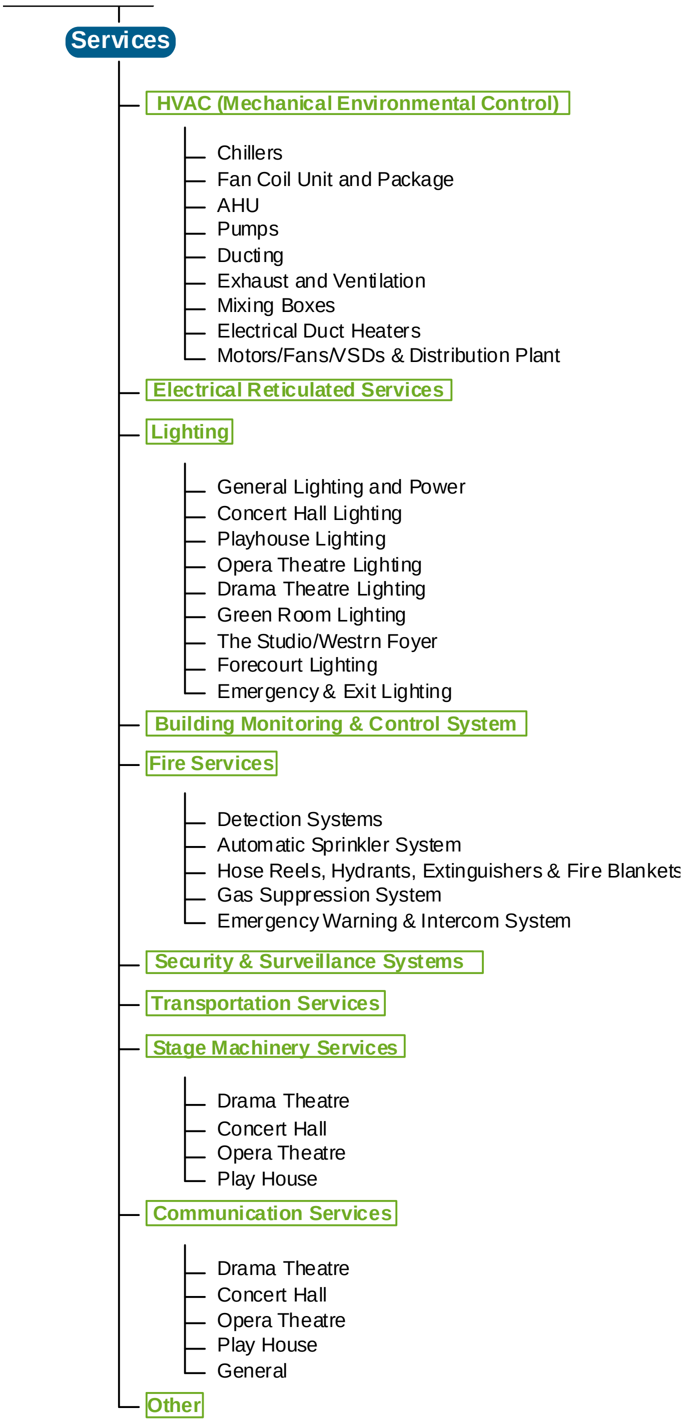

Figure 12. A tree structure for SOH service information based on Bromilow et al (1986).

Levels of service are defined by identifying critical success factors and setting levels of service that will contribute to their achievement (Willington City Council, 2003). Performance measures are then developed to assess the performance of the asset against the service levels. Levels of service and performance measures are established from:

- Customers' needs and expectations;
- The Sydney Opera House strategic direction; and
- Legislative requirements.

In SOH cases, most of the services are considered as contracted services. Hence, besides establishing key drivers for the level of services, SOH should primarily establish a monitoring scheme for the contracted services in which to assure quality services and add to its own knowledge system.

4.1.2 Iconic Building and Performance Arts Centre

The Sydney Opera House is one of the most well known iconic buildings in the world and also a performing arts centre. A set of similar iconic buildings and performing arts centres should be sourced to support the SOH benchmarking.

Suggested examples of iconic buildings to look at include St Basil's, Red Square, Moscow, The Tower of London, The Taj Mahal, The Leaning Tower of Pisa, The Empire Sate Building, New York, and The Chrysler Building, New York. Also the opera houses such as La Scala, Covent Garden, Paris Opera, Esplanade in Singapore can be a target. These similar buildings can facilitate identifying best practices on maintenance including information structure of building, assets and services.

However, there are many differences in different organisations such as legislative requirements, culture, etc. This increases the difficulty in benchmarking comparison.

4.1.3 Summary

To benchmark the information of building, assets and services on maintenance of SOH, a set of benchmarking partners shall be sourced and the best practices shall be identified. This will be carried out during the development of this project.

In general, information of building, assets and services shall be aggregated into the tree-structure containing categories and sub-categories. Figure 4 illustrates a proposed tree-structure that contains two main categories and then sub-categories based on a model by the IAI North American FM Domain Committee, which could be applied to the SOH cases.

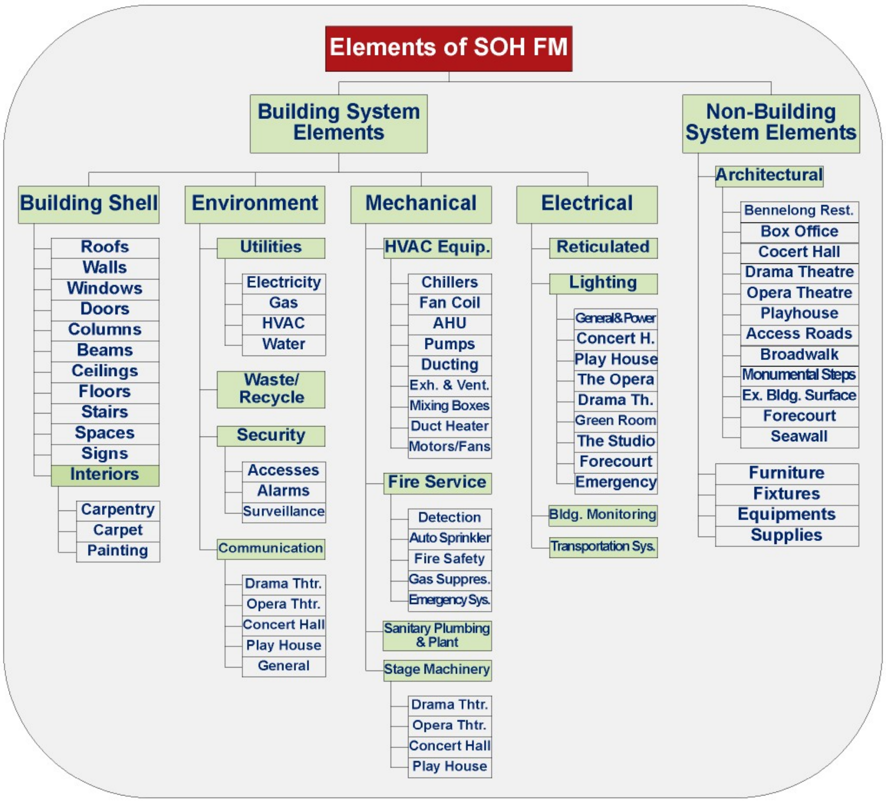

Figure 13. A tree-structure that could be applied to SOH cases.

4.2 Collection of Information

Collecting data is essential for asset maintenance, but not an end in itself (Wilson, 2005). Capturing the right data and identifying appropriate ways of collecting data are two important aspects. Some data required might be available in other ways, e.g. the data on energy usage might be collected by the maintenance contractor or the supplier. Alternatively, an organisation could simplify the process of data collection through its contractors specially when set new contracts. However, the control and data requirement definition should be kept as an organisation's priority.

4.2.1 Data Collection Methods

Some methods of data collections by Barrett (1998) are listed as follows.

- Standard Questionnaire

  (It is good for establishing trends and discovering regularities)

- Focused Interviews: used to establish in depth analysis
- Structured/Direct Observation: is for both systematic and quantitative (currently used by SOH for BFI & BPI – visual inspection)
- Tracing (unobtrusive observation): looking into changes or reflection not produced in order
- Literature Search: enables the facilities managers to identify similar building and organisation, which may provide useful information on other approaches.

  (This method could be introduced to SOH for external performance comparison)

- Study Visits: enables the user to learn from the experiences of others
- Archival Records: inexpensive method, but only relates to what happened, rather than why.
- Simulation: not a method for initial data collection, but it is a useful tool for obtaining reactions to new proposals.

Seems SOH applies the structured/direct observation method for collecting data. Data from the electrical and mechanical services and other building elements are gathered by maintenance and cleaning contractors for reporting and archiving.

In the next section, SOH data collection methods and process are analysed along with the asset registration. It is followed by a comparative analysis of the current practices on data collection method and asset registration.

4.2.2 SOH Cases

4.2.2.1 Data for Benchmarking

SOH has developed a method of scoring and collecting data for Building Presentation Index (BPI) and Building Fabric Index (BFI), which are used to record and assess the presentation and the condition of the physical fabrics of the facilities. The collected data and management reports are implemented in Microsoft Excel spreadsheets. The SOH current method for collecting data and scoring (BPI and BFI, 1994) is illustrated in Table 16 while an analysis for improvement is presented in Table 17 (a) and (b).

Table 16: An illustration of SOH current methods for collecting data and scoring (BFI & BPI).

<table>
<tr><th>Building Fabric Index (BFI)</th><th>Building Presentation Index (BPI)</th><th>BFI & BPI Rating</th><th>BFI Score Structure</th><th>(BPI) Cleanliness Score Structure</th><th>(BPI) Tidiness Score Structure</th></tr>
<tr><td rowspan="7">Definition:
A method of scoring the way the Bldg. is perceived

Method:
Through detailed inspection of Bldg. elements, room by room

Elements:
(all finishes, doors, handrails, glazing, landscape…ect.)

By Whom:
Maintenance Contractors and staff

Inspection Frequency:
- (Daily) for the Bldg elements.
- (Two times a quarter) for functional spaces
- (Monthly) for the public areas</td><td rowspan="7">Definition:
A method of scoring three separate items that have an effect on the way the Bldg. is perceived

Method:
Through the Bldg. tidiness and cleanliness

*Overall Impression: a score given to the general appearance of the room on first entering it

*Tidiness: scored on the staff management and presenting the work environment

*Cleanliness: scored on the quality of cleaning provided by contractors

By Whom:
Cleaning contractors and staff

Inspection Frequency:
- (Twice daily) for the Bldg.
- (Three times a week) for joint inspection with SOH
- (Weekly) inspection is assessed by reporting tool</td><td>100%</td><td>As new, no signs of Wear & Tear</td><td>As new</td><td>As new</td></tr>
<tr><td>90% - 99%</td><td>Very minor signs of wear & tear</td><td>Totally free of dust, dirt, litter, stains and odours</td><td>Only essential items visible and neatly presented, nil customisation, improvisation or personalisation (eg clean desk)</td></tr>
<tr><td>80% - 89%</td><td>Minor signs of wear & tear</td><td>Minor signs of dust, dirt or stain - but not obvious. No litter or odours</td><td>Furnishings and fittings, customisation, improvising, personalisation, temporary signs and notices, works etc. Neatly presented</td></tr>
<tr><td>70% - 79%</td><td>Some wear & tear, though still in working condition</td><td>Overall appearance affected by dust, dirt, litter, stains or odours</td><td>Furnishings disorganised. Customisation, improvising, personalisation, temporary signs and notices, works etc. Cluttered</td></tr>
<tr><td>60% - 69%</td><td>Excessive wear & tear, though still in working order</td><td>Obvious signs of by dust, dirt, litter, stains or odours</td><td>Extremely cluttered, difficult to clean</td></tr>
<tr><td>25% - 59%</td><td>Major damage affecting operation of Bldg. elements</td><td>Significant accumulation of dust, dirt, litter, stains or odours</td><td>Untidiness creates a potential safety hazard</td></tr>
<tr><td>1% - 24%</td><td>Major damage health or safety</td><td>Hazardous accumulation of dust, dirt, litter, stains or odours</td><td>Untidiness creates an immediate safety hazard</td></tr>
</table>

Table 17 (a): An analysis of the SOH data collection method.

Techniques	Methodology	Analysis
Simple and Frequent	Everything is weekly scored	§ Used by SOH § Technique is simple (subjective) to reduce the workload § A more sophisticated rating theme and less frequent could uplift the process and make detailed data available
Less Frequent	The interval between scoring exercise is extended and could be more sophisticated	§ SOH could be divided into two halves for rating purposes, each have takes one week in scoring § The staff will though spend double the time allowed before
Hierarchical	A leading measure is used. When the rating is below a certain value, a precise scoring is carried out.	§ SOH uses a sophisticated rating method for further analysis, when the overall impression is below 70%
Automatic	Using sensors and monitoring systems	§ Very expensive systems § Not truly applicable for BFI & BPI
No data collection	By advising general staff to call a service number, in case of incidents.	§ Could be beneficial for BFI & BPI § Requires infrastructure and assigned staffs.

Table 17 (b): An analysis of the SOH data collection method.

- BFI & BPI are only carried by visual inspection exercise
- SOH has developed its scoring system from an existing system at the Parliament House in Canberra
- All SOH staff are getting a monthly report from the FM department which involves cleaning issues only
- Although BFI & BPI are purely a visual inspection exercise, they also gather information from other house staffs. For the Mechanical and Electrical services, SOH's contractors do the inspection job
- The evaluation criteria of BFI is used for both inner rooms and public spaces at SOH
- When scoring for BPI, benchmarking target varies due to:
- Room importance (i.e. if same room type, one for executive meetings and the other is for department meetings, the executive gets higher target)
- Available resources (means with more resources, the target will be elevated)
- Every fortnight, a non official evaluation exercise for BPI is done by gathering around 10 people from every SOH department, where each one is giving a separate scoring sheet, to evaluate the space presentation. The idea is for the FM staff to adjust their scoring if there is an obvious problem and also to get the general staff involved in the evaluation process which has a positive effect on them in general.
- The official BPI evaluation is carried by three FM members with one evaluation paper for every space
- Mechanical and electrical service inspection is carried by two contractors

4.2.2.2 Asset Registration

The SOH asset registration is introduced as follows:

- Only assets that worth $5,000 in value are registered for accounting purposes
- Assets less than $5,000 are subjective to the department's manager to register
- Each of the registered assets should comprise:
  - Barcode;
  - Life expectancy information;
  - Price; and
  - Supplier information
- Asset registration system is different than the BM system
- Asset registration is done manually

4.2.3 Comparative Analysis

Best practice guidelines for asset registration (UniOn Functional Requirements, 1993) suggest that:

- The asset register provides the main record of the organisation's physical assets like (fixed, long term, tangible, non-current) in terms of their ID and description.
- It must record all details of the acquisition, utilisation, servicing and disposal of such assets whether they be leased, owned, sub-let or on loan to the organisation.
- All assets are to have their life cycle costs and where applicable, their space information, recorded.
- All assets must be recorded at a detailed level.
- Each asset also needs to be classified as accountable, that is recorded and reported in financial statement, or non accountable.
- The distinction is drawn on the basis of value and expected life of the asset.
- The exact dividing line may vary at each organisation.

One example that fulfils the best practice of the UniOn Functional Requirements (1993) is Campbelltown City Council - NSW. The council manages 224 public buildings, through the Asset, Services and Supply Department, which include libraries, sport complexes, swimming pools, early childhood centres, fire brigades, senior citizen centres, etc.

All building spaces are categorised into 61 functional zones, i.e. activity room, bath and shower area, cleaner's room, main switch room, etc. which cover all assets within these zones. Each functional zone is given certain attributes for an extensive asset registration and data collection processes. The process of registration and collecting data is done by using a Personal Device Assistant (PDA) where the attributes and measurable setting are uploaded from the system, and then information is downloaded back to the system. Following is an example of the building functional zone structure that can be applied for the council's buildings that have the same zones, Table 18.

Table 18: An example of the building functional zone.

Activity Room
Dimension Attributes: - Ceiling height (m) - Entry door width measurement (mm) - Floor area (m2) - Kitchenette bench area (m3) - Kitchenette bench top area (m3) - Wall area (m2) - Window area (m2)
User Text Fields: - Exhaust fan type - No. of ceiling fans - No. of storage rooms - Window area (% of wall) - Window security screens
User Number Fields: - No. of fire extinguisher - No. of light fittings - No. of power outlets
User Check Fields: - Fire alarm - Fire exit - Fire Extinguisher - Fire hose reel
User List Fields: - Basin type - Tap fitting type - Ceiling finish - Floor finish - Internal wall finish - Lighting type - User's age group

4.2.4 Summery

Data collection is a very important part of asset maintenance. It is crucial that the management develops a data collection strategy which could optimise the result of data collection effort in order to produce the best information that will enable to satisfy different management requirements (Shiem-Shin, 1996).

Current SOH gaps in data collection and asset registration:

1. SOH only benchmarks two indexes (BFI & BPI) using house resources
2. The BM system is one year old and it is yet not clear of its drawbacks
3. Lack of resources and manpower
4. Manual process of data collection and scoring
5. Asset registration process may not be enough
6. Building services are assessed on monthly bases by visual inspection and fault reporting methods

Opportunities and Recommendations

1. Data collection process shall usually acknowledge the availability of recourses and manpower.
2. Benchmarking indexes such as energy usage index, profitability index, utility index, etc. are required.
3. The data model in the current software development of SOH shall allow the hierarchy of tracking down a piece of data about any element in the building, to be adopted for element/asset registration procedure.
4. Building services shall be given more attention, where monitoring devices could be used to register the flow of energy and discover the leakage and weaknesses.

5 RECOMMENDATION ON AN INTEGRATED INFORMATION MODEL

This chapter will focus on an integrated information/software environment for supporting benchmarking and facility management (FM).

5.1 An Integrated Information Environment

Good information is vital for businesses. Nowadays many different information sources co-exist within one businesses/company. Integration of these sources can improve the quality of the information. For example, integration can reduce common mistakes such as working with out-dated information. In addition more sophisticated analyses and queries can be developed providing information of a higher quality.

The integration of (heterogenous) information sources supports the alignment of different processes. For example space planning and maintenance operations can benefit from integrated planning and consequently potentially reduce business interruptions.

Figure 14 presents a proposed framework on an integrated information/software environment for SOH. Several high-level processes have been identified that could benefit from this environment:

- Maintenance processes using engineering data;
- Business processes using scheduling, venue access, security data;
- Benchmarking processes using building performance data.

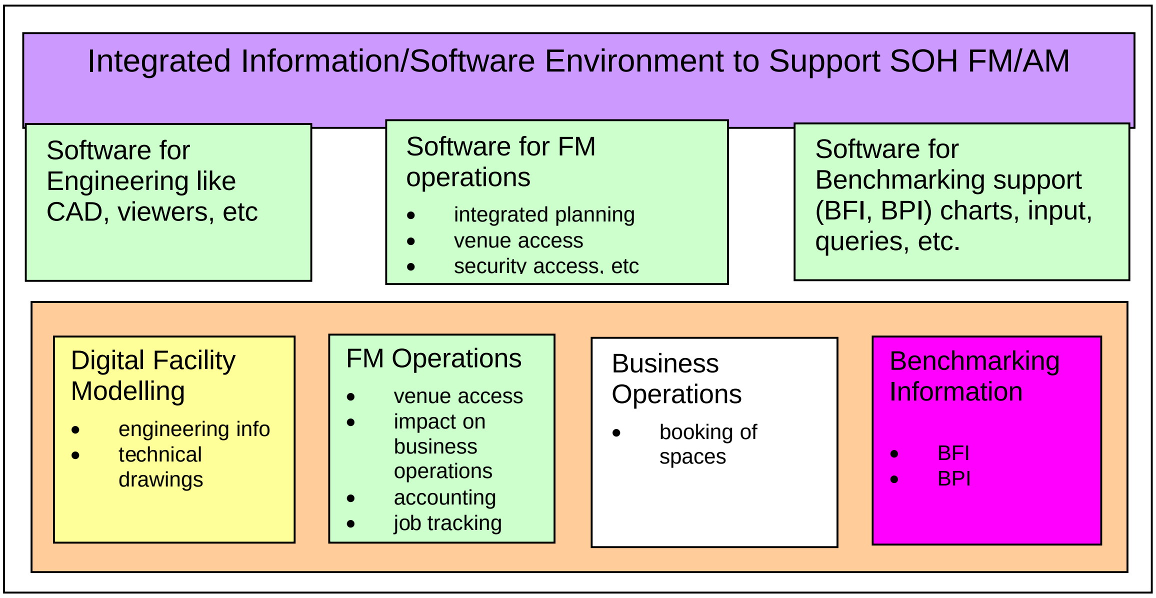

Figure 14. An integrated information/software environment for supporting Sydney Opera House FM.

Integration of information sources related to these processes enables a certain alignment of the processes. For example, a maintenance work for repairs in a meeting room can use the information from the room booking system: when is the meeting room is free, perform the work.

Consequently the integration supports the coordination of different FM/AM processes and potentially minimizing the business interruption. Obviously the information environment can be extended by many other sources of information such as asset management, OHS, etc. In addition such a framework can become the body of knowledge for the Sydney Opera House storing best practices and implementing rules on top the information environment reducing risks and mistakes.

5.2 SOH Cases

The Sydney Opera House has created a functional specification for software development for supporting the Building Presentation Index (BPI) and the Building Fabric Index (BFI). This has been done because their current system (Excel Based) was found not to be robust enough.

5.2.1 SOH Key Requirements

Several key requirements can be extracted from this document regarding benchmarking support:

- Robust system;
- To be able to record scores (and additional text) of every benchmarking element in every room of the SOH;
- Ability to build reports that aggregate the scores in multiple ways to allow analysis on multiple levels of detail;
- Deal with missing scoring data or data collected by random inspections;
- Calculate BFI and BPI automatically based on element score;
- Re-use of existing benchmarking data;
- Different outputs (graphics, tabular and reports);
- Different levels of reporting (drilling down to element level);
- Preferably based on SQL2000 because of in-house expertise;
- Potential intra web access.

5.2.2 Data Layout

'In its simplest form the database will record a score given every element in every room of the SOH' (SOH Functional specification for software development). Each room (800 rooms) can be identified by its door and each door (1600 doors) has a unique ID. The hierarchy as used by SOH is presented in Figure 15.

BFI and BPI scores have to be entered on element level with a time stamp. Aggregating these values scores on higher levels can be computed. Flexibility is very important as it is necessary to insert new elements, rooms, etc.

Level 1	*Building and Site*
Level 2	*Storey Settings*
Level 3	*Location zone*
Level 4	*Functional Space*
Level 5	*Room Type*

Figure 15. A hierachy for decomposing the SOH.

5.2.3 Conclusions

The following conclusions can be made:

- Currently there is no international/standardized benchmarking data model;
- Interoperability between different information systems in the SOH could support business alignment. For example benchmarking, planning, maintenance/ scheduling, engineering data could be combined to support integrated planning;
- Flexibility is mentioned for inserting new elements. Flexibility is also very important for future extensions of the system.

5.3 Recommendations on an Integrated Information Model

5.3.1 Requirements

The following list of requirements is developed for SOH consideration:

Interoperability

1. Link with engineering data/ digital facility model for visualisation purposes and for keeping up to date with new/modified elements.
2. Link with procurement information especially when performance contract types are going to be used. For example 1) cost information for each element for potential identification of expensive and cheap elements. Another example is to quickly find the responsible person/contract when an element fails.
3. Flexible query support supporting queries like:
    - give all the objects scoring on the BPI below x resulting in a list of spaces or elements such as walls, doors etc scoring below x;
    - give all the objects scoring on the BFI below x resulting in a list of spaces or elements such as walls, doors etc scoring below x;
    - When are these elements scheduled for preventive maintenance (linkage necessary to maintenance schedule);
    - When can we increase the performance of bad performing elements (linkage necessary to business planning);
    - etc.

4. Keep track on who has performed the benchmark evaluation.

Visual Reporting

1. Use of IFC model supporting different views on the data such as
   - locations of rooms;
   - functional tree such as ‘all amenities’.
2. Display of good/bad performing elements/spaces by using for example colour codes.
3. Display results compared to last month (relative changes or absolute, etc.)
4. Visual reporting on demand (each time of the day/week) via intranet.
5. Event driven such as notify when certain elements rooms are under a specific performance.

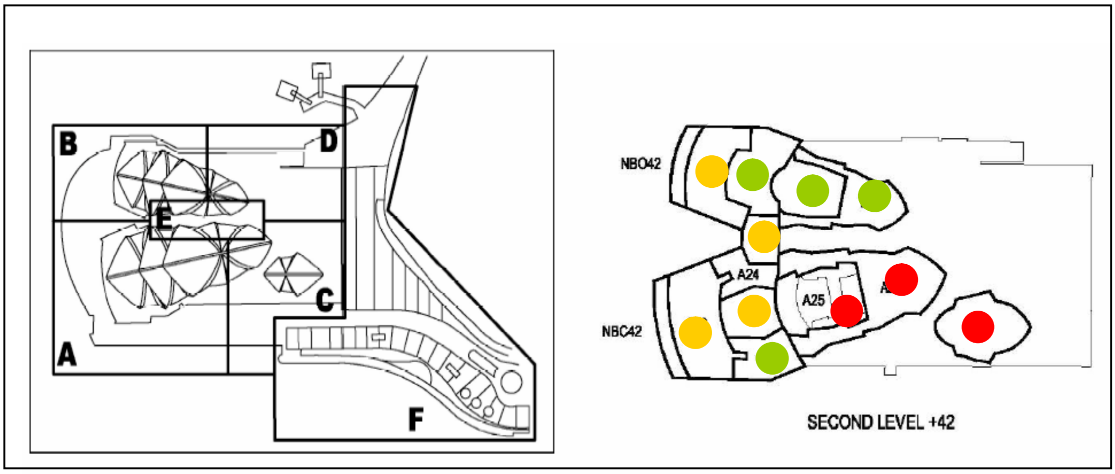

Figure 16. An example how to present BPI and BFI more graphically by color coded indexes.

Data Collection

For collecting data several tools are available. Sensors for example are getting more and more mainstream and are capable of giving feedback in a consistent manner. For example: sensors measuring humidity, temperature, daylight, etc can be used to collect data. However the input must be put in the benchmark equation.

For manual benchmarking, data retrieval and data insertion can be supported by for example element identification. Bar codes, numbers or even chips such as RFID (http://www.sunshinetechnologies.com.au/) can help to identify the elements in the SOH. This decreases the change of entering performance data to the wrong element. PDA’s and Tablet PC’s can be used retrieve data or to enter data that can be synchronised directly or indirectly with the database.

5.3.2 Simplified Data Model for Benchmarking

Figure 17. presents a simplified data model for storing and retrieving benchmarking data. Basically the SOH has several zones. Zones have several functional spaces. The functional spaces contain elements such as doors, walls, etc. Several elements are already available in the Digital Facility Model such as the elements, doors, walls, etc.

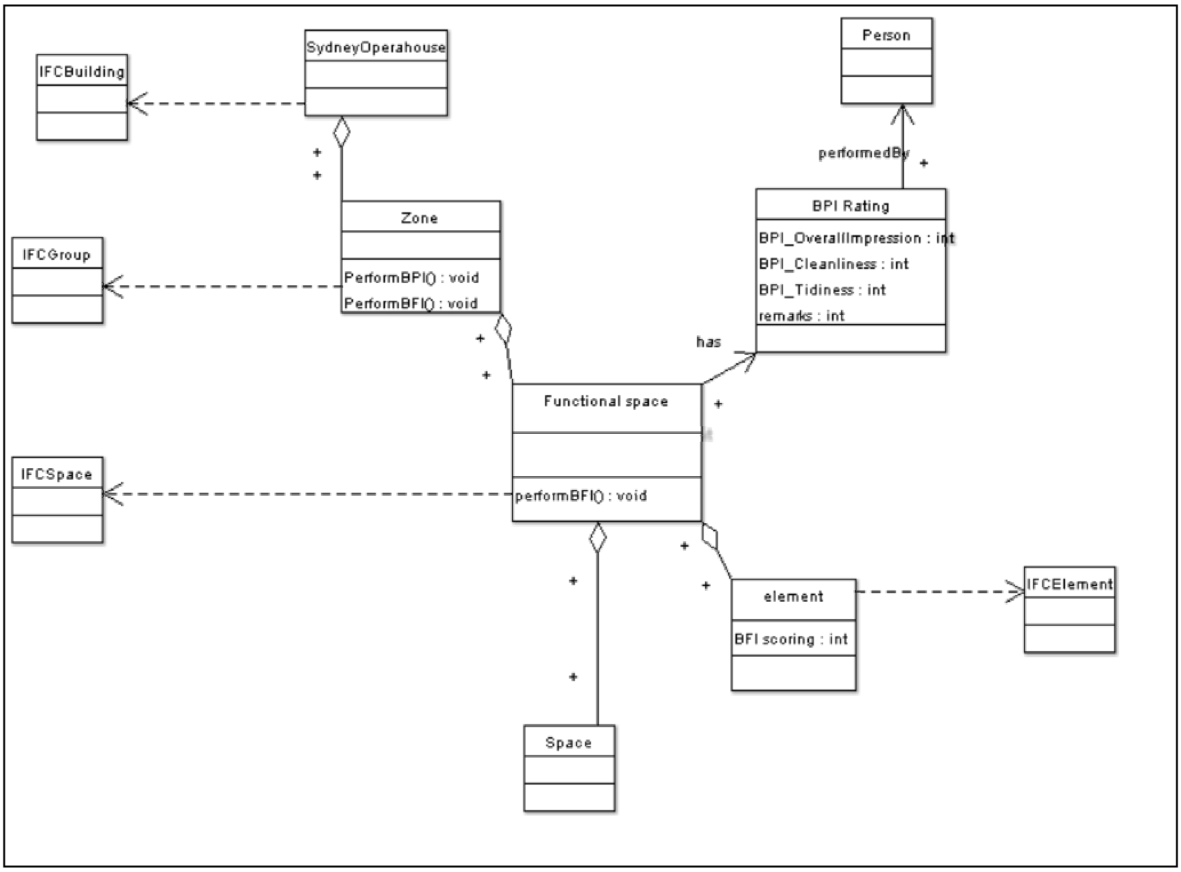

Figure 17. Simplified datamodel for supporting benchmarking including relations to the IFC.

Many elements can be linked to the IFC model. Functional Spaces can be linked with the IFC Space. Furthermore using IFC objects such as IFC group the hierarchy used by the SOH can be matched.

5.3.3 Technical Issues

5.3.3.1 Centralised Approach

The centralised approach is to have an integrated data model containing all relevant information for the Sydney Opera House for different departments, Figure 18. Such a data model would have a benchmarking module containing the necessary benchmarking data. All other necessary data would be re-used. The data would be reasonably maintainable. However the applications need to be compliant with this data model. It seems that extending the IFC data model could potentially be such a data model. In addition a heterogenous solution containing for example a SQL database and links to the IFC model is also feasible. Heterogenous is this context means that the IFC data model and the SQL model are different types of databases and consequently not homogeneous.

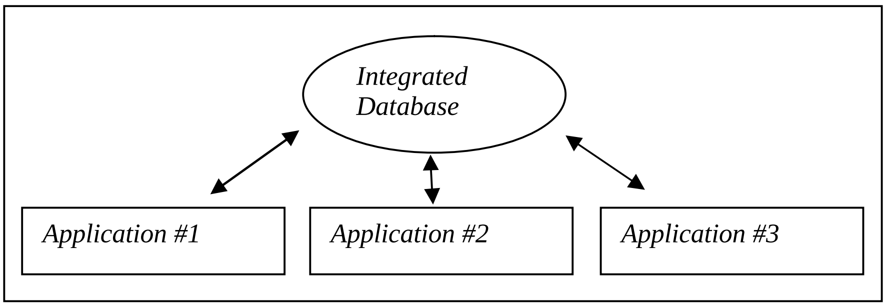

Figure 18. An integrated data model.

5.3.3.2 Decentralised Approach

Already several systems are installed such as ‘MainPac’ and space planning software. These software systems have their own database or data storing mechanism (could be as simple as a directory of files). Overlap of information can be present. This means that similar information resides in different databases resulting in redundancy. This situation changes in the data must be communicated to several other databases in order to keep all systems up-to-date. Integration of these databases means that these relationships have to be determined and implemented, Figure 19. When many applications are available the amount of relationships can increase rapidly.

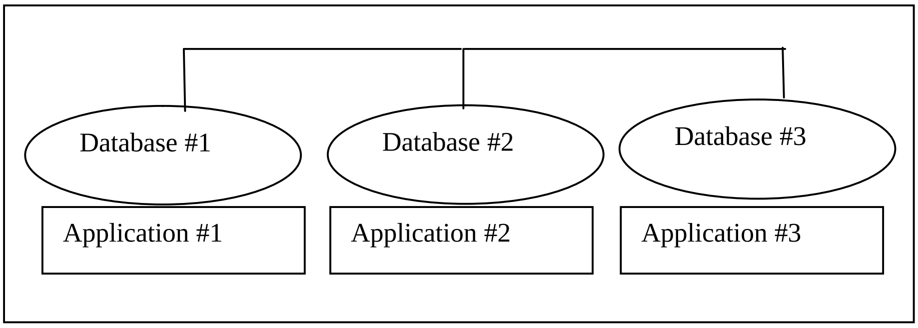

Figure 19. An decentralised aproach.

The decentralised approach is nowadays becoming a feasible approach. Standardized communication languages are available and Querying over different systems is possible. The unique ID of each element can provide a simple means for integration. For example a room planning calendar service could provide booking information based on a room ID (and a date). The maintenance calendar could do the same thing for maintenance operations. Location service could provide the location of an element by submitting its ID. Software applications can use these services to provide its users more information, Figure 20.

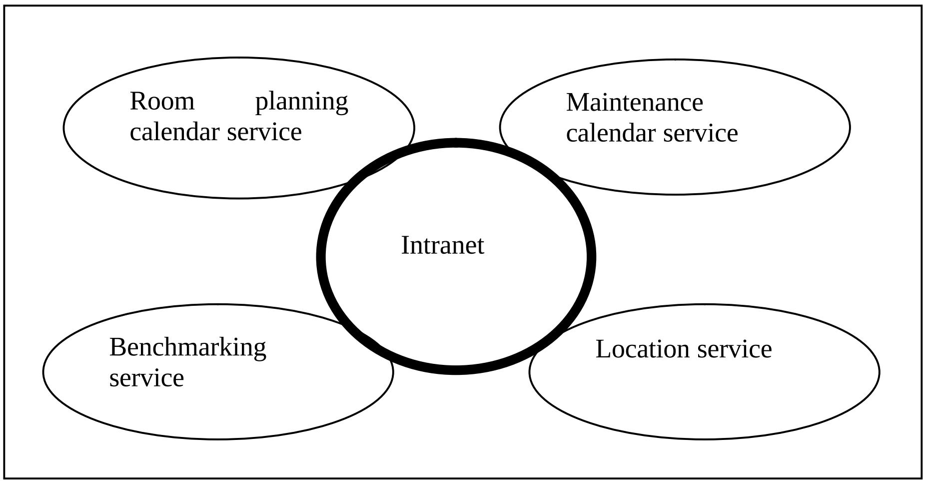

Figure 20. Suggested web services for the Sydney Opera House.

An advantage of these web services approach is that the systems are loosely coupled. Updating a system or completely replacing one can be done without problems when the service is kept the same. In addition new services can join the intranet in order to deal with future extensions.

5.3.4 Conclusions

It is clear that a software environment for facility management can be very holistic. Introducing a complete holistic environment at once is not very feasible for many obvious reasons. A more evolving/growing software system is more feasible. More functionality can be added gradually. The evolving approach is arguably also valid for benchmarking itself. It is likely that the benchmarking procedure will evolve during time. For example what is taken into account (what elements and what to measure) regarding benchmarking will arguably change over time. The information system supporting this should therefore evolve as well. Consequently flexibility and adaptability (open system) is therefore very important on the long run.

6 APPENDIX

IFC Elements checked with Sydney Opera House elements proposed for BPI and BFI

The following table will crosslink IFC elements with the elements used for BPI and BFI. This will give an overview of which elements are already supported by international standardization of the IFC and which elements have to be defined as proprietary objects / properties.

SOH Category Number	SOH Name	IFC Name	SOH Category Number	SOH Name	IFC Name
000	Building General	IFCBuilding	2400	HVAC	
0100	SubStructure		2500	FireSafety	
0200	Structure		2600	Electrical Service	
0400	Stairs	IFCStair	2700	Communications	
0500	Roof	IFCRoof	3000	Catering	
0700	Window	IFCWindow	3300	Roads, Paving	
0800	Doors External	IFCDoor	3600	Landscaping	
0900	Partitions	IFCSpace	3700	Drainage:stormwater	
1000	Handrails, Barriers	IFCRailing	3800	Drainage:sewage	
1100	Doors:internal	IFCDoor	4600	signage	
1200	Wall finishes	IFCCovering	5000	Stage Machinery	
1300	Floor finishes	IFCCovering	5100	Stage Lighting	
1400	Ceiling finishes	IFCCovering	5200	Stage audio	
1500	Furnishes	IFCFurnishing Element	5300	Stage audio Visual	
1700	Sanitary Systems		5600	Security	
1900	Water service		6000	Workshops	
2000	Gas Service		9100	Artwork	
2300	Central Plant				

IFCSystem/ IFCGroup for grouping various elements.

IFCProxy for objects such as Stage Machinery, etc.

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