FM as a business enabler

Solutions for managing the built environment

CRC for Construction Innovation participants

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John Holland

WOODS BAGOT

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Rider Hunt

Queensland Government
Department of **Main Roads**
Department of **Public Works**
Department of **State Development, Trade and Innovation**

Building Commission

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Foreword

Sydney Opera House is internationally acclaimed as an icon of 20th century architecture and contributes immensely to Australia in terms of cultural, commercial and tourism value. The management, maintenance and protection of Sydney Opera House as a performing arts centre and its iconic status is paramount. It was recognised that a facility which was conceived nearly 50 years ago requires the highest quality of facilities management to enable this icon to be protected while it still functioned as a business enterprise.

The Government was approached under the Facilities Management (FM) Action Agenda and Cooperative Research Centre (CRC) for *Construction Innovation* to support this initiative along with a number of industry participants and research organisations. Our support has played a part in ensuring the protection of this national icon of the built environment while assisting with applied research contributing to the body of FM industry knowledge.

The FM Exemplar Project has focussed on the three main research streams: digital modelling, services procurement and performance benchmarking. These have been combined into an integrated FM solution intended to have applications for the broader FM industry. The project also has an international flavour with iconic facilities from around the globe being invited to participate, providing an opportunity to learn from others and showcase Australia's FM applied research expertise on the world stage.

The project also addresses a number of recommendations coming out of the FM Action Agenda, which is one of more than 30 sector-specific Action Agendas developed by the Government in partnership with industry. They provide a powerful mechanism for industry and Government to work together to identify opportunities and impediments to industry development. I am proud to be the champion of a number of Action Agendas, including the FM Action Agenda which promotes the industry's vital role in improving the productivity and sustainability of Australia's built environment.

A large number of individuals and organisations identified in this report have been involved with the FM Exemplar Project at various times. We have been fortunate to have such an excellent mix of high quality, committed industry and research professionals from the CRC for *Construction Innovation*. They are to be congratulated for their generosity and willingness to work collaboratively to achieve these outcomes with benefits to the Sydney Opera House, the FM industry and the community at large.

I commend this report to you.

The Hon Bob Baldwin MP

Parliamentary Secretary to the Minister for Industry, Tourism and Resources

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Acknowledgements

Australian Government

**Department of Industry,
Tourism and Resources**

Project partners

Industry	Government	Research

Preface

Sydney Opera House is not only an Australian icon, but has now been transformed by the Facilities Management (FM) Exemplar Project into an example of best practice in applied research through the collaborative efforts of Government, Sydney Opera House and the CRC for *Construction Innovation*'s research and industry partners. The FM Exemplar Project has provided a unique opportunity to investigate and develop professional FM practice demonstrating its significant contribution in supporting a high-profile multi-faceted business enterprise such as Sydney Opera House.

In the pursuit of its objective to explore FM as a business enabler, the FM Exemplar Project has focussed on the three research streams: digital modelling, services procurement and performance benchmarking. However, beyond these essential components of modern FM, the project has combined them into an integrated FM solution. The intent of the project was always to use the uniqueness and complexity of Sydney Opera House to develop a body of knowledge which would form the basis for future innovation, learning and standards with applications for the broader FM industry.

We are confident that the FM Exemplar Project has exceeded expectations and truly represents world class applied research from which vast recognition, productivity and sustainability benefits will flow.

Minister Ian Macfarlane MP, Warren Entsch MP, and more recently Bob Baldwin MP and the staff of the Department of Industry, Tourism and Resources are to be applauded for their unflagging support of the FM Action Agenda and its FM Exemplar Project in recognition of the importance of '**Managing the Built Environment**'.

Similarly the CRC for *Construction Innovation* have been exceptionally fortunate in the leadership and commitment demonstrated by our project participants including Sydney Opera House, Transfield Services, Rider Hunt, CSIRO, University of Sydney, Brisbane City Council, Queensland Department of Public Works, Queensland University of Technology, Woods Bagot and the Facility Management Association of Australia.

We would like to thank and congratulate all who have contributed to this project.

We are proud to commend this report to you.

John V. McCarthy
Chair, CRC for *Construction Innovation*
Chair, FM Action Agenda

Keith D. Hampson
CEO, CRC for *Construction Innovation*

Stephen P. Ballesty
Project Leader, FM Exemplar Project: Sydney Opera House, CRC for *Construction Innovation*
Chairman, Facility Management Association of Australia
Deputy Chair, FM Action Agenda
Director, Rider Hunt

About the FM Action Agenda

The Australian Government's Facilities Management (FM) Action Agenda chose Sydney Opera House as the focus of its FM Exemplar Project and partnered with the Cooperative Research Centre (CRC) for *Construction Innovation* to develop innovative strategies across three research themes. The findings have been integrated in order to achieve an FM solution beyond its component parts demonstrating FM as a business enabler.

The Australian Government, through the Department of Industry, Tourism and Resources, seeks to make Australia more competitive by working closely with industry to identify new opportunities for growth. Action Agendas are a means by which selected industries work with the Australian Government to identify and then implement strategies to overcome impediments to growth.

The focus in Action Agendas is on the actions industry itself can take to achieve its objectives.

The FM Action Agenda had its origins in requests to the Australian Government from the Facility Management Association of Australia (FMA Australia) on behalf of the industry. FMA Australia identified a number of key concerns for the industry. These included recognition of the industry, establishment of a distinct facility management career path, industry-wide innovation, recognition of sustainability as a driver of business in the future, and the impact of regulation in the industry. The FM Action Agenda was announced by the Hon Ian Macfarlane MP, Minister for Industry, Tourism and Resources, on 19 January 2004, and one of the outcomes of the FM Action Agenda was the FM Exemplar Project: Sydney Opera House, to demonstrate FM as a business enabler.

About the Cooperative Research Centre for Construction Innovation

The CRC for *Construction Innovation* is a national research, development and implementation centre focussed on the needs of the property, design, construction and facility management sectors. Established in 2001 and headquartered at Queensland University of Technology as an unincorporated joint venture under the Australian Government's Cooperative Research Program, *Construction Innovation* is developing key technologies, tools and management systems to improve the effectiveness of the construction industry. *Construction Innovation* is a seven-year project funded by a Commonwealth grant, and industry, research and other government support. More that 300 individuals and an alliance of 21 leading partner organisations are involved in and support the activities of this CRC.

There are three research areas:

• Program A — Business and Industry Development

• Program B — Sustainable Built Assets

• Program C — Delivery and Management of Built Assets.

Underpinning these research programs is an Information Communication Technology (ICT) Platform.

Each project involves at least two industry partners and two research partners to ensure collaboration and industry focus is optimised throughout the research and implementation phases. The complementary blend of industry partners ensures a real-life environment whereby research can be easily tested and results quickly disseminated.

FM as a business enabler is part of a series of publications produced by the Sydney Opera House: FM Exemplar Project and presents the collective findings from the *Digital modelling*, *Services procurement* and *Performance benchmarking* reports. It outlines the integration of these streams into an integrated FM solution that demonstrates FM as a business enabler.

Acronym list

3D	Three Dimensional
AM	Asset Management
BCI	Building Condition Indices
BFI	Building Fabric Indices
BPI	Building Presentation Indices
CAD	Computer-Aided Design
CCTV	Closed Circuit Television
FM	Facilities Management
FMA Australia	Facility Management Association of Australia
GIS	Geographic Information System
ICT	Information and Communication Technology
IFC	Industry Foundation Classes
IAI	International Alliance for Interoperability
KPIs	Key Performance Indicators
PAC	Performing Arts Centre
SAM	Strategic Asset Maintenance
TAM	Total Asset Management
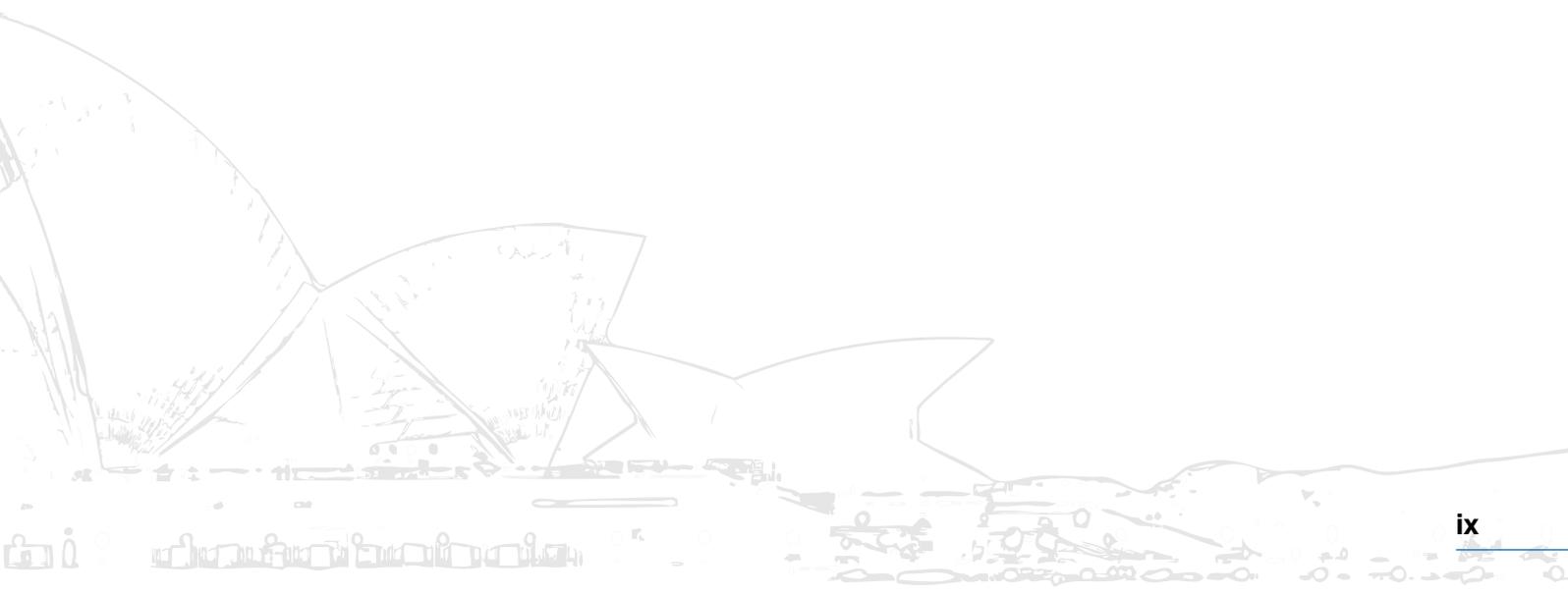
Executive summary

Objectives

As a functioning performing arts centre, commercial enterprise, tourist attraction and major national asset, Sydney Opera House must continue to demonstrate the optimal use and effectiveness of its facilities management (FM) to provide value for its stakeholders. To better achieve this, the Cooperative Research Centre for *Construction Innovation* focussed on the following three themes for investigation in the FM Exemplar Project — Sydney Opera House:

- *digital modelling* — developing a building information model capable of integrating information from disparate software systems and hard copy, and combining this with a spatial 3D computer-aided design (CAD)/geographic information system (GIS) platform. This model offers a visual representation of the building and its component elements in 3D, and provides comprehensive information on each element. The model can work collaboratively through an open data exchange standard (common to all compliant software) in order to mine the data required to further FM objectives (such as maintenance) more efficiently and effectively.

- *services procurement* — developing a multi-criteria performance-based procurement framework aligned with organisational objectives for FM service delivery

- *performance benchmarking* — developing an FM benchmarking framework that enables facilities/organisations to develop key performance indicators (KPIs) to identify better practice and improvement strategies.

These three research stream outcomes were then aligned within the broader context of Sydney Opera House's Total Asset Management (TAM) Plan and Strategic Asset Maintenance (SAM) Plan in arriving at a business framework aligned with, and in support of, organisational objectives.

The Sydney Opera House is managed by the Sydney Opera House Trust on behalf of the Government of the State of New South Wales. Within the framework of the TAM Plan prepared in accordance with NSW Treasury Guidelines, the assimilation of these three themes provides an integrated FM solution capable of supporting Sydney Opera House's business objectives and functional requirements. *FM as a business enabler* showcases innovative methods in improving FM performance, a better alignment of service and performance objectives and provides a better-practice model to support the business enterprise.

Key findings

The research has established that:

- alignment of services, performance criteria and supporting information with an organisation's business objectives is crucial for the organisation to achieve an integrated FM solution

- digital modelling using the open data exchange standard such as industry foundation classes (IFC) has clearly demonstrated benefits in the support of FM processes, asset management applications and broader organisational objectives

- alignment of performance with organisational objectives requires the use of performance benchmarking to develop effective KPIs used in establishing an integrated performance hierarchy assessment model. This performance assessment model is used to address any shortfall that exists between the organisation's objectives and good practice targets.

- an integrated information FM framework needs to be supported through:

  - an open data exchange standard across multiple applications

  - the use of data mining as an information gathering tool for analysis across the TAM Plan and FM service delivery to support the overall business framework and decision-making.

- in the case of Sydney Opera House, where FM service delivery is integral to the core objectives of the enterprise, innovative steps were taken to ensure contractor understanding and appreciation of organisational culture. These steps contributed to moving the perception of FM services procurement and delivery from the simple provision of operational-level necessity to an integrated strategic element.

- The FM Exemplar Project research should be expanded to include other facility types to verify the datasets and performance benchmarks. The research could then be used to develop an integrated FM solution framework with broader industry application.

The FM Exemplar Project has aimed to provide a tangible basis to showcase innovative methods to improve FM performance and promote best practice in order to better measure and manage the economic, social and environmental impacts of FM across industry, business and the community.

Integrated FM solution model through performance alignment
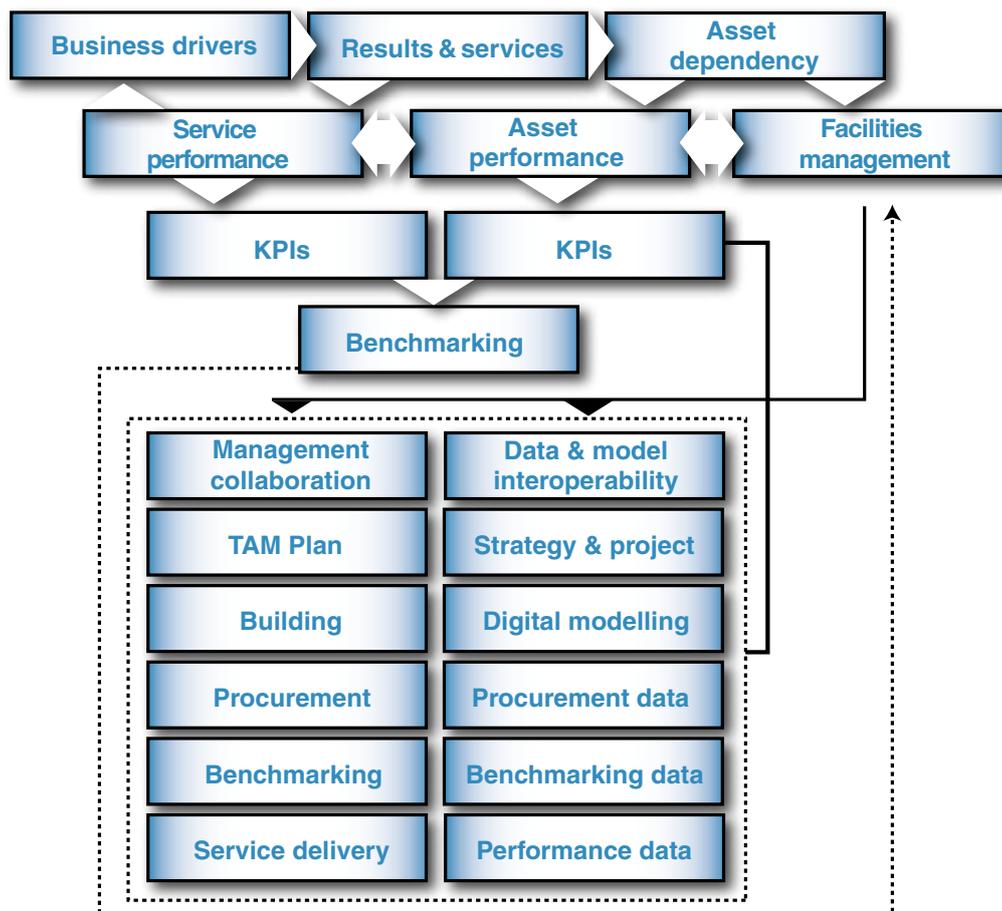
Courtesy of Sydney Opera House, Australia — international benchmarking survey participant

1. Introduction

1.1 Background and focus of publication

Facilities Management (FM) is "a business practice that optimises people, process, assets and the work environment to support delivery of the organisation's business objectives", Facility Management Association of Australia's Glossary of Facility Management Terms (1998).

The need for information

The face of business has dramatically changed in the past 60 years as corporations have responded to increasing competition in a business environment that has expanded exponentially from local, to national, to global. These pressures have forced corporations to be flexible and responsive to rapidly changing market conditions, political impacts and regulatory requirements.

This accelerated rate of change has also seen senior management increasingly brought to account in relation to critical areas such as corporate governance and performance management.

Shareholders and stakeholders are no longer satisfied with using annual reports to measure performance outcomes. Correspondingly, senior management are no longer able to use historical information such as annual reports to make decisions that impact on organisational performance.

Performance management, therefore, is all about timely performance measurement, and senior management not only need to have this information, they need to have it in a format that enables strategic decision-making.

The need for integrated information systems

FM has benefited from embracing this approach, since it has brought some focus on its contribution toward organisational objectives. However this added focus has also driven the need for the integration of disparate information management systems, firstly in order to better align FM performance objectives with the organisational objectives, and secondly to further FM objectives in terms of better and more effective FM practices and service delivery.

In response to this increasing need, the Facilities Management (FM) Exemplar Project used Sydney Opera House to conduct research on FM, with the focus on maintenance management. The project focusses on the three FM research streams specific to Sydney Opera House, with the immediate objective of using the research to demonstrate FM as a business enabler and to provide insight into the need to develop a more generic integrated FM solution for the FM industry as a whole.

About the FM Exemplar Project: Sydney Opera House

Sydney Opera House is recognised throughout the world as a building icon of 20th century architecture and an iconic symbol of Australia. As a performing arts centre (PAC) it is one of the busiest in the world, staging some 1500 performances per year, attended by 1.1 million patrons, with a further 1000 non-performance-related events ranging from exhibitions to corporate launches and weddings. An estimated 4.5 million people visit Sydney Opera House each year, with many taking tours and visiting the five restaurants and bars.

Although difficult to quantify, it has been estimated that Sydney Opera House contributes more than $200 million per annum to the economy. As a business Sydney Opera House generates some $38 million per annum from sales, services and sponsorship, and receives $34 million in annual NSW Government grants including $19 million for maintenance (excluding one-off capital renewal grants)[1].

The success of Sydney Opera House and its many partners ranging from performing arts companies to restaurateurs, retailers and business partners, is intimately linked to the world-famous building and therefore to the standard of FM at Sydney Opera House. The corporate vision and goals reflect the synergy between business, building and FM through such references as "inspiration of the building", an "architectural masterpiece" and "leveraging its assets".

More than in most buildings, FM at Sydney Opera House is a core business function directly contributing to the visitor experience and therefore to the success of the business. For many visitors to Sydney Opera House, including those who "tread the boards", the building is the attraction — part of the experience.

[1] Sydney Opera House Trust, "From Inspiration to Execution, Sydney Opera House Trust Annual Report 2005", Sydney Opera House Trust, Sydney, 2005

The Sydney Opera House FM Exemplar Project comes at a pivotal time in the history of FM at Sydney Opera House. FM is delivered by a Facilities Portfolio that is undergoing a process of change from a team distanced by disparate systems, to one that is fully engaged in the core business activities of performing arts and tourism.

Figure 1 illustrates some of the information silos and manual handling between silos used by the FM team at Sydney Opera House.
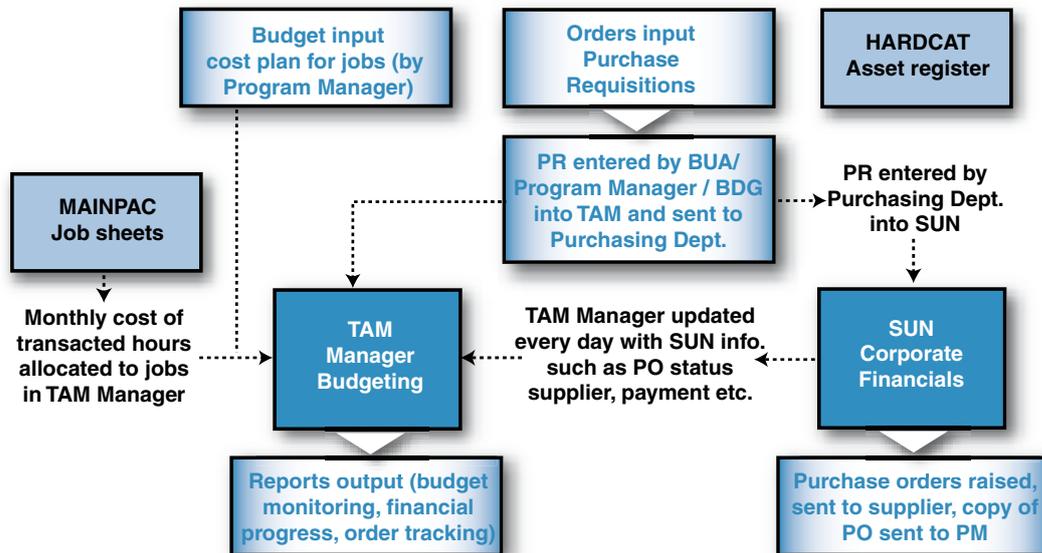
Figure 1   Systems presently deployed at Sydney Opera House

The project was initiated by the FM Action Agenda, supported by the Australian Government's Department of Industry, Tourism and Resources through the FM Action Agenda, and delivered by the Cooperative Research Centre (CRC) for *Construction Innovation* along with Sydney Opera House, FMA Australia, Transfield Services, Rider Hunt, Woods Bagot, Brisbane City Council, Queensland Department of Public Works, CSIRO, QUT and University of Sydney.

The project features three key themes.

1. Digital modelling research developed a building information model capable of integrating information from disparate software systems and hard copy, and combining this with a spatial 3D computer-aided design (CAD)/geographical information system (GIS) platform. This model offers a visual representation of the building and its component elements in 3D, and provides comprehensive information on each element. The model can work collaboratively through an open data exchange standard (common to all compliant software), in order to mine the data required to further FM objectives (such as maintenance) more efficiently and effectively.

2. Services procurement research developed a performance-based procurement framework aligned with organisational objectives, that uses multiple criteria, weighted and defined in terms of performance objectives, for FM service delivery.

3. Performance benchmarking research developed an FM benchmarking criteria framework that enabled facilities/ organisations to formulate key performance indicators (KPIs) to identify better practice and improvement strategies.

For Sydney Opera House, the digital modelling, services procurement and benchmarking research streams provide a basis for optimising their FM practice and performance. The effective integration of these three streams should therefore produce superior outcomes for FM, and better outcomes for organisational strategy and decision-making. It is in this respect that the project aimed to achieve collaboration across these three areas as a basis for demonstrating FM as a business enabler.

1.2   Integrated FM solution

Digital modelling, services procurement and performance benchmarking present different dimensions of the FM equation. These three areas are closely related.

Significantly, as the research has developed into each of the three study areas, they have been found to be mutually supportive — effective risk-sharing in procurement requires historic information and benchmarks for future performance, benchmarking gathers vast quantities of data that can only be exploited if properly analysed and digital modelling provides the means to manage such data.

While the digital model has not been used to support contractual administration processes within this project, the data model used to represent Sydney Opera House also supports the capture and storage of this information. If the required extensions were made, the digital model would directly support the procurement processes. Data mining could be used to report on trends which could also be used to influence the selection of procurement methods in the future.

Hence the integration across the three areas is crucial in providing the supporting information and processes in the development of the integrated FM solution used for improving FM performance. The alignment and placement of this integrated FM solution within the framework of a Total Asset Management (TAM) Plan in turn, is crucial in its ability to support an organisation's objectives.

The integrated FM solution, through its alignment with the organisation's objectives as outlined in the TAM Plan, demonstrate FM as a business enabler.

Courtesy of Pinacoteca Giovanni e Marella Agnelli, Italy
— international benchmarking survey participant
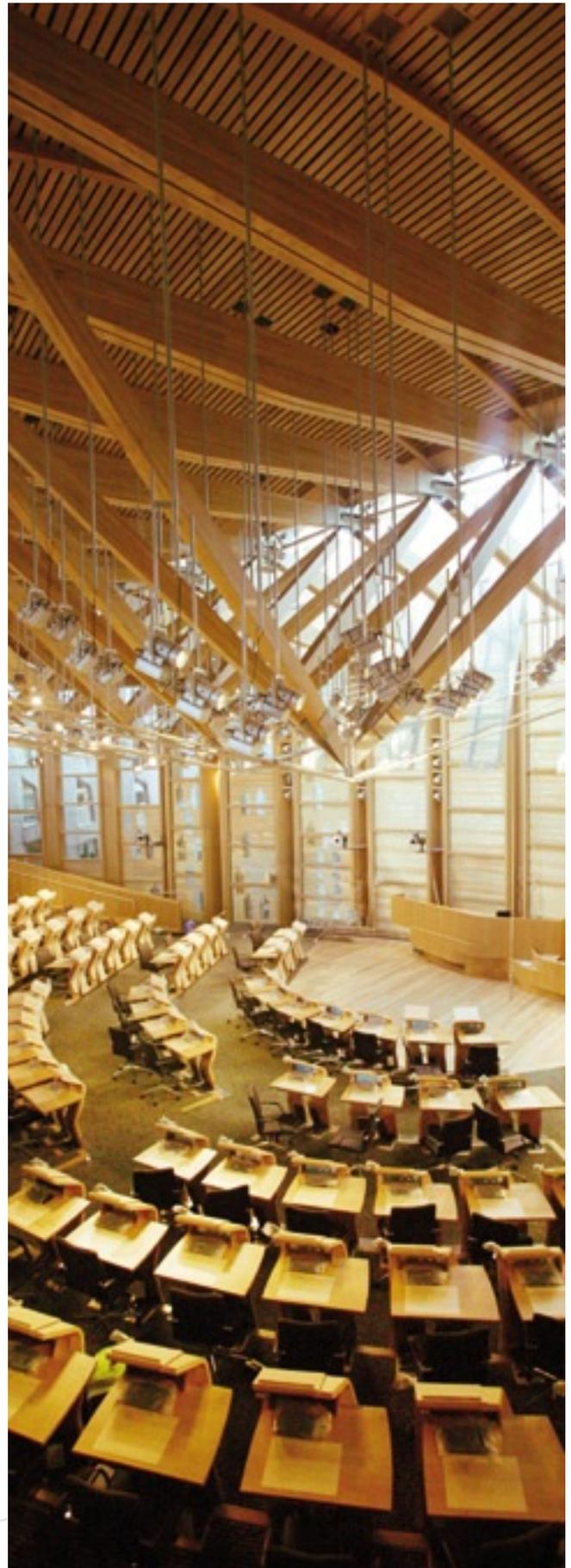
Courtesy of The Scottish Parliament, Scotland
— international benchmarking survey participant

2. Development of an integrated solution for FM

2.1 Objectives

Corporate goals and business priorities determine the level of service delivery for the organisation and bring special requirements to asset functions. For example, iconic and performing arts facilities have different results and services requirements to factories, resulting from their business characteristics.

These results and services form the objectives of a Results and Services Plan, which sits within the broader framework of TAM. Marquez and Gupta (2006) have defined Asset Management (AM) as "collaborative activities of management that determine the facilities' objectives, strategies and implementation". This definition has similarities with the Facility Management Association of Australia's definition of FM quoted previously. FM can be considered to be the business practices that support the objectives of asset management.

2.2 Total Asset Management at Sydney Opera House

Sydney Opera House's objectives are set out in a "Results and Service Plan" (as required by the NSW Treasury), which is comparable with a corporate plan. The Sydney Opera House "Total Asset Management Plan" identifies the linkages between services and assets by assessing the dependency of service delivery on asset performance. Key performance indicators (KPIs) that demonstrate the relationship between service outcomes and asset condition also reveal the role of FM as business enabler at Sydney Opera House and its integration with service delivery. Figure 2 illustrates the integration of business objectives (results and services), asset planning and FM.

TAM planning in accordance with the NSW Treasury guidelines comprises the following:

- Asset Strategy Plan
- Capital Investment Strategic Plan
- Asset Maintenance Strategic Plan
- Asset Disposal Strategic Plan
- Office Accommodation Strategic Plan
- Heritage Asset Management Plan.

Courtesy of Sydney Opera House, Australia — international benchmarking survey participant
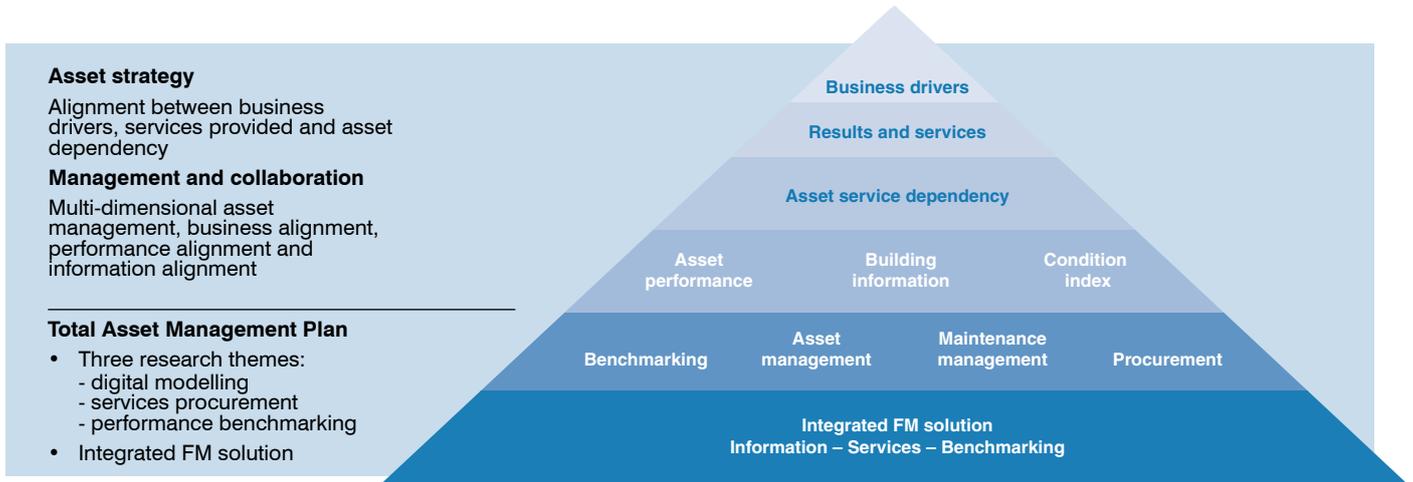
Figure 2 The role of the integrated FM solution in supporting the TAM Plan, and TAM's contribution toward the business outcomes

TAM planning is intended to support the primary functions of a facility in order that the required resources are adequately funded with performance measures put into place so that the functional efficiency and effectiveness can be monitored and deficiencies overcome.

As with any successful business enterprise Sydney Opera House Trust has defined corporate business goals as follows:

- be Australia's pre-eminent showcase for performing arts and culture and an international leader in the presentation of developing artists and their work

- attract and engage a broad range of customers and provide compelling experiences that inspire them to return

- maintain and enhance Sydney Opera House as a cultural landmark, performing arts centre and architectural masterpiece

- create a customer-focussed workplace where people are recognised for their contribution, realise their potential and are inspired to achieve outstanding results

- invest in the performing arts, cultural activities and audience development by maximising business results for Sydney Opera House and leveraging its assets, resources and brand.

Results, services and asset dependency

Within the TAM Plan, Sydney Opera House's results and services are clustered into three groups related by outcomes:

- *Performing arts service* covering programming and producers unit, venue services, support to the arts and education program. It delivers the outcomes on culture activities, support to the performing arts industry and education to young people.

- *Visitor experience service* covering visitor service, amenities and tourism. It delivers the outcomes on continuous appeal to visitors and theatre patrons, promoting Sydney Opera House as an icon nationally and internationally, and contributing to economic growth.

- *Building and property service* covering presentation and preservation of Sydney Opera House and its security. It delivers the outcomes on an outstanding and unique architectural masterpiece, on its capabilities as a place of public entertainment and heritage building, and on comfort and a safe environment for visitors.

Similarly, Sydney Opera House's assets are grouped by related themes. This enables the dependency of services upon assets to be illustrated in a simple table, effectiveness measures to be identified, and gap analysis undertaken as shown in the following tables.

Table 1   Asset dependency to the service clusters (Sydney Opera House TAM Plan 2006)

Service cluster	Asset groups as defined in Sydney Opera House's TAM Plan							
	Theatre technical facilities (audio, lighting, staging and stage management)	Security systems (CCTV, cyberlocks and swipecards)	Staff and presenter facilities (offices, dressing rooms and toilets)	Visitor facilities (retail, catering, bars public toilets)	Mechanical, electrical and hydraulic systems	Fire services	Information and communication technology (ICT)	Building and site (structural and building fabric)
Performing arts	H	L	M	M	M	H	H	L
Visitor experience	M	M	L	H	L	H	H	H
Building and property	M	H	M	M	H	H	H	H

Notes:
H: High risk to service from a substandard functional space or asset group
M: Medium risk to service from a substandard functional space or asset group
L: Low risk to service from a substandard functional space or asset group

Table 2   Example of asset performance definition and gap analysis (Sydney Opera House TAM Plan 2006)

Asset group	Required performance	Gap	Management response
Visitor facilities	a) Compliance with relevant legislation. b) Facilities (signage, retail, catering etc.) appropriate for a world class PAC and tourist attraction.	• Lack of equitable access. • Inadequate signage and information (a frequent complaint by customers).	• Develop renewal plans. • Signage Manual completed, enhance way-finding and comply with heritage requirements (nil funding available for installation).
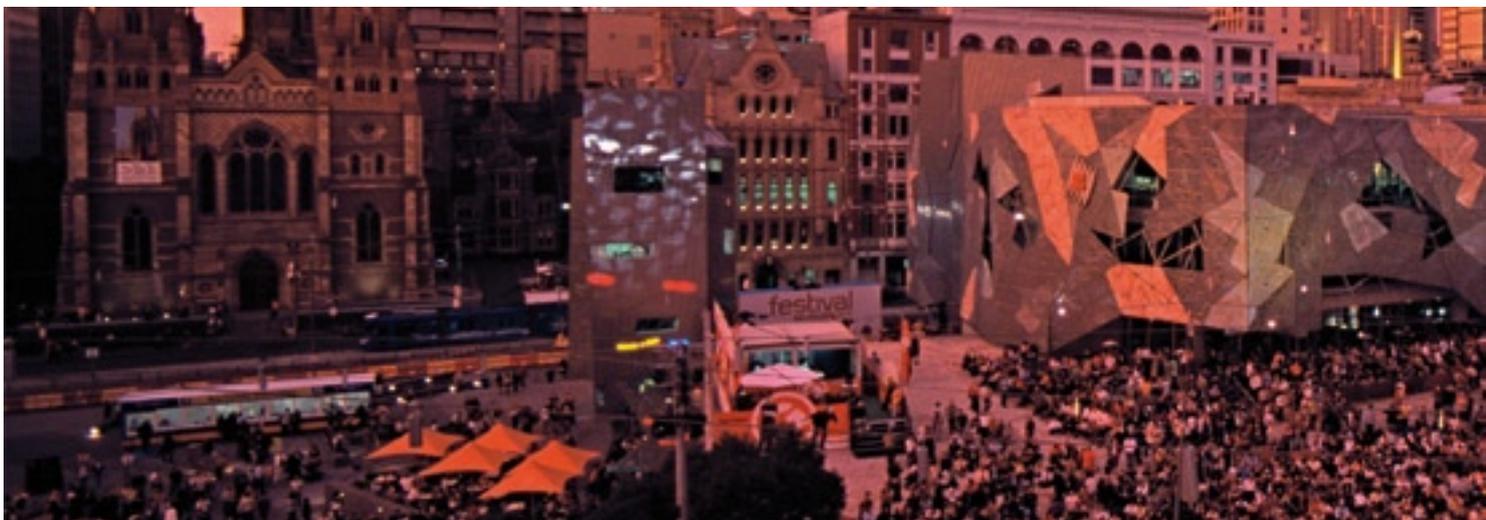
Table 3   Example of service and asset performance measures (Sydney Opera House TAM Plan 2006)

Service cluster	Service performance measure	Asset performance
Visitor experience	Tour attendances Number of people taking paid tours	Customer satisfaction and growth of the tours business is dependent upon well-maintained assets – which other measures suggest could be improved to meet our vision to "excite and inspire the imagination".
	Building Presentation Index Cleanliness of the building compared to "as-new". Building Fabric Index The condition of the building compared to "as-new".	Both indices are reported at 10% below target, indicating that heritage values, conditions for staff and presenters, and visitor experience need to improve to deliver our vision in full.
	Customer Satisfaction Survey Satisfaction of visitors and patrons following a visit to Sydney Opera House.	Customer satisfaction with facilities is rated at 7 to 8 out of 10. This is consistent with Presentation and Fabric indices and similarly below that required to provide visitors with a truly "inspiring experience".

The role of the TAM Plan is to identify the linkage between business goals, services and assets to achieve the highest possible total return on investment, and eventually to reduce the gap between existing asset functionalities, service delivery requirements and maintenance provisions. Asset performance standards and measures at the corporate and asset levels have been developed in the TAM Plan for Sydney Opera House to best support business goals and service delivery.

An example of the asset performance standard and measure at Sydney Opera House to support its dependent services is the asset performance satisfaction levels demanded by performing arts companies. These satisfaction levels highlight any serious issues and provide drivers for developing procedures, processes, or, in some instances, capital expenditure for the improvement of building services.

Courtesy of The Federation Square, Australia — international benchmarking survey participant

The role of digital modelling in the development of an integrated FM solution
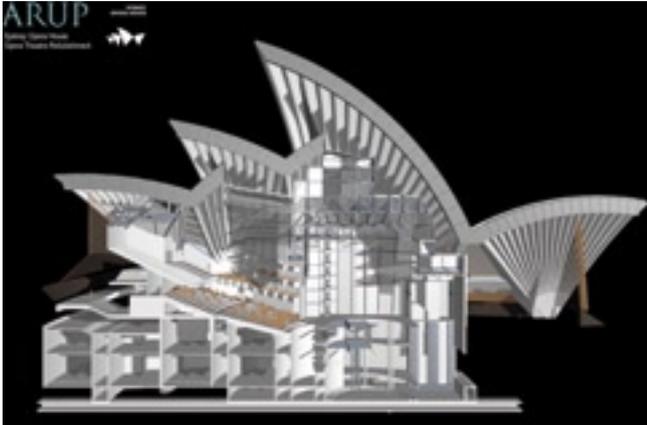
Figure 3   A three-dimensional (3D), computer-aided design (CAD) example of the visual component of digital modelling at Sydney Opera House — in this case presented as a sectional side-elevation. Courtesy ARUP & Johnson Pilton Walker JPW. Copyright Sydney Opera House.

FM generates, and is dependent upon, a vast array of information and inputs that begin with strategic plans and projects, and extend to include facilities data, maintenance schedules, performance records and cost data. As the data hierarchy develops, it transcends the specific needs of the FM department and aligns with the performance of the organisation as a whole. The value of digital modelling in the development of an integrated FM solution is through its provision of enhancing data through its currency, accessibility and the ability to correlate one dataset with another.

The integrated FM solution in turn provides the information derived from the correlation and processing of data to support organisational objectives, and demonstrates FM as a business enabler.

Figure 1 (see Introduction) illustrates the range of data sources used in FM at Sydney Opera House to which can be added numerous other types of data including drawings and operational manuals that support the flow of FM operations, as illustrated in Figure 4.
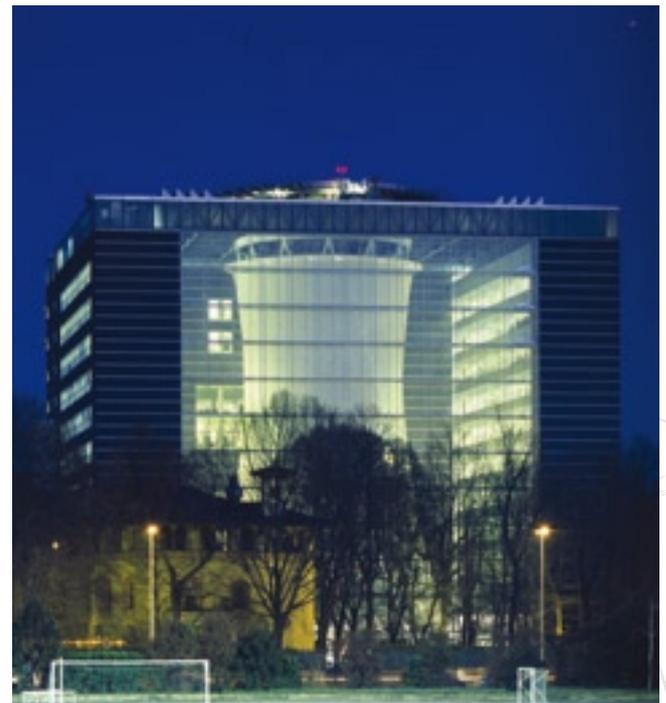
Courtesy of Pirelli Real Estate Headquarters, Italy — international benchmarking survey participant
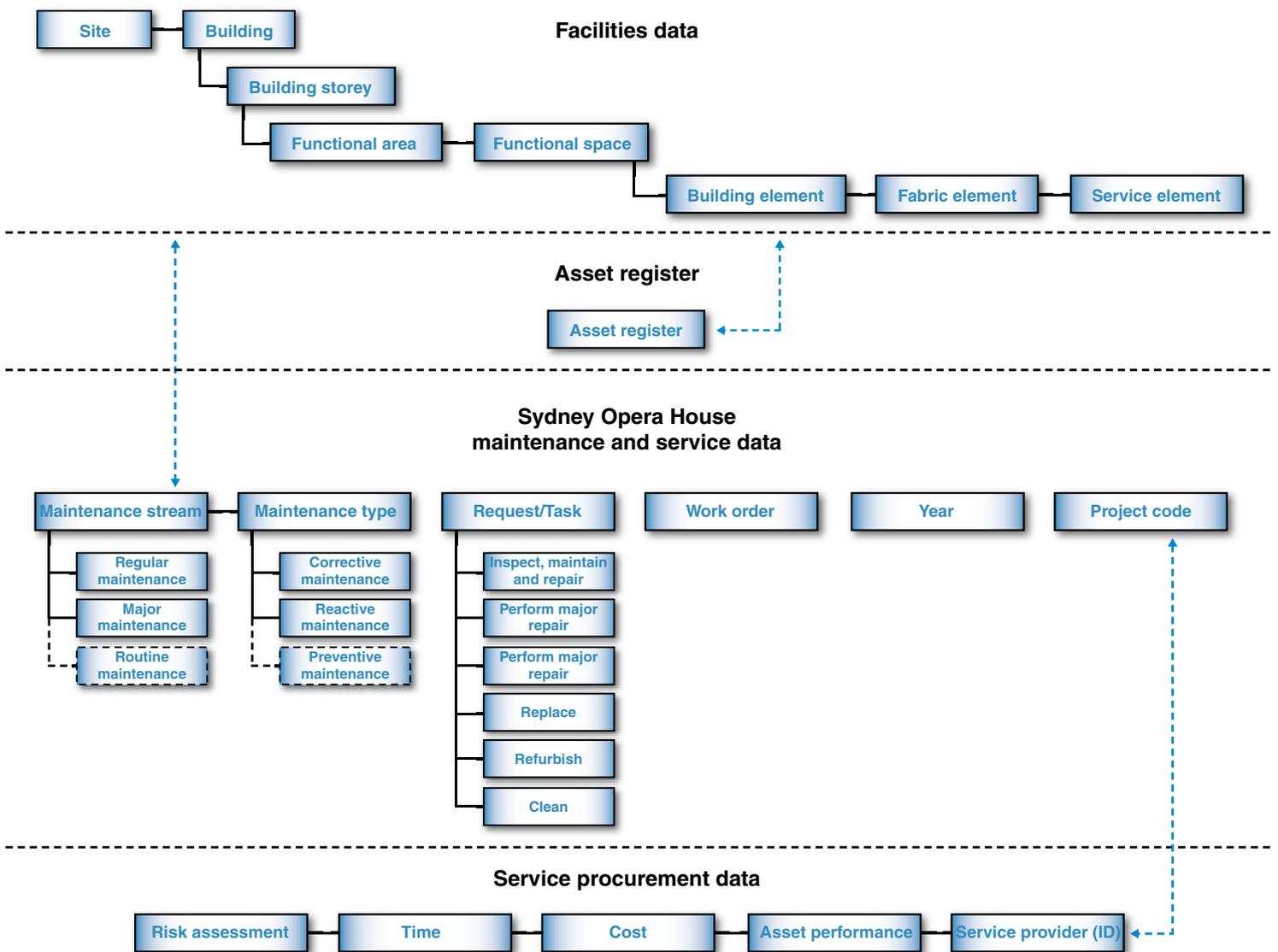
Figure 4   Illustration of the different datasets and information dependency

Digital modelling, through the establishment of a building information model, can be designed to support such information dependencies as shown in Figure 4. The information model offers a visual representation of the building and its component elements in 3D CAD, and provides comprehensive information on each element, and can integrate property data for GIS data. The model enables the collection of data from disparate software systems, hard copy, and new model-based systems, through the use of an open data exchange standard (common to all compliant software). This data can then be further analysed and processed to provide the information needed to support the business process.

The digital modelling concept recognises and allows for the fact that it is unlikely that one single application package will meet the needs of all parties involved in asset management, from strategic partners to the designers and constructors, to facilities managers and maintenance personnel. The International Alliance for Interoperability (IAI)[2] has addressed this key issue through the development of a standard information protocol for the construction industry known as an industry foundation class (IFC). Software that adopts the IFC protocol will be able to readily share data with other compliant software enabling practitioners to select the best software for a given application and to share data between systems.

[2] *The IAI is a worldwide alliance of over 550 construction industry businesses and government agencies covering Architecture, Engineering, Construction and Facilities Management (AEC/FM) from 21 countries.*

Generic attributes of digital modelling

The key generic attributes are:

- robust geometry — objects are described by faithful and accurate geometry that is measurable

- comprehensive and extensible object properties that expand the meaning of the object — objects in the model either have some pre-defined properties, or the IFC specification allows for the assignment of any number of user or project-specific properties according to a common format. Objects can be richly described with items such as a manufacturers' product code, or cost, or date of last service.

- semantic richness — the model provides for many types of relationships that can be accessed for analysis and simulation, for example "is-contained-in", "is-related-to", or "is-part-of"

- integrated information — the model holds all information in a single repository ensuring consistency, accuracy and accessibility of data

- lifecycle support — the model definition supports data over the complete facility lifecycle from conception to demolition. For example, client requirements data such as room areas or environmental performance can be compared with as-designed, as-built or as-performing data — a vital function for FM.

Digital modelling benefits

The key benefit of digital modelling is its accurate geometrical representation of the parts of a building in an integrated data environment. Related benefits are:

- faster and more effective processes — information is more easily shared, can be value-added and reused

- better design — building proposals can be rigorously analysed, simulations can be performed quickly and performance benchmarked, enabling improved and innovative solutions

- controlled whole-of-life costs and environmental data — environmental performance is more predictable, lifecycle costs are understood

- better production quality — documentation output is flexible and exploits automation

- automated assembly — digital product data can be exploited in downstream processes and manufacturing

- better customer service — proposals are understood through accurate visualisation

- lifecycle data — requirements, design, construction and operational information can be used in FM

- integration of planning and implementation processes — government, industry and manufacturers have a common data protocol.

Courtesy of Australian Parliament House, Australia — international benchmarking survey participant

The digital modelling research demonstrated the significant benefits in digitising design documentation, and operational and maintenance manuals. Since Sydney Opera House does not have an integrated digital model of their facilities, there was an opportunity to investigate the application of digital facilities modelling using a standardised and re-usable digital model for FM applications. While recent works at Sydney Opera House have used 2D and 3D CAD systems, the opportunity for digital modelling and further interoperability benefits still remained, since each consultant was still free to choose their own software package and work to only a general specification for 2D drawing data presentation.

Since 2002, a number of projects in Finland, Sweden, Norway, Germany, France, Singapore, UK and Australia have demonstrated the capacity of digital models to represent and process data across a range of integrated applications including:

- amalgamation of architectural, structural and building services design information
- automated building code checking
- automated manufacturing of components
- construction programming, including visualisation
- thermal performance calculations
- automated take-off of material schedules
- facilities management.

The ability to integrate data from a number of software packages is dependent upon "interoperability", defined as the seamless sharing of building data between multiple applications (or disciplines) over any or all lifecycle phases of a building development project. Although digital modelling may be considered as an independent concept, in practice, the business benefits of digital modelling are dependent on the shared use and value-added creation of integrated model data.

To access model data therefore requires an *information protocol*, and although several vendors have their own proprietary database formats, as mentioned previously, the only open global standard is that published by the IAI in the form of IFCs.

IFC is regarded as a standardised form of digital modelling and has been developed to support architecture, engineering, construction and FM domains.

The FM Exemplar Project has established that a digital model is an appropriate and potentially beneficial technology enabling storage and retrieval of integrated building, maintenance and management data for Sydney Opera House. Specifically the research team has demonstrated a prototype integrated digital model capable of handling integrated information using Bentley Structural, Graphisoft ArchiCAD, the CRC for *Construction Innovation* IFC Viewer and a link with Sydney Opera House's building condition index (BCI) database.

There are many advantages in using an integrated digital modelling approach, such as consistency in the data, intelligence in the model, multiple representations, an integrated source of information for existing software applications, and integrated queries for data mining. The standardised building model acts as the main data structure which can be extended with other data sources as each element (wall, furniture, room, grouping elements) has a unique identifier. This unique identifier can be used to correlate different datasets, opening up query capabilities across different datasets.

The IFC open building exchange standard provides comprehensive support for FM functions, and offers new management, collaboration and procurement relationships based on sharing of data. The major advantages of using an open standard are:

- information can be read and manipulated by any compliant software
- reduced user "lock in" to proprietary solutions
- third party software can be the "best of breed" to suit the process and scope at hand.

Standardised digital model solutions consider the wider implications of information exchange outside the scope of any particular vendor. Information can be archived as ASCII files for archival purposes, and data quality can be enhanced as the now single source of users' information has improved accuracy, correctness, currency, completeness and relevance.

The following FM model schema in IFC has been recommended by the FM Exemplar Project team for the development of FM information interoperability for Sydney Opera House:

- *IfcFacilitiesMgmtDomains* defines basic concepts in the FM domain. It captures information that supports specific business processes that are completely within the domain of interest of the facilities manager. Together with the *IfcProcessExtension*, *IfcSharedMgmtElements* and *IfcSharedFacilitiesElements* schema, it provides a set of models that can be used to exchange information between FM applications.

- *IfcSharedMgmtElements* defines basic concepts that are common to management throughout the various stages of the building lifecycle. It captures information that supports the ordering of work and components, the development of cost schedules and the association of environmental impact information. The primary classes in the schema are all subtypes of *IfcControl* and act to manage or regulate the conduct of the project in some way.

- *IfcSharedFacilitiesElements* defines basic concepts in the FM domain. It supports ideas including:

  - furniture
  - grouping of elements of systems furniture into individual furniture items
  - asset identification
  - inventory of objects.

- *IfcProcessExtension* captures ideas about the planning and scheduling of work and the tasks and procedures required for its completion.

Since IFC is a predefined standard, it covers a large scope of interoperability that includes disciplines such as architecture, structure, fire engineering, building services and FM domains and, as a result, it is complicated. For domain-specific applications such as FM, some detailed domain-specific information may be lacking, and this can be overcome through extending IFC towards an enriched domain-specific model and customising it for the specific use of Sydney Opera House.

The current availability of FM applications based on digital modelling is in its infancy but focussed systems are already in operation internationally and show excellent prospects for implementation systems at Sydney Opera House. To support the FM processes using the IFC, guidelines and modelling practices formalised in the form of a Sydney Opera House specification was developed. This specification describes how information and conventions specific to Sydney Opera House can be incorporated in the digital model. Tests with partial digital FM model data demonstrated that the creation of a complete Sydney Opera House digital FM model is realistic, but subject to resolution of compliance and detailed functional support by participating software applications.

Courtesy of Portcullis House, UK
— international benchmarking survey participant
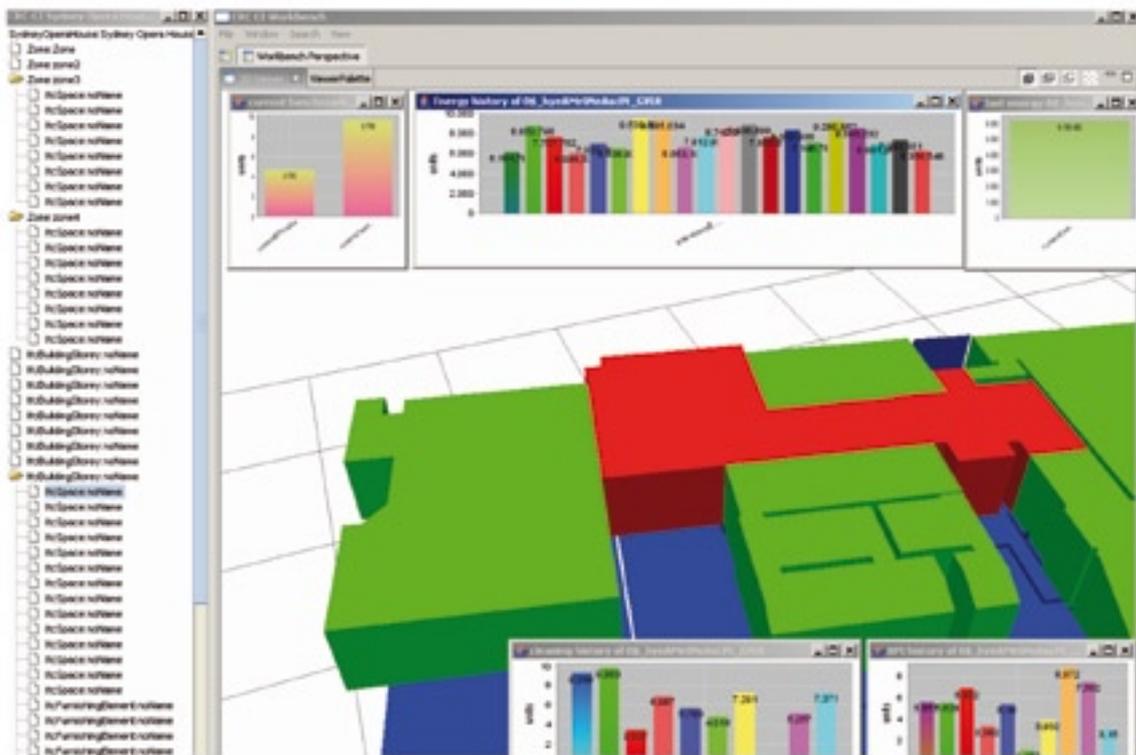
Figure 5   A showcase of integrated FM information model using IFC

Figure 5 presents the showcase for the integrated FM information system for Sydney Opera House. The showcase develops an integrated FM information model that combines the IFC models and a benchmarking data model containing Building Presentation Indices (BPI) and Building Fabric Indices (BFI) of Sydney Opera House. It allows facilities managers to view the 3D models of Sydney Opera House and locate the building condition assessment data collected from building maintenance and cleaning services.

The digital modelling showcase demonstrates the enrichment of information through the development of integrated FM information models using IFC. When combined with data-mining techniques the resulting analysed information is then aligned with FM performance criteria, TAM and ultimately business drivers.

The showcase has demonstrated successfully that IFC-based exchange is possible with several common digital-model-based applications through the creation of a new partial model of the building. Data exchanged has been reasonably geometrically accurate, considering the complexity of Sydney Opera House's structure, and the volume and scope of the rich information supported in describing the types of building element objects, and their properties and relationships.

The structural model has been imported from an architectural CAD system where the IFC model was enriched with spatial elements such as rooms and furniture elements based on the Sydney Opera House specification. Based on this enriched IFC file, a showcase system has been developed on which the Sydney Opera House information can be visualised and restructured. Facilities performance and cleaning contract data has been inserted and correlated with the IFC model offering functionality to query and to get visual feedback of this correlated dataset.

Courtesy of Portcullis House, UK
— international benchmarking survey participant

The following conclusions were made:

- Standardised digital modelling as an integrated information platform for FM delivery is feasible.

- IFC offers interoperability between CAD systems, enabling re-use of building information.

- The IFC model being standardised can use a variety of different software FM systems.

- Commercial FM software systems are available using IFC data.

- Related software such as energy modelling and monitoring are available using IFC data.

- The IFC model is extensible and can incorporate organisation-specific requirements.

- Integrated datasets can be constructed offering enhanced query results and visualisation.

The digital modelling research stream has developed a framework for an integrated FM information system for Sydney Opera House. In this framework, IFC is used for information exchange and model interoperability between different FM applications including CAD systems, FM and benchmarking data repositories.

This framework can be extended to cover the aspects of collaboration and communication across the organisation at different locations by using intranet/internet network for information provision.

The building and engineering data, corporate strategic planning data, FM operational data, performance and KPI monitoring data, and benchmarking data are collected in a digital format and stored in different repositories or a centralised database for supporting multiple FM applications. IFC is used for FM information exchange and model interoperability. Intranet/internet network functionality is added to the different FM applications to provide a common space for collaboration and communication across the entire organisation or the departments at different locations.

As a result of digital modelling's clearly demonstrated benefits in the support of FM processes, asset management applications and broader organisational objectives, the FM Exemplar Project team support and endorse the adoption of IFC by the FM industry as an integral information management tool in supporting FM as a business enabler.

Figure 6 shows an example of IFC-compliant software for FM that charts energy management.

RYHTI software is developed for the management of buildings or entire building stocks. Developed in cooperation with leading real estate owners and maintenance organisations, the RYHTI system is based on modules enabling the development of operation models and to process data into information.

The Esplanade — Theatres on the Bay, Singapore — international benchmarking survey participant
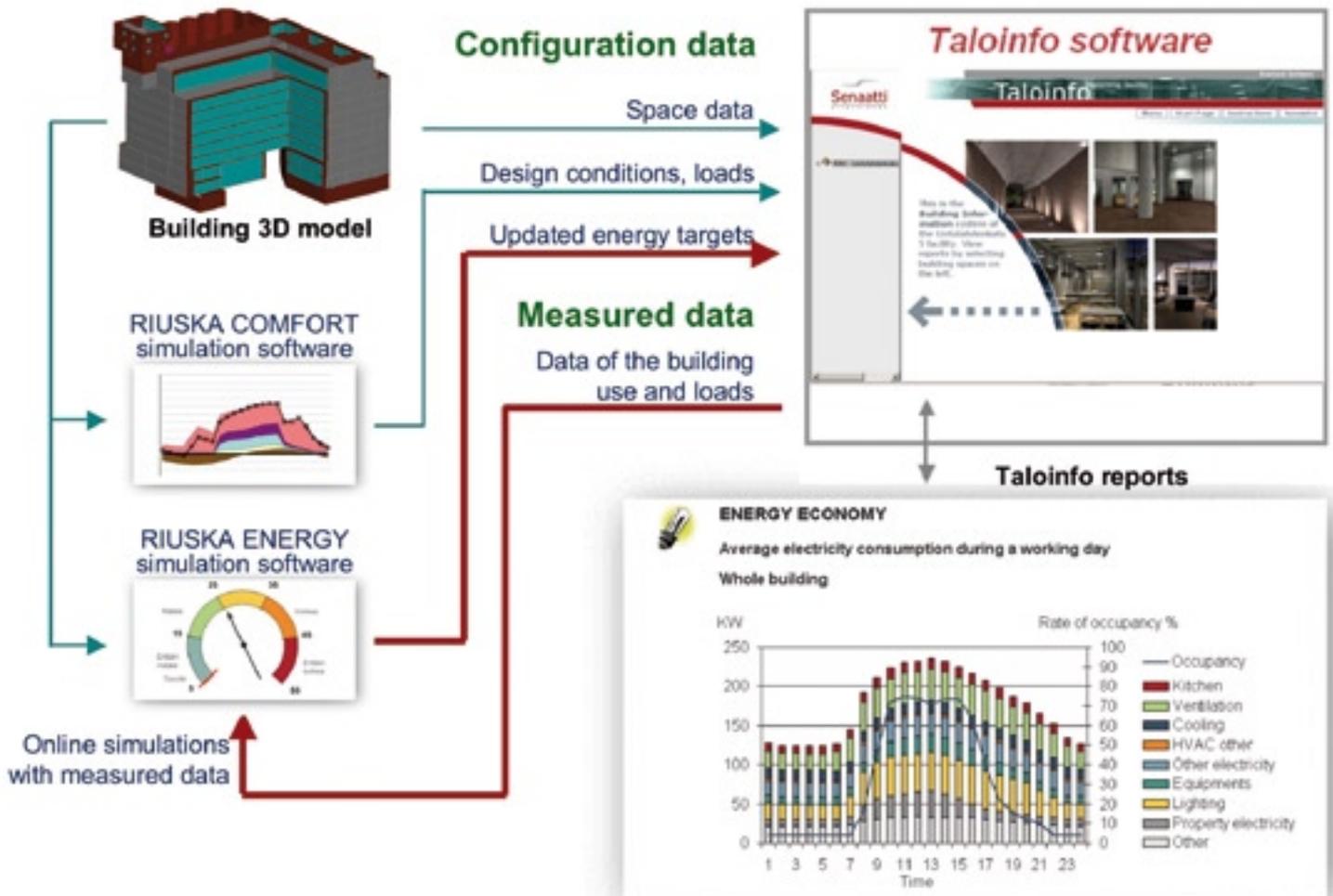
Figure 6 Use of Product Models in Taloinfo System for the generation of energy usage reports for Senate Properties, Finland, Olaf Granlund (Courtesy of Olaf Granlund)

The role of services procurement in the development of an integrated FM solution

The practice of outsourcing part or all the FM services by organisations is relatively commonplace in the industry, and for Sydney Opera House, the procurement process became an opportunity to align FM with business objectives and deciding best-value selection.

The research into procurement is presented as a case study which outlines an approach to FM procurement in which alignment with the principal's business objectives and culture are the central considerations. While such an approach to procurement has undoubtedly been taken before, the case study will be of value to those seeking to implement or improve an FM procurement strategy that is integrated with core business activities and organisational culture.

The research program took into account Sydney Opera House's decision to continue to outsource general building maintenance and cleaning functions, while retaining management skills and knowledge in-house through a professional management team and a small trade workforce. The case study followed the tendering of the building maintenance and cleaning contracts to replace two contracts that were expiring.

Prior to developing specifications for each of the contracts, an extensive consultation process with stakeholders was undertaken. From this it became apparent that there was a general view that the existing contracts did not support the Sydney Opera House business in terms of performance or means of delivery. By continuing to work with stakeholders, procurement processes and contract specifications were developed that reflected the expectations of Sydney Opera House as a whole. In comparison to previous procurement methods, a number of innovations were developed that are briefly discussed below.

- *Building Condition Indices (BCI)* — developed for building fabric condition and cleaning using a percentage-based scoring system with 100% equalling "as new" and defined standards below this in 10% decrements. Indices were further linked to time-based criteria (e.g. opening times) and aligned to service standards. The indices also provide a tool for internal benchmarking and comparison.

- *Expressions of Interest (EOI)* — documentation was prepared in anticipation of a large number of applicants of whom only a small number would have the requisite skills and experience. These concerns were addressed by including within the EOI four key questions to which inappropriate answers automatically eliminated an applicant. Having reduced the initial number of applicants the remaining EOIs were evaluated in detail to produce a final list for interview. Invitations to EOI interviews insisted that each company was represented by contract management staff rather than a sales team.

- *Request for tender (RFT)* — documentation incorporated mandatory pre-tender workshops as an essential aspect of the procurement process. Following circulation of a draft RFT all tenderers were invited to attend individual workshops to discuss and develop the document. To encourage free and open discussion the workshops were informal and did not form part of the tender evaluation process. On completion of the workshops the RFT document was finalised and formally issued to tenderers.

- *Culture and enterprise* — throughout the procurement process it was made clear to tenderers that an understanding of the Sydney Opera House culture and enterprise would be critical to the success of a tender. This was achieved through in-depth discussions during the pre-tender workshops and by encouraging tenderers to use other means to gain a full understanding of the Sydney Opera House business (such as annual reports, attending performances and taking public tours).

- *Stakeholder representation* — in addition to extensive stakeholder consultation, the stakeholders were represented on the tender evaluation committee. This required that time was spent explaining the procedures and probity of evaluation processes to people not usually involved in such workings. Emphasis was placed on the role of committee members in championing the appointed contractor at the end of the process.

These innovative steps contributed to moving the perception of FM services procurement and delivery from the simple provision of operational level necessity to an integrated strategic element. FM must support an enterprise's core business and culture. Though it is still too early to confirm the success of either contract featured in the case study, a post-tender survey of all participants provides some insight into the effectiveness of the procurement process. The majority of tenderers and all the tender evaluation committee members participated in the survey, which led to a number of conclusions:

- There was a high level of confidence in the process.

- There were no significant differences in the opinions of successful and unsuccessful tenderers.

- The EOI process was effective in the timely reduction of the number of applicants.

A number of characteristics were identified that separated those invited to tender from the other applicants interviewed at the EOI stage and they were:

Those invited to tender demonstrated:	Those not invited to tender:
• a personal passion for Sydney Opera House — the icon • comprehensive research through web, annual reports, informal site visits (including public tours and attending a show) • an adaptability to tailor corporate systems to client needs • an understanding of "inspiring experiences" • a team culture with most or all attendees participating in the interview.	• lacked personal affinity for Sydney Opera House • had not attempted to view Sydney Opera House from the patron's or tourist's point of view • offered a corporate "service package" with expectations of client compliance • allowed one person to dominate the interview (essentially a sales pitch).

While the case study emphasises the experience of Sydney Opera House, it also demonstrates the value provided in the alignment of procurement strategies with overall business objectives. Where the provision of FM services is less central to core organisational culture, a study of procurement strategies and methods from published research and FM good practice will supply FM with alternative procurement routes.

Sydney Opera House's FM team are confident that they have selected two contractors capable of making a positive contribution to Sydney Opera House as a business enterprise. The real test of the procurement process will be the long-term success of the building maintenance and cleaning services contracts. The FM Exemplar Project team concluded, therefore, by recommending that a further post-tender review be undertaken in 12 months time.

The role of performance benchmarking in the development of an integrated FM solution

Benchmarking and KPIs provide tools for measuring the effectiveness of an organisation and making comparisons with other organisations. KPIs are generally internal measures used to monitor strategically important activities within an organisation. They may be used to monitor trends and/or set targets that are central to an organisation's success. By comparison, benchmarking may be considered a comparative process between organisations that can be used to establish best practice. The same data that underpins KPIs may be used in benchmarking. Depending upon the willingness of a group of organisations to share data, the range of benchmarks is likely be smaller than the range of KPIs used by an organisation — this relationship can be illustrated in the form of a Venn Diagram (see Figure 7).
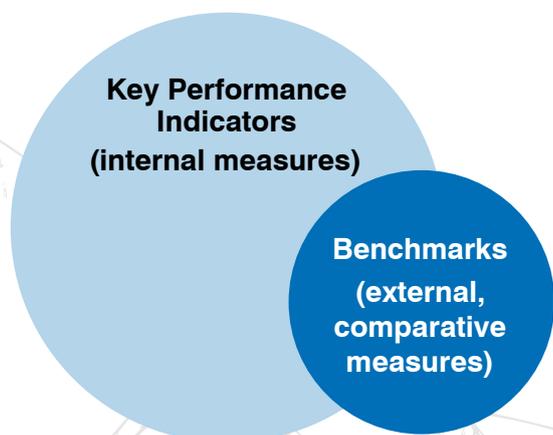
Figure 7   KPIs and benchmarking

Within the Australian FM industry there are a number of examples of comparative benchmarking data.

Tertiary Education Facilities Management Association (TEFMA)

TEFMA is an association of facilities managers working in the tertiary education sector of Australia, New Zealand, Hong Kong and Singapore. It conducts an annual benchmark survey that contains cost and performance data in 12 areas:

*   backlog liabilities
*   cleaning and waste management
*   energy
*   grounds
*   maintenance
*   operating costs
*   parking
*   recycling
*   refurbishment
*   security
*   statistical data
*   water.

Property Council of Australia (PCA)

The PCA represents a wide range of interests in the property market including institutional and private investors, developers, asset managers, building consultants, and construction companies and suppliers. The PCA annually publishes state-based office benchmark surveys covering operating income, statutory charges, operating expenses and recoverable expenses. Expense-based items are listed below:

*   administration
*   airconditioning
*   carparking
*   cleaning
*   electricity
*   energy management
*   fire protection
*   gas and oil
*   insurance
*   landscaping
*   lifts and escalators
*   pest control
*   repairs and maintenance
*   security
*   supervision.

In 2004, the PCA published a "white paper" on corporate real estate performance measurement that noted that whilst cost per unit area or per employee data was common, the measurement of the asset management contribution to an organisation was less well defined.

Facility Management Association of Australia (FMA Australia)

In 1999, FMA Australia published *Facility Operating Cost Benchmarks* that identified facility costs for office, education, health and industrial facilities.

In each of the above examples the benchmarks for the most part use readily definable, financially descriptive measures to compare similar and common types of facilities. For PACs or iconic buildings, however, there are no publicly available FM benchmarking datasets.

The FM Exemplar Project investigated the practicality of developing FM benchmarks for PACs and iconic buildings by using data already collected by such organisations, the objective being to provide a framework by which icons such as Sydney Opera House would have a basis to benchmark their performance. A particular challenge in the benchmarking of icons is that their very uniqueness might compromise the validity of any comparison between two such facilities.

The research team undertook an international survey of various iconic facilities and PACs that sought to establish:

• the level of interest in developing a set of benchmarking tools

• the range of FM-related KPI data collected by each organisation

• whether existing KPI data could readily be used to establish benchmarks.

Of 82 facilities contacted worldwide, 22 responded to the initial survey and 15 completed a second, more detailed, survey (see Table 4). The organisations were selected on the basis of existing contacts with members of the research team, thereby increasing the likelihood of obtaining a response. Although the number of participants was small, it was considered easier to focus on a small group to initially establish a benchmarking framework that could then be extended to other organisations rather than trying to coordinate a larger group.

Table 4 Summary of participants by building function

Function	Survey stage 1	Survey stage 2
Gallery/ Museum	3	3
Hotel	1	0
Office	3	1
Other	1	0
Parliamentary	3	3
Performing arts centre	10	8
Stadium	1	0
Total	22	15

Most organisations participating in both surveys were PACs, followed by galleries/museums and parliamentary buildings (14 out of 15). These 14 organisations are profiled in Table 5.

Courtesy of Philharmonie Berlin, Germany
— international benchmarking survey participant

Table 5   Profile of benchmarking participants

No.	Facility/Organisation	City	Country
1	Adelaide Festival Centre	Adelaide	Australia
2	Queensland Performing Arts Centre	Brisbane	Australia
3	Australian Parliament House	Canberra	Australia
4	Federation Square	Melbourne	Australia
5	Sydney Opera House	Sydney	Australia
6	Telstra Stadium	Sydney	Australia
7	Canadian Museum of Civilization	Quebec	Canada
8	Royal Danish Theatre	Copenhagen	Denmark
9	Opera National de Paris — Opera Bastille	Paris	France
10	Philharmonie Berlin	Berlin	Germany
11	Gasteig (includes Philharmonie München)	Munich	Germany
12	Pirelli Real Estate Headquarters	Milan	Italy
13	Pinacoteca Giovanni e Marella Agnelli	Turin	Italy
14	The Scottish Parliament	Edinburgh	Scotland
15	The Esplanade — Theatres on the Bay	Singapore	Singapore
16	HSB Turning Torso	Malmo	Sweden
17	Burj Al Arab	Dubai	UAE
18	Portcullis House	London	UK
19	Royal Festival Hall	London	UK
20	Smithsonian National Air and Space Museum	Burke	USA
21	The Sears Tower	Chicago	USA
22	Minnesota Orchestra Hall	Minneapolis	USA

Fifteen organisations completed both surveys and confirmed their interest in developing benchmarking tools. However, the establishment of comparative benchmarks was found to be more difficult than originally thought. The two surveys found that, with the exception of electricity consumption, the range of FM-related KPIs currently collected was limited and varied in nature between the organisations. It was therefore not possible to use existing KPIs to develop a comprehensive set of benchmarks and to meet the research's ultimate objective of formulating a framework for benchmarking.

Although the Survey stage 2 sample group contains only 14 organisations covering three functions there are nevertheless significant differences in the age, size and number of employees between the facilities. This serves to demonstrate the challenge of developing benchmarking tools when these differences are likely to contribute to the ranking of facilities by a benchmarking framework. Unless these differences can be eliminated or accounted for,

benchmarks should only be used as an indicator of best practice.

Notwithstanding its limited scope and size the survey has yielded two datasets that may have some value to a future benchmarking exercise. The survey found that outsourcing of FM services is common to 11 of the 14 organisations. This opens up the possibility of benchmarking procurement methods (a possible extension of the procurement research), contract management and contractor performance. In addition, monitoring trends in FM procurement may reveal useful information on the benefits of different approaches.

While it is reasonable to expect that all organisations collect at least basic information regarding electricity, water and gas consumption in the form of units consumed and cost through periodic billing from suppliers, some of the respondents to the survey stated that such information was either not retained, or not within the FM function.

This led the research team to suspect that many icons may either not be regarded as business enterprises, or that the gathering of this information was not seen to be the responsibility of the FM function. Ten organisations provided electricity consumption data, but traditional measures such as those demonstrated in the argument made by PCA in its CRE white paper referred to previously were of no assistance, given neither megawatts per hour nor megawatts per square metre relate energy use to business activity. For facilities such as Sydney Opera House, this comparison exercise may be more valid using a comparison of electrical consumption with the number of performances, and the number of patrons and/or opening hours.

The benchmarking research has found that current FM benchmarking practices are confined to common or similar building types and need further development to fully illustrate the value of FM as a business enabler. An opportunity has been created with 14 organisations worldwide to begin the development of more appropriate FM benchmarks for iconic facilities and PACs, possibly relating electrical consumption to business activity as a starting point.

Analysis of the benchmarking data from Survey stage 1 has identified that the highest-order items that could be considered core to FM benchmarking framework would include:

- condition assessment — building structure and services, public spaces, internal fittings and finishes
- energy management — rate of consumption and management
- accessibility — security provision and information for visitors
- contractor's performance — quality of service, safety, timeliness and compliance.

These are shown in Table 6.

Survey stage 2 was sent to stage 1 respondents to elicit more detailed information, particularly regarding condition assessment and energy management. Analysis of responses identified that:

- criteria used to evaluate are equally shared by simple data measure and engineering assessment / computer modelling / simulation, and of those responses 90% indicated that their facilities evaluated energy against design standards
- most facilities are assessed manually and assessments tend to be more detailed when the interval between assessments is extended.

Furthermore, the Survey stage 2 also identified the assessors and frequency involved in conducting assessment from highest to lowest ranking as follows:

- condition — assessed by internal staff, consultants and contractors (annually, quarterly, monthly, weekly and daily)
- presentation — assessed by internal staff, visitors/customers and contractors (annually, monthly, weekly and daily)
- energy management — assessed by internal staff, consultant and contractors (monthly, annually, quarterly and weekly).

Measurement metrics and particularly KPIs should be tempered by the corporate objectives and culture. For iconic facilities, and specifically PACs, this may require reference to the mission or vision, or issues such as the "six areas of key performance for arts centres: recognition for excellence, value for money, pride in a key symbol, 'the experience', artistic and industry development, and access and equity" (Radbourne 1998).

Table 6   Performance benchmarking areas used in the current implementation of benchmarking stream

Key performance areas	Status drivers	Benchmarking framework
1. Recognition for excellence	1. Functionality	1. Condition assessment
2. Value for money	2. Landmark status	2. Energy management
3. Pride in a key symbol	3. Operational efficiency	3. Accessibility
4. The experience	4. Cultural heritage	4. Contractor's performance
5. Artistic and industry development		
6. Access and equity		

It is noted that different organisations and/or facilities (even different PACs) have different levels of sophistication and development in performance measurement systems for FM. Given the wide variation in roles, missions (for example, the focus may be financial in some but artistic in others) and facilities portfolios, it is not surprising that there are variations in FM systems.

Further research on the FM Exemplar Project outputs would assist in developing a broader FM benchmarking framework which could have applications to other facility types and benefit the FM industry and the community at large.

Courtesy of Sydney Opera House, Australia — international benchmarking survey participant

3. Information alignment

3.1 Alignment of information in the FM process

The digital modelling team in the FM Exemplar Project has investigated the feasibility of using a standardised digital model that incorporates IFC for the integration of FM information to support collaborative FM activities and processes. Having demonstrated successful outcomes of the digital model the team recommended that the Sydney Opera House should use a set of guidelines to help in adopting digital modelling for FM.

FM as a business enabler extends the digital modelling research findings to outline:

- its support of the activities and information dependency across the enterprise and the TAM Plan in the information hierarchy
- the integration of the modelling of building, FM and performance as a whole to support service delivery.

3.2 Modelling of building, FM and performance information

As Figure 8 shows, performance information is supported through the development of building condition index KPIs and service provider performance KPIs, which are compared against actual performance data and benchmarking information to identify gaps. Performance Information in turn provides the information necessary for FM operational requirements including procurement information relating to service providers, building information, and maintenance and service information.

FM operational information in turn supports the FM planning information required for operational and capital expenditure maintenance tasks and projects, and associated budget information. FM planning information is itself a vital component of the Strategic Asset Maintenance (SAM) Plan which contributes to the TAM Plan.

The TAM Plan itself is built upon a set of collaborative activities comprising investment planning, asset design, KPI monitoring, risk assessment, asset decommissioning and disposal planning, and monitoring of levels of FM streams.
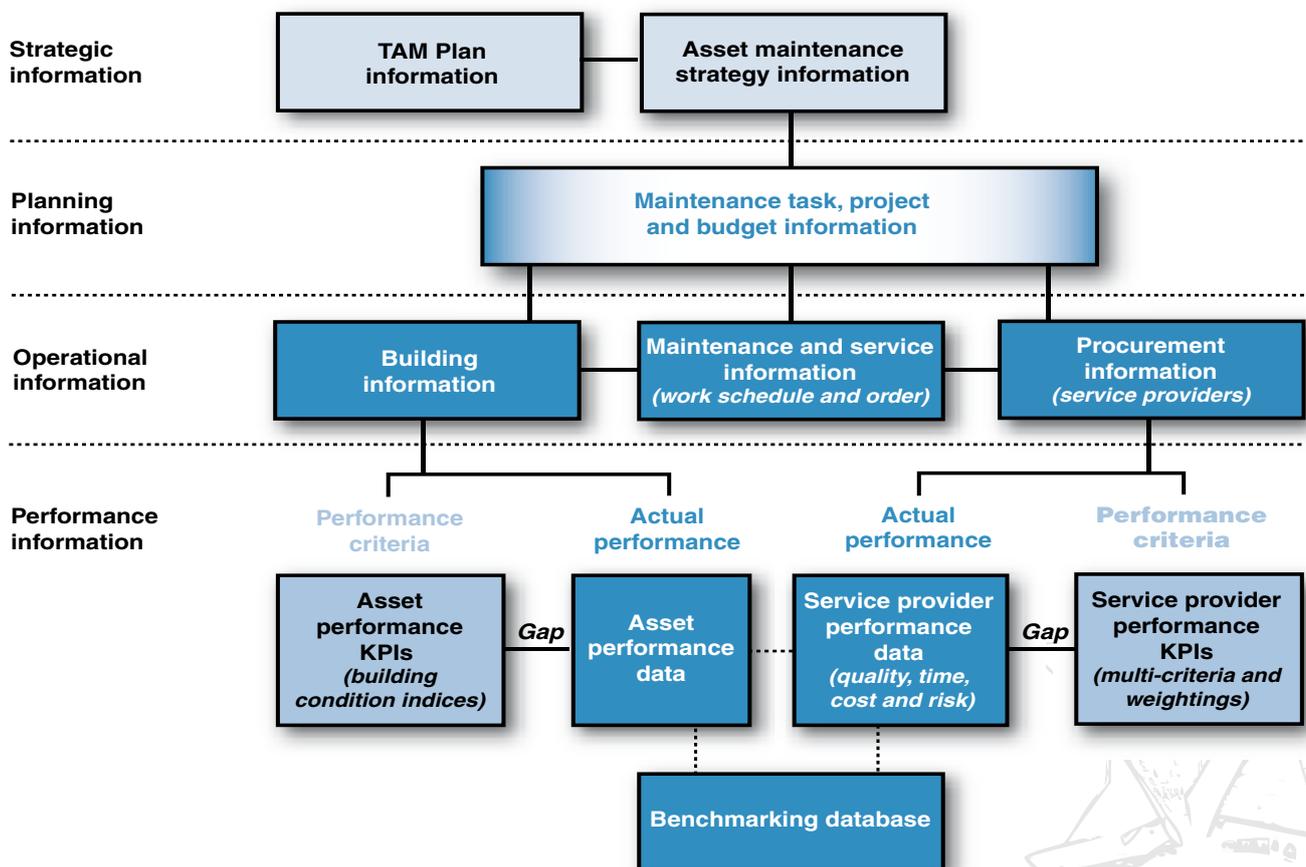

Figure 8   An integrated hierarchical information model to support the TAM process

In order for TAM to operate as an integral component of the organisation's hierarchical system of information, the key areas of information needed are:

- performance information and KPIs across all levels

- knowledge of asset dependency and trends

- condition assessment information

- inventory of investment, budget and finance

- information about resources

- the ability to transition TAM Plan information to the management of FM streams at all levels, in order to align with organisational objectives, and to close the information loop for continual improvement.

Maintenance management and operational information

FM, and specifically the maintenance role, can be optimised by using standardised procedures for tracking all maintenance projects and tasks, allocating time and resources for jobs, addressing financial shortfall (or prioritising) with respect to budget, and identifying best value selection of procurement routes for outsourcing services.

The key areas of information and information applications required by the maintenance management and operational processes are:

- visualisation of the management of infrastructure, asset, space and furniture

- historical maintenance services data, cost and service providers

- generation of real-time reports of ongoing activities projects and task data

- work order generation and work prioritisation

- tracking of scheduled and unscheduled maintenance activities

- tracking of work orders

- tracking of capital and labour cost

- asset registers

- lifecycle project information.

The lifecycle project stores information and data related to the lifecycle management of a maintenance project, and includes the total lifecycle cost of the maintenance project, and the aspects of operability and quality. The lifecycle maintenance project information enables management to measure the impact of a decision affecting the project as whole.

These information-capture activities are mostly supported by the IFC model for data integration. The resulting information obtained can therefore be integrated and aligned to support TAM, the integrated FM solution and ultimately organisational objectives.

Courtesy of The Scottish Parliament, Scotland — international benchmarking survey participant

3.3 Integrated FM solution model through information alignment

Figure 9 presents a model proposed for an integrated FM solution, focussing on the alignment of FM information with business process requirements, and the mining of data for further analysis and processing into information for supporting management decision-making.
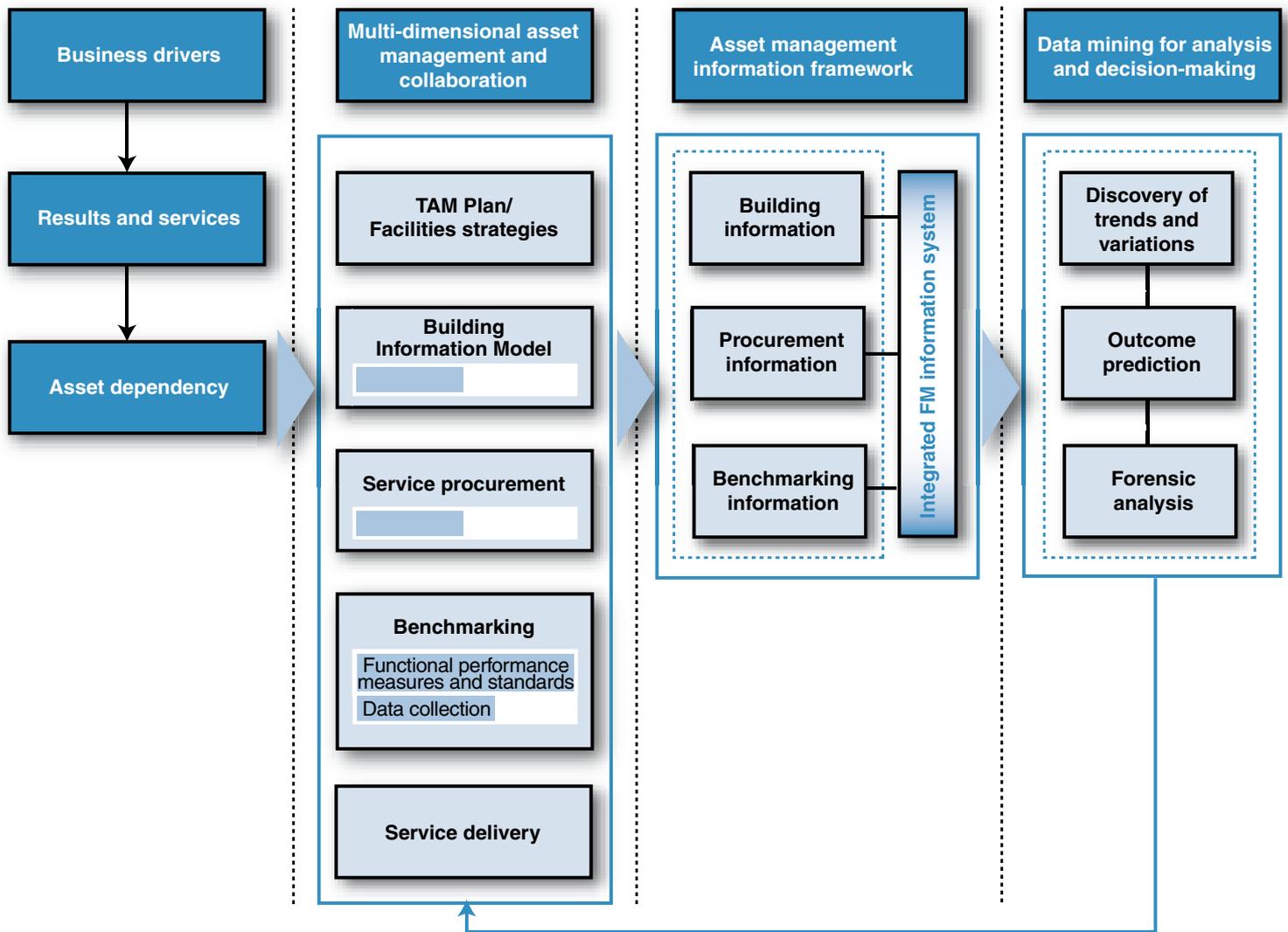
Figure 9   Integrated FM solution model through information alignment

Data mined from the Integrated FM Information System (which is supported by building information, procurement information and benchmarking information streams) is collated and analysed to establish lead indicators that impact firstly on service delivery and its contribution to TAM and facilities strategies, and ultimately contribute to organisational objectives. While business drivers still dictate the criteria and strategies used down the information chain, it is the ability to integrate the data into usable information that completes the continuous performance improvement loop.

While the generic framework developed demonstrates its value in aligning information with corporate objectives for the FM industry, further development would be required to achieve a comprehensive solution.

4. Performance alignment

4.1 Performance alignment with business drivers

Performance is regarded as a key measure of any system. Performance assessment plays an important role in the overall asset management process and determining service levels for the organisation. This section develops performance alignment by following the routes below:

- establishment of integrated performance measurement
- defining measurable, reliable and informative KPIs
- alignment of KPIs with business drivers
- use of benchmarking for developing and monitoring performance targets.

4.2 Establishment of integrated performance measurement

Where business drivers can be translated into a hierarchy of performance metrics a powerful strategic FM service delivery framework would result. The hierarchy is in a form of mapping, namely, operational level performance measurement aligned with strategic level performance targets. These measurements

are used as monitors or feedback to corporate planners, facilities managers and operators, to allow them to report the real impact of actions at specific and overall performance levels.

Sydney Opera House has developed a set of hierarchical performance measures across the range of its business activities, including KPIs for corporate services, asset status and service providers.

The integrated hierarchical performance measurement at Sydney Opera House provides benefits of overall performance control for management (see Figure 10).

4.3 Developing key performance indicators (KPIs)

KPIs are developed to capture the most critical business drivers to measure and monitor performance. The challenge is to develop a set of informative, measurable and reliable KPIs and manage them in a hierarchy to provide an overall picture of performance for the organisation.

Figure 11 presents a pathway for developing KPIs and aligning with business drivers. Based on the service delivery needs, performance targets are set to monitor which performance outcomes are to be achieved. The performance targets are then managed into a hierarchy such as, for example, performance targets for corporate assets, facilities performance and service provider performance. Measurement, reliability and information are considered to be the key factors in defining and implementing KPIs to provide decision support to management.
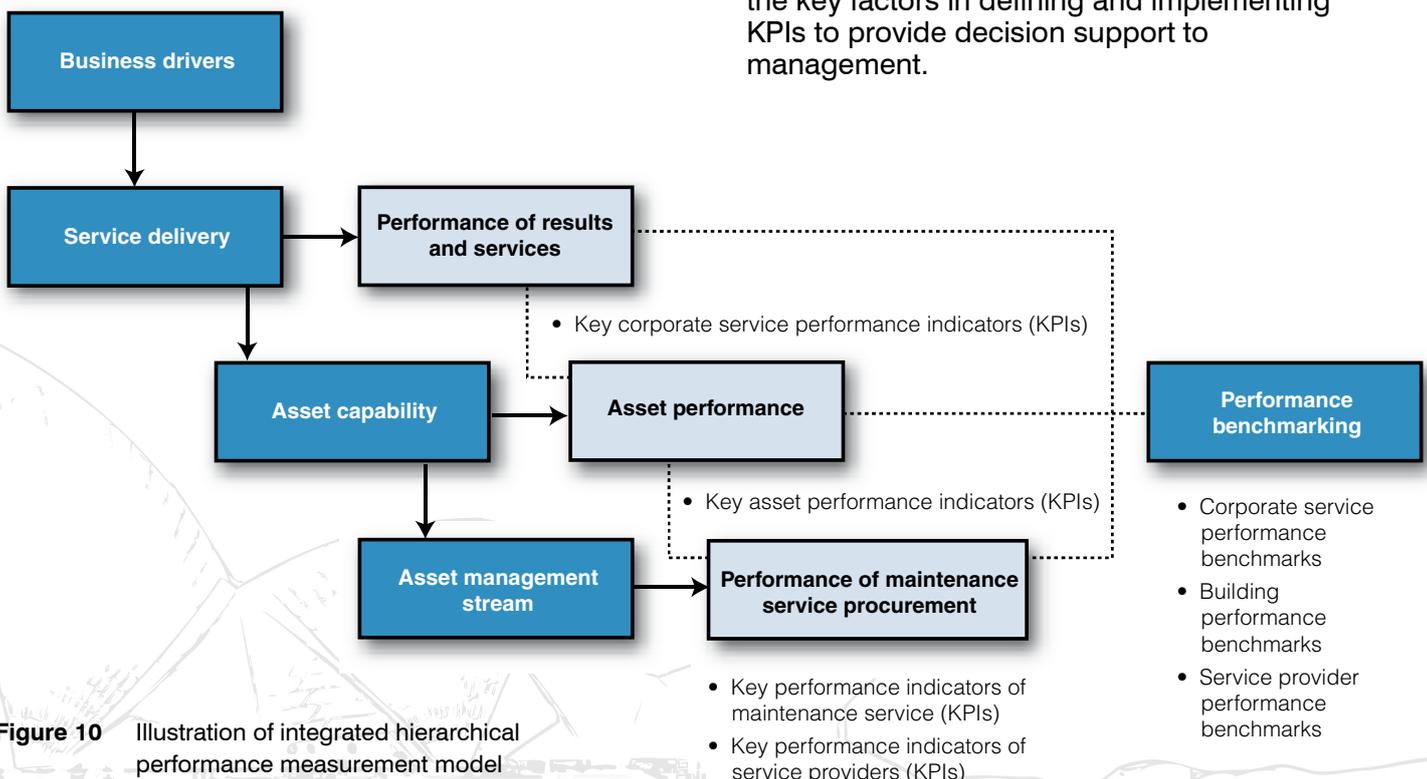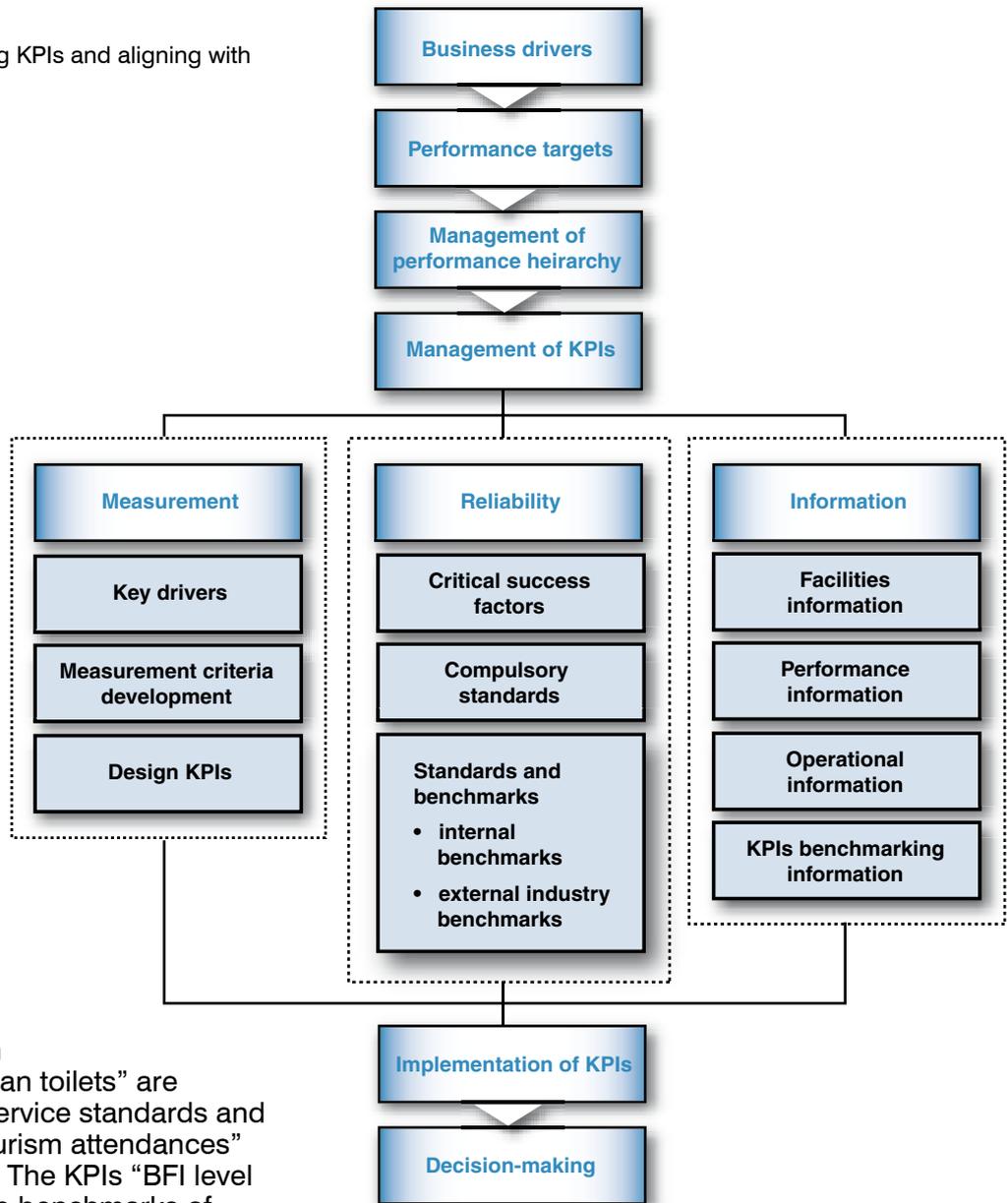

Figure 10   Illustration of integrated hierarchical performance measurement model

Figure 11   Pathway for developing KPIs and aligning with business drivers


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                    │  Business drivers   │
                    └─────────────────────┘
                              ↓
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                    │ Performance targets │
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                    │   Management of     │
                    │ performance heirarchy│
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                    │  Management of KPIs │
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Measurement	Reliability	Information
Key drivers	Critical success factors	Facilities information
Measurement criteria development	Compulsory standards	Performance information
Design KPIs	Standards and benchmarks • internal benchmarks • external industry benchmarks	Operational information
		KPIs benchmarking information

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                    ┌─────────────────────┐
                    │ Implementation of KPIs│
                    └─────────────────────┘
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                    │   Decision-making   │
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An example of the KPIs implementation at corporate performance level at Sydney Opera House is shown in Table 7, where the KPIs such as "Better signage" and "Clean toilets" are designed to reflect the key service standards and requirements to support "Tourism attendances" and "Customer satisfaction". The KPIs "BFI level is raised" has a linkage to the benchmarks of Building fabric performance.

Table 7   An example of corporate level performance measures at Sydney Opera House

Service group	Service standards	Service results	Examples of performance indicators
Tourism services	• Tourism attendances • Customer Satisfaction Index	• Increased attendances • Customers satisfied	• Better signage • Clean toilets
Security	• Security incidents • Customer Satisfaction Index	• Customers feel safe	• Increase in visitors
Presentation and preservation of the Sydney Opera House	• Building Fabric Index	• Building preserved and in good order	• BFI level is raised

4.4   Integrated FM solution model through performance alignment

Figure 12 presents a model proposed for an integrated FM solution. It focusses on the alignment of performance at different levels to support business needs and service delivery requirements.
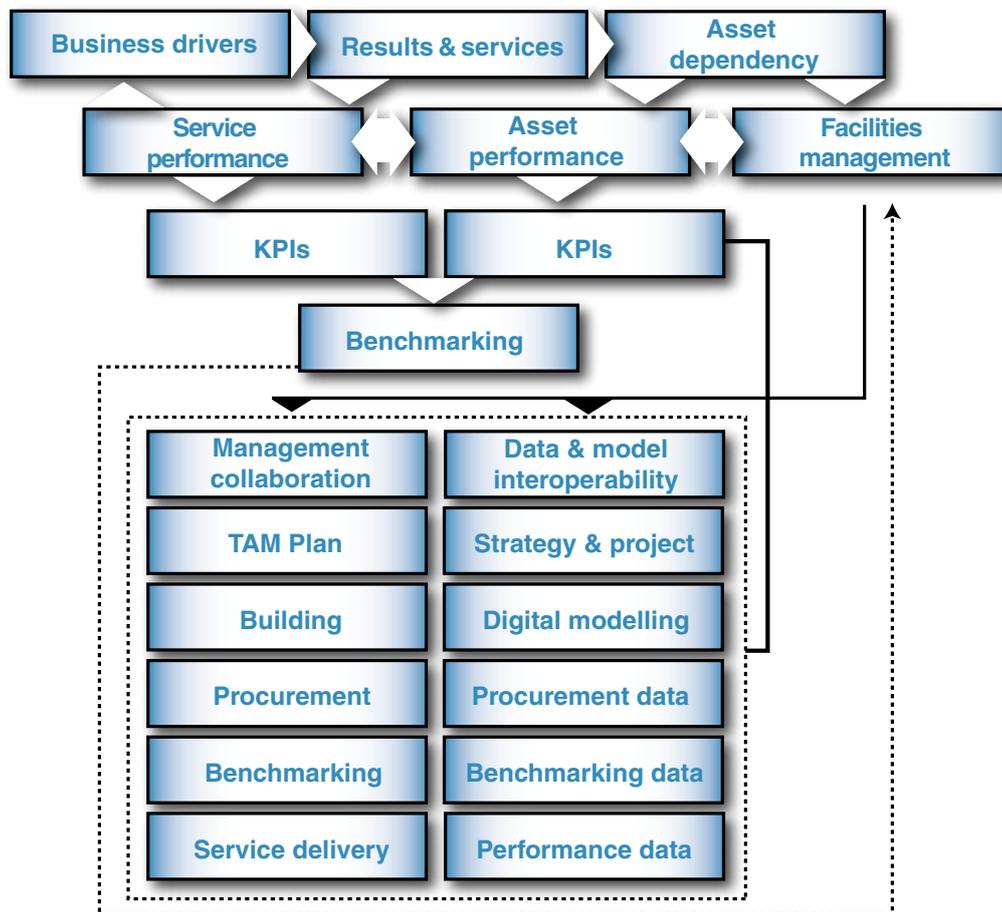

Figure 12   Integrated FM solution model through performance alignment

The model identifies business drivers, results and services, asset dependency, FM and collaboration against FM service delivery. The performance requirement at each level is defined against specific business needs.

Business drivers ultimately dictate the criteria for the Results and Services Plan, which in turn provides targets for the management of assets and provision of service delivery to support them.

Benchmarking provides a useful tool to examine how assets are managed over time or through a comparison with similar assets, against internal KPIs. They provide feedback to facility and asset managers for refining the selection of procurement methods and for identifying asset management gaps. While internal benchmarking examines *historical* data for performance measurement, external benchmarking collects data from a group of peers for *comparative* performance measurement.

This model demonstrates the alignment of the performances with the organisation's overall business objectives, and can be used to allow FM to address the disparity between actual performances and good practice targets, relative to the organisation's business objectives.

5. Project outcomes

5.1 Conclusions

The complexity inherent in modern FM systems and processes quite often equates to disparate information systems that require heavy manual input in order to produce the information collectively required from them for the effective execution of management. In these circumstances the integration of information management systems, rather than the traditional "silo" style approach of handling information, play a pivotal role in information provision for organisational decision-making and processes.

At the same time, the integration of these information systems assists facilities managers to better manage what has always been a diverse portfolio of responsibilities.

Using Sydney Opera House as a case study, this publication outlines an integrated FM solution model that uses the assimilation of information from the Digital modelling, Procurement and Benchmarking reports to refine service delivery standards and the criteria used in the procurement process.

The TAM Plan of Sydney Opera House is introduced to provide a context for integration of the three streams developed by the FM Exemplar Project, and sit within the framework of the SAM Plan.

The integrated FM solution model establishes the relationship between business drivers, the TAM Plan and FM streams. Business drivers lead to an asset strategies and service plan, while asset dependency bridges the asset groups with the dependent services. FM streams in turn are managed in an integrated approach to provide support to service delivery.

The integrated FM solution model demonstrates the need for alignment of information, services, and performances in order to support organisational objectives and business activity.

The development of information alignment combines the findings from digital modelling research and extends it towards a generic framework for the FM industry. It suggests the following routes for development of information alignment:

- identify FM activities and information dependency in the FM process

- provide an integrated information environment through the development of integrated models for building data, FM data and performance data

- provide an integrated platform through using IFC for information exchange and interoperability for supporting collaborative FM activities and processes

- provide decision support by using data-mining techniques to produce information, allowing facilities managers to capture emergent issues and learn from experience.

Alignment of performance is developed through translating business drivers into a hierarchical performance metric and building the linkage between performances at multiple levels. It suggests the following for the development of performance alignment:

- establish a hierarchical services delivery assessment model

- development of a range of high-level KPIs

- use performance benchmarking protocols to address disparities between the organisation and good practice targets.

Although a digital model may be considered as an independent concept, in practice, the business benefits are dependent on the shared use and value-added creation of an integrated FM model. Sydney Opera House's experience demonstrates that it is possible to apply the principle of interoperability and commence implementation of a digital model for even the most complex of facilities. Internationally, the digital modelling concept with an open IFC specification has been shown to be an appropriate and beneficial technology, enabling storage and retrieval of integrated FM data linked to performance measures that in turn support business objectives.

Regardless of whether dealing with iconic facilities or not, if facilities are to be more than a business cost centre to be minimised, FM must focus on delivering value, through quality service and improved utility based on efficient information systems. This is the essence of the FM Action Agenda's vision that "the Facilities Management industry will be the foremost contributor to a productive and sustainable built environment through excellent and innovative management of facility services". Using the Sydney Opera House, the FM Exemplar Project will contribute to the recognition of the importance of improved innovation, education and standards.

5.2   Future developments

While Sydney Opera House has been the focus of the FM Exemplar Project, the research findings and frameworks are intended to be applicable to other facilities and service streams.

The FM Exemplar project team's recommendations are that future research should cover, but not be limited to, the following main actions:

- Develop data collection from other facility types and FM streams.

  Sydney Opera House has provided the case study for digital modelling, services procurement and performance benchmarking in developing an integrated FM solution model. The case study can be extended to include a broader range of public and private sectors with similar core business or FM functionalities.

- Expand the integrated FM solution model for broader FM industry application.

  While the integrated FM solution model focusses on the experience of Sydney Opera House, a collection of the experience from other sectors will expand the model towards broader FM industry application.

- Continue to develop performance benchmarking and collection of benchmarks across all service levels.

  Collecting performance benchmarks across all service levels provides a significant support for developing focussed KPIs and standards for organisations such as Sydney Opera House. Ultimately the use of appropriate KPIs may have an impact on the selection of the services procurement route.

- Implement the integrated FM information system and use data-mining techniques to provide an integrated support for decision-making.

  A future implementation for the integrated FM information system will capture and store the hierarchical performance information to support the procurement processes.
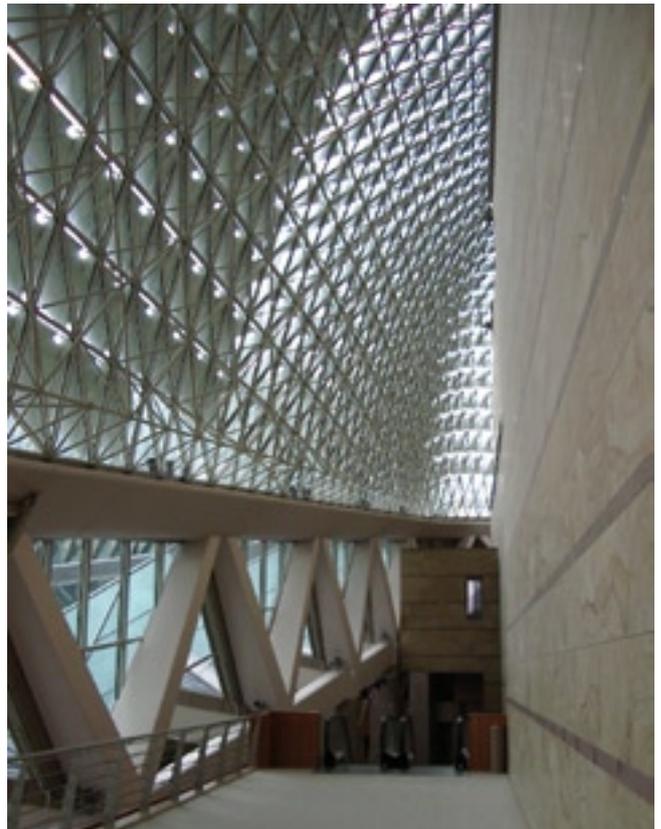
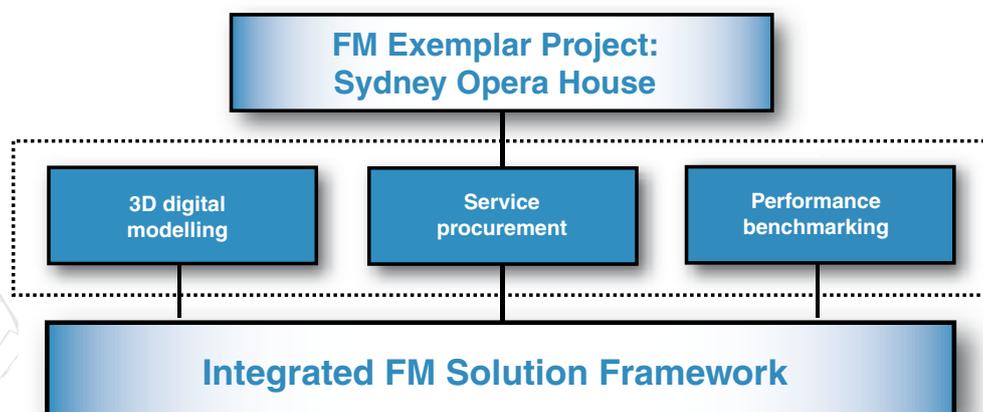The Esplanade — Theatres on the Bay, Singapore — international benchmarking survey participant

Figure 13   Illustration of a scenario of a future integrated FM system based on the integration of information resources as demonstrated by this project

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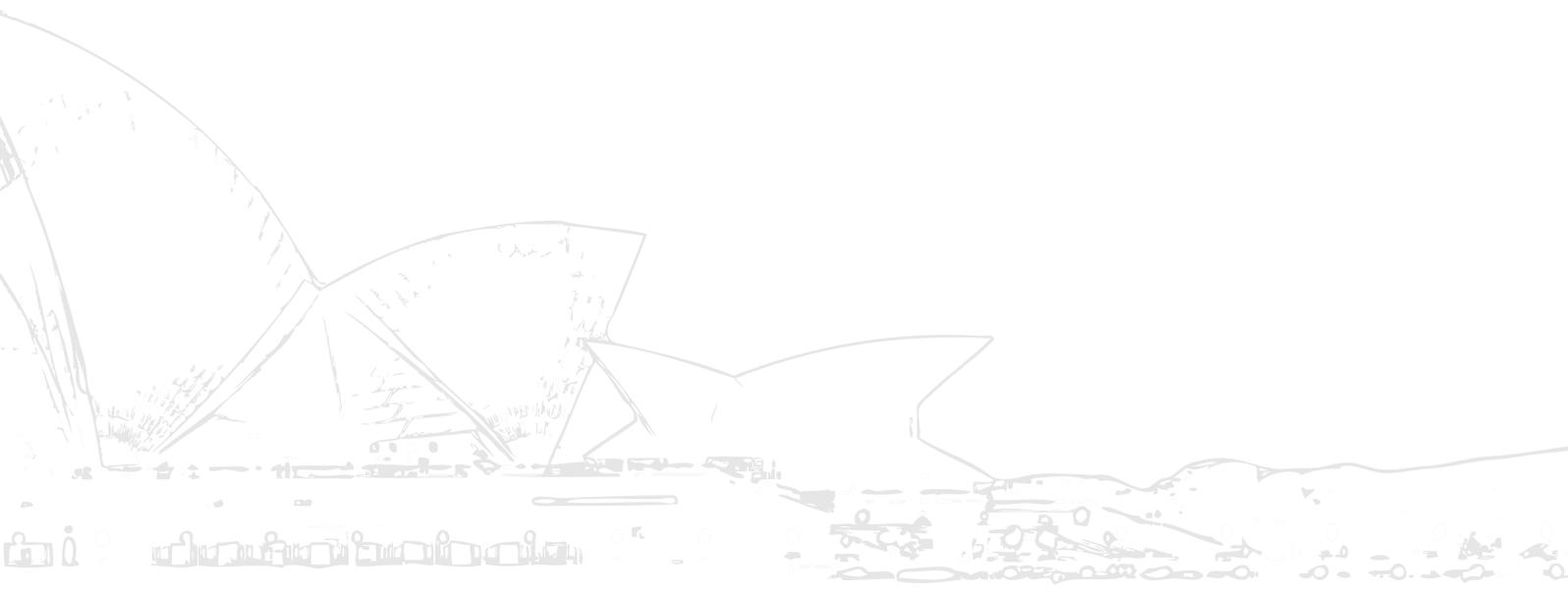
FM as a business enabler

Sydney Opera House is recognised throughout the world as a building icon of 20th century architecture. The Cooperative Research Centre (CRC) for *Construction Innovation* and the Australian Government's FM Action Agenda chose this iconic symbol as the focus of its Facilities Management (FM) Exemplar Project and partnered with industry, government and research to develop innovative strategies across three research themes.

1. *Digital modelling* — developing a building information model capable of integrating information from disparate software systems and hard copy, and combining this with a spatial 3D computer-aided design (CAD)/geographic information system (GIS) platform. This model offers a visual representation of the building and its component elements in 3D, and provides comprehensive information on each element.

2. *Services procurement* — developed a multi-criteria performance-based procurement framework for FM service delivery

3. *Performance benchmarking* — developed an FM benchmarking framework that enables facilities/organisations to determine key performance indicators (KPIs) to identify best practice and improvement strategies.

This project provides a broad range of practical input from client, consultants and service providers. The project's outcomes will in turn support the industry's FM Action Agenda. The innovative methods delivered by this project should be implemented across the FM industry at the strategic, management and operational levels.

Further research on the FM Exemplar Project outputs would assist in developing a broader application of the integrated FM solution to other facility types and benefit the FM industry and the community at large.

This executive summary is also available.

For copies of this industry publication and/or its executive summary go to
www.construction-innovation.info or contact:

Cooperative Research Centre for *Construction Innovation*
9th Floor, Level 9, QUT Gardens Point
2 George Street, Brisbane, Qld, Australia 4000
Telephone: +61 7 3864 1393
Email: enquiries@construction-innovation.info