Digital Asset Information Management (DAIM): *A Guide and Manual*

Final Industry Report, Project 2.51

Developing a Cross-sector Digital Asset Information Model Framework for Asset Management

October 2018

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Sustainable Built Environment National Research Centre

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SBEnrc Core Members

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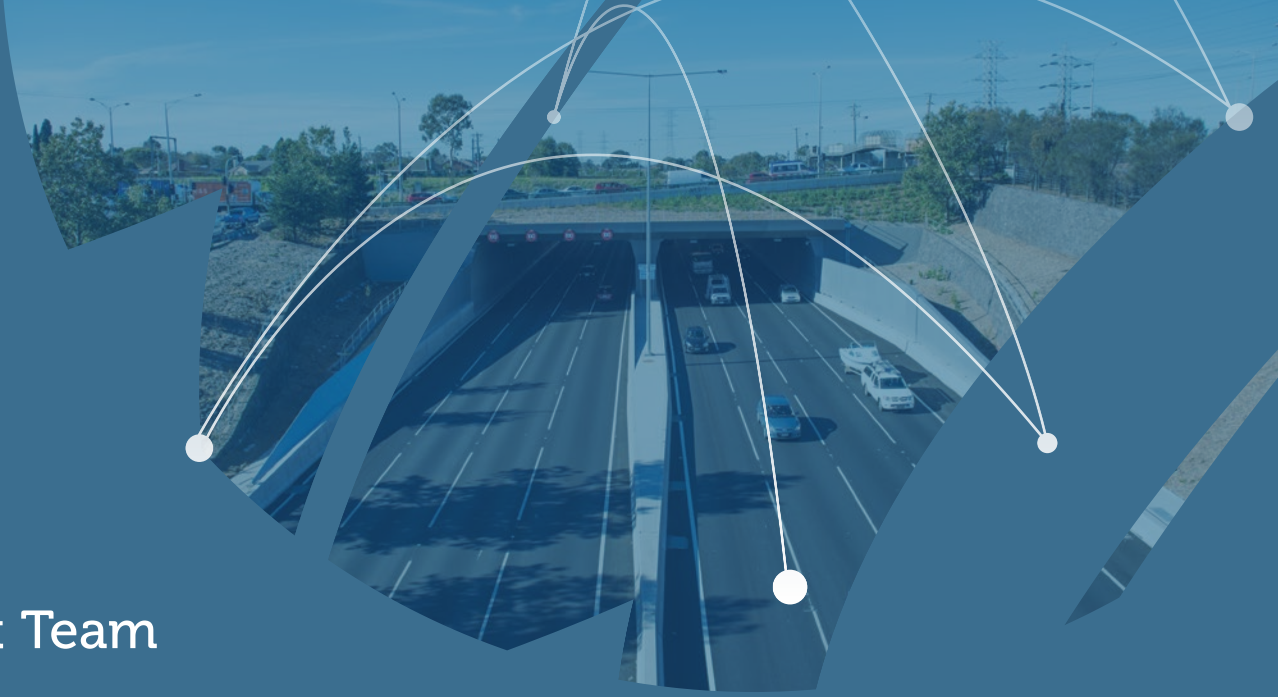

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Preface

The Sustainable Built Environment National Research Centre (SBEnrc), the successor to Australia's Cooperative Research Centre (CRC) for Construction Innovation, is committed to making a leading contribution to innovation across the Australian built environment industry. We are dedicated to working collaboratively with industry and government to develop and apply practical research outcomes that improve industry practice and enhance our nation's competitiveness.

We encourage you to draw on the results of this applied research to deliver tangible outcomes for your operations. By working together, we can transform our industry and communities through enhanced and sustainable business processes, environmental performance and productivity.

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Executive Summary

Asset management is the systematic process of deploying, operating, maintaining, upgrading and disposing of built environment assets. Effective asset management requires the involvement of all levels of an organisation in planning, control and monitoring of asset performance that combines management, financial, economic and other activities and practices.

Over the past decade, Building Information Modelling (BIM), as an intelligent 3D model-based process to inform and communicate project decisions, has received much attention in the design and construction stages of buildings and transport infrastructure. However, the use of BIM for asset management has only recently been recognised in terms of its benefits to managing assets when using 3D models.

This SBEnrc Project 2.51 initially focussed on a comprehensive review of current digital asset management practices in order to promote BIM and other digital engineering technologies for more effective use in informed asset management decisions. This was done for the four core areas of asset data exchange, asset classification, asset location referencing, and asset information requirements. Following the review of current practice, this *Digital Asset Information Management: A Guide and Manual* was developed to assist in the increased uptake of digital asset management across the housing, building and transport infrastructure sectors.

This report is one of a suite of three reports generated within Project 2.51 "Developing a Cross-sector Digital Asset Information Model Framework for Asset Management". Its purpose is to present material that will be used directly by industry practitioners in increasing the level of use of BIM-based technologies in the implementation or improvement of asset management systems within their organisations. The other reports are:

- The *Digital Asset Information Management: Research Report* which provides material that was used during the project to inform and support the preparation of this report and the Case Studies report. The information provided therein is likely to be of more interest to academics and researchers so that they can more fully understand how the material in the other reports was developed.
- The *Digital Asset Information Management Case Studies* report which presents a range of scenarios across residential and building facilities and transport infrastructure. This is intended to provide an overview of existing asset management practices to inform industry of the possibilities and to provide background for strategic planning of asset management uptake.

This *Guide and Manual* was developed to provide advice on the transition to digital asset management across the housing, building and transport infrastructure sectors. It is targeted at personnel involved in the implementation of asset management. The report covers the process of establishing or reviewing an asset management system through consulting stakeholders on the information that is already available and the results required from the asset management system. The methods of gathering the information required to move from the current state of knowledge about assets to a full system are covered, from

the worse-case scenario of not having any reliable data, through the use of traditional 2D contract documentation, retrieving data from poorly structured BIM files, through to well defined and managed BIM to meet the full asset requirements. Issues around staging this process are also discussed, as this may assist in effective implementation.

The use of BIM for asset management lags behind other BIM-based initiatives in the building and infrastructure supply chain. A number of other asset management projects commenced while this project was underway. They were focussed on particular asset types and hence provided useful inputs to the work within this project in defining a comprehensive cross-sector model. The scope of this project was deliberately focussed on housing, buildings and transportation infrastructure – sectors of particular interest for SBEnrc's industry partners. An immediate need is to expand the coverage of the work in this project to other types of infrastructure assets.

The results of the initial stages of 'full BIM' asset management systems are also beginning to be discussed. BIM tools to support asset management are subject to rapid evolution. This evolution also needs to be monitored. In the medium term, further work is also required on how asset management as a discipline adapts to the availability of digitally rich information. We cannot claim that we have been genuinely innovative within asset management until the necessary human processes have adapted to maximise the return on investment in BIM for asset management. This should also cover defining and then providing non-competitive information that should be shared across the architecture, engineering and construction sector to improve our entire industry.

Along with the associated Case Studies report, this Guide and Manual will aid in the wider adoption and consistent curation of digital information for maintaining and operating assets across the built environment supply chain, improving the efficiency of managing community assets, the return on investment, and sustainability, resilience and safety.

1. Introduction

This Digital Asset Information Management: A Guide and Manual is one of three documents produced by SBEnrc Project 2.51 *Developing a Cross Sector Digital Asset Information Model Framework for Asset Management*[1] (as shown in Figure 1). The three documents are complementary:

1. Digital Asset Information Management: Research Report
2. Digital Asset Information Management: A Guide and Manual (this document)
3. Digital Asset Information Management: Case Studies

This document is intended as a 'users' guide' to the implementation of BIM as the basis for digital asset management. It does not cover the significant background material that people new to this process will need. This in-depth and background information is provided in the *Research Report*. The *Case Studies Report* describes a number of housing, building and transport infrastructure assets and explains the processes followed by the project's industry partners to capture asset information and recommendations for the future.

This document covers the following:

1. The strategic processes that are recommended before embarking on the implementation of a digital asset information management system, or in linking BIM-based processes to an existing asset management system;
2. Capturing information on assets for which no documentation exists;
3. Capturing asset information from 'traditional' documentation deliverables (drawings, specifications, manufacturers' literature, etc.);
4. Adapting existing BIM models that were generated without considering how the asset data could be extracted; and
5. Using BIM to automate the digital asset management process.

This report serves as both a guide and a manual. Section 2 *Implementing BIM-based Asset Management* provides a manual for users, while other sections serve as a guide for asset managers to better prepare.

Figure 1 summarises a number of influential Australian initiatives and SBEnrc research projects relevant to the digital transformation of housing, building and infrastructure. For instance, *The Digital Canberra Action Plan 2014-2018* provides a platform for identifying and promoting how business, the community and the government can diversify the digital economy and deliver more efficient, faster services. *DIGITAL1ST: Advancing our digital future* is the Queensland Government's strategic direction to position Queensland as a leader in digital government now and in the future.

SBEnrc's digitalisation research journey has been ongoing since 1996, through its predecessors, first the Construction Research Alliance and then the Cooperative Research Centre for Construction Innovation. In 2012, SBEnrc *Project 3.28: National BIM Guidelines and Case Studies for Infrastructure* paralleled the CRC's landmark document of 2009, *National Guidelines for Digital Modelling (Buildings)*. Other SBEnrc Projects, 1.45, 2.24, 2.34, 2.46 and 3.48, continued this journey by integrating big data and other digital technologies. This SBEnrc Project, 2.51, with an overarching approach across housing, buildings and transport infrastructure, sought to develop a digital asset information management guide and manual to support the operation and maintenance of key assets. It has determined enabling information management technologies and developed a framework for capturing, structuring and exchanging asset information digitally, while taking into account its classification and practical uses.

[1] SBEnrc P2.51: https://sbenrc.com.au/research-programs/2-51/

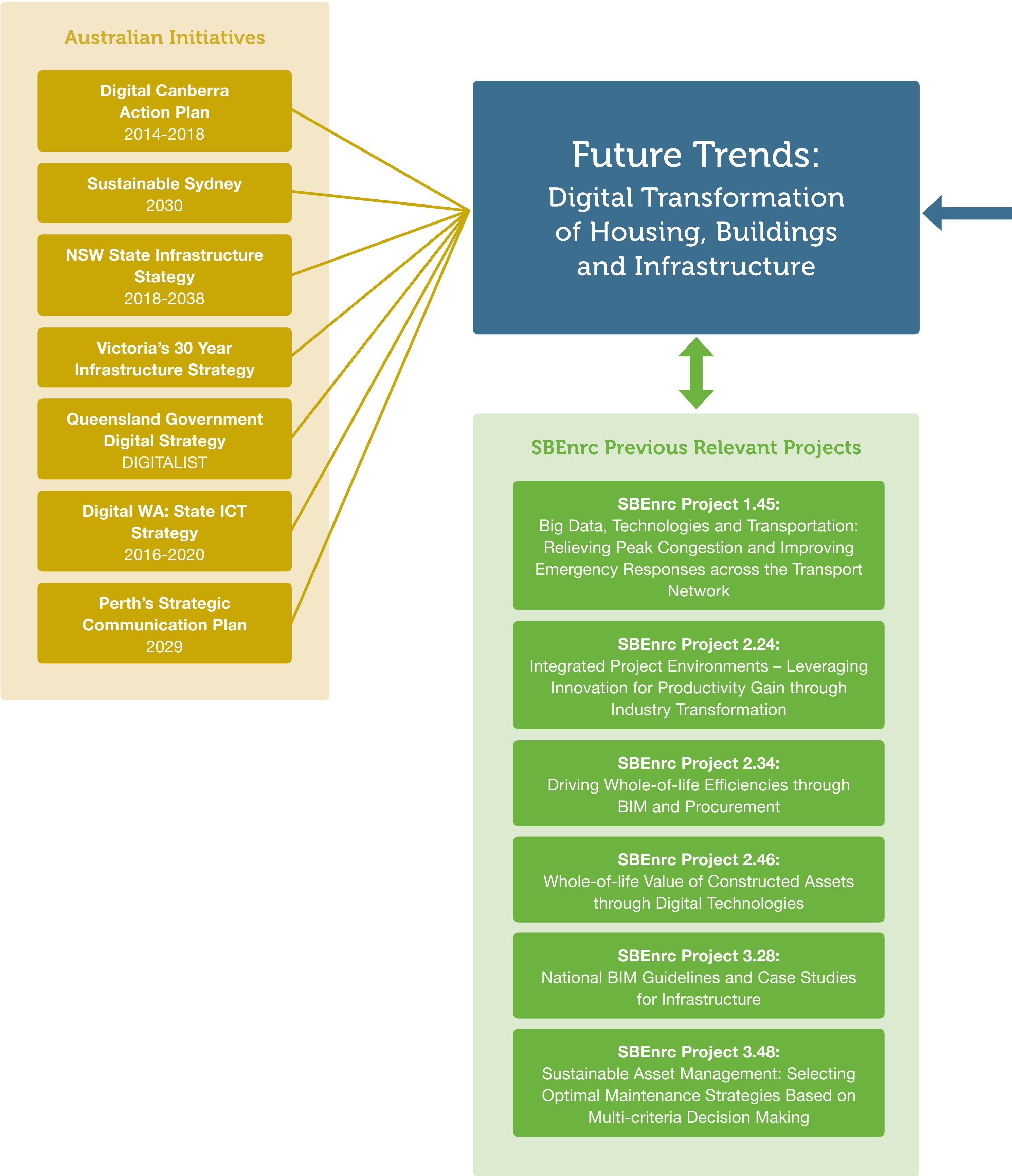
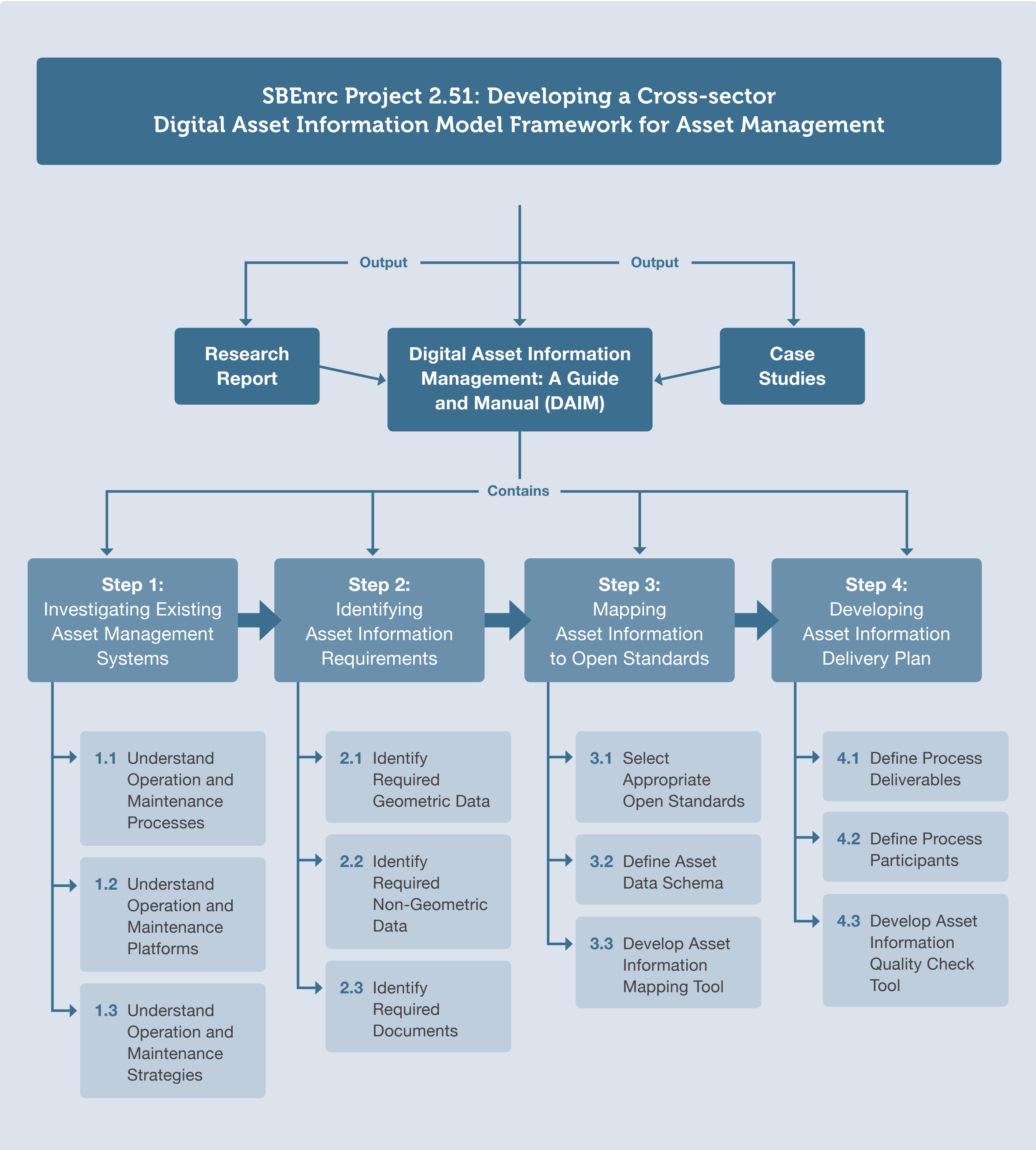


Figure 1: Overarching process chart


SBEnrc Project 2.51: Developing a Cross-sector
Digital Asset Information Model Framework for Asset Management
Output
Output
Research Report
Digital Asset Information Management: A Guide and Manual (DAIM)
Case Studies
Contains
Step 1: Investigating Existing Asset Management Systems
Step 2: Identifying Asset Information Requirements
Step 3: Mapping Asset Information to Open Standards
Step 4: Developing Asset Information Delivery Plan
1.1 Understand Operation and Maintenance Processes
1.2 Understand Operation and Maintenance Platforms
1.3 Understand Operation and Maintenance Strategies
2.1 Identify Required Geometric Data
2.2 Identify Required Non-Geometric Data
2.3 Identify Required Documents
3.1 Select Appropriate Open Standards
3.2 Define Asset Data Schema
3.3 Develop Asset Information Mapping Tool
4.1 Define Process Deliverables
4.2 Define Process Participants
4.3 Develop Asset Information Quality Check Tool

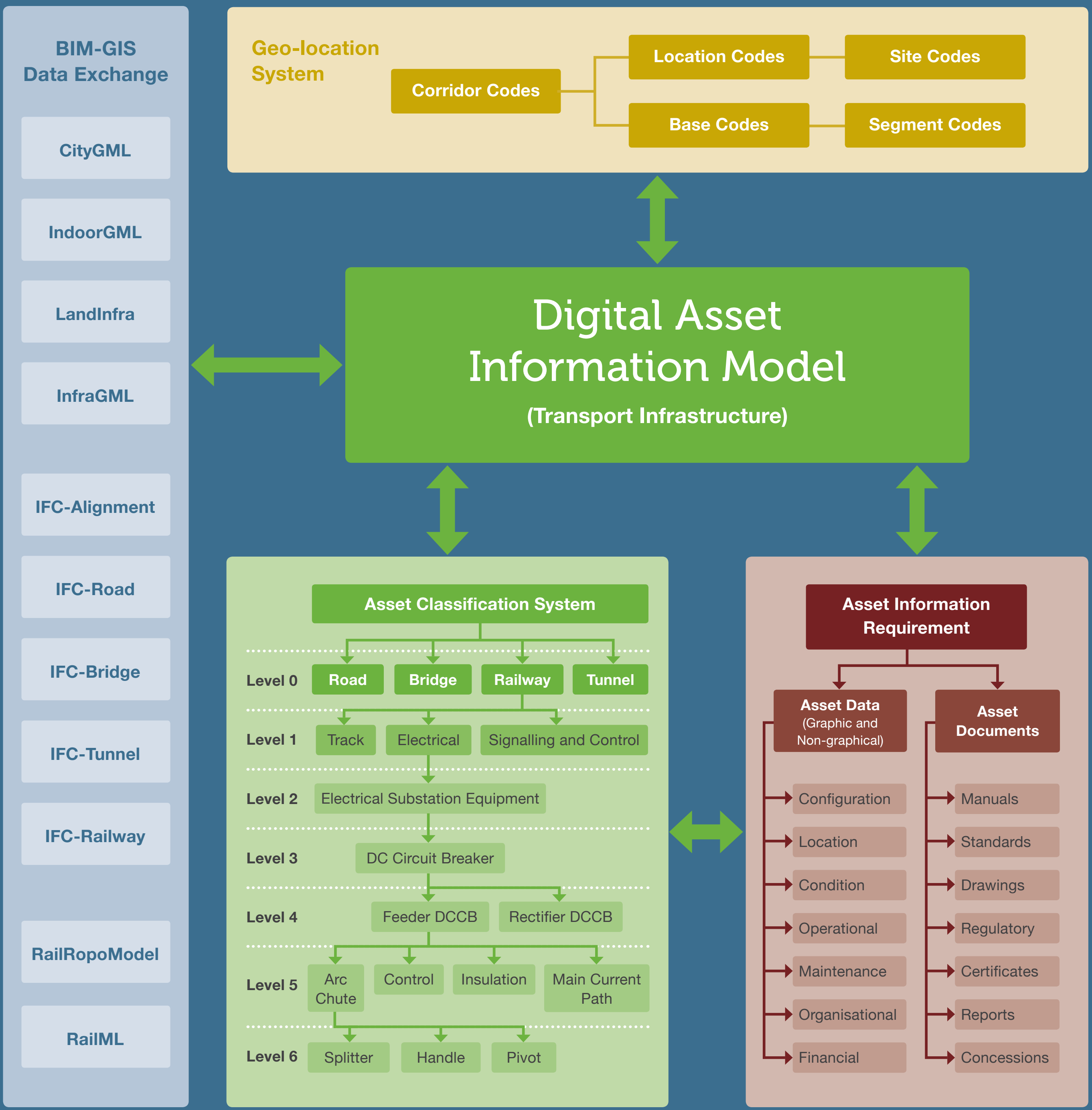


Figure 2: The framework developed for a Digital Asset Information Model (shown here for transport infrastructure)

2. Implementing BIM-based Asset Management

The purpose of this Digital Asset Information Management (DAIM): A Guide and Manual is to guide industry practitioners to efficiently:

1. define asset information requirements based on their business strategies;
2. collect asset information throughout project lifecycles; and
3. transfer collected asset information to their existing asset management systems.

This SBEnrc Project 2.51 research led to the development of the framework in Figure 2 for a Digital Asset Information Model for transport infrastructure. Housing and building assets have a similar structure to this.

The model includes four main modules:

1. Asset Information Requirement;
2. Asset Classification System;
3. Geo-location System; and
4. BIM/GIS Data Exchange.

A detailed explanation of these modules can be found in the project Research Report. For construction projects without a BIM/GIS implementation, the first three modules should be interlinked with each other to improve asset data searching and updating. For projects with BIM/GIS implementation, the first three modules should be linked/incorporated into the BIM/GIS Data Exchange platform.

In order to implement the Digital Asset Information Model Framework in practice, an overall workflow was developed, as shown in Figure 3.

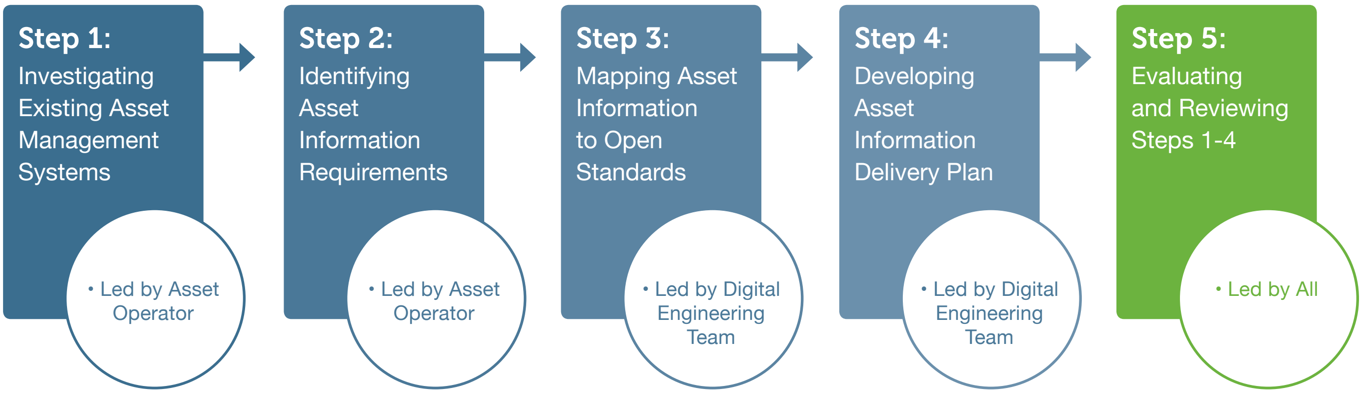


Figure 3: Workflow for implementing the Digital Asset Information Model Framework

2.1 **Step 1:** Investigating Existing Asset Management Systems

This step is focussed on investigating existing asset management systems that are used by asset operators. The purpose of the investigation was to:

- Understand the Asset Operator's current operation and maintenance processes;
- Understand the Asset Operator's current asset management tools or platforms including their functions, data inputs and outputs, and underlying data schemas; and
- Understand the Asset Operator's short-term and long-term asset management strategies.

The following summary is from a case study of a large Australian state government roads agency, VicRoads, conducted by the SBEnrc research team in partnership with staff from VicRoads (see P2.51 *Case Studies Report*[2]). The goal of VicRoads is to deliver social, economic and environmental benefits to communities throughout Victoria by managing the arterial road network and its use as an integral part of the overall transport system.

Document review, and internal interviews and workshops were conducted to help the research team understand VicRoads' current asset management practices.

Collected documents included:

- VicRoads organisation chart
- Design and construction specifications
- Asset management documents:
  - Pavement
  - Street lighting
  - Intelligent traffic system
  - Bridges
- Road design publications and standards

[2] https://sbenrc.com.au/research-programs/2-51/

Reviewed asset management tools and/or platforms included:

- vMap
- RAI: Road Asset Inventory system
- SCATS (Sydney Coordinated Adaptive Traffic System): an adaptive urban traffic management system that synchronises traffic signals to optimise traffic flow across a whole city, region or corridor
- STREAMS: an international award-winning Intelligent Transport System (ITS) that supports road authorities to help save lives, reduce congestion and make road networks safer
- AMCS (Asset Monitoring and Control System): a street lighting management system for electrical assets
- Connect: Financial System (formerly known as PARMS)
- RAS (Road Asset System): system for managing structural assets (bridges, gantries, noise walls etc.), including locations information and inspection reports
- Spreadsheets across various regions to document and manage most other road related assets, including pavements, drainage, traffic barriers, road side vegetation and furniture

Interviews and workshops held with VicRoads' departments included:

- VicRoads' Smart Journey Systems, Asset Management Team (ITS Asset Management)
- VicRoads' Smart Journey Systems, Delivery team (ITS Project Delivery)
- Network Design Services Team (VicRoads In-house Design)
- Asset Services (Corporate Asset Management)

Five main findings were found from the interviews, workshops and after reviewing the above data:

1. The data schemas used by the current asset management tools/platforms are various in terms of asset location referencing and asset hierarchy systems;
2. The asset data handover process is document-driven which is time-consuming, labour-intensive and prone to human errors;
3. Digital Engineering and BIM technologies are rarely applied;
4. There is a lack of well-defined processes for asset data quality checking and assurance; and
5. The Asset Information Requirement for each discrete or individual asset management tool/platform (i.e. RAI, SCATS, STREAMS and AMCS) is well-defined. However, there is not an integrated Asset Information Requirement developed which considers these various requirements and integrates for efficiency.

Further information on this VicRoads example can be found in the P2.51 Case Studies Report.

2.2 **Step 2:** Identifying Asset Information Requirements

This step is focussed on identifying and defining asset information requirements based on the results of Step 1. Asset information in this Manual is classified into two categories (as summarised in Figure 4): Data (geometrical and non-geometrical) and documents. Geometrical data describes an asset's actual geometrical attributes in terms of location (position and spatial). Non-geometrical data consists of configuration, condition, operational, maintenance, organisational and financial attributes.

Definitions of the data groups are as follows:

- **Location:** Location data contains physical and geospatial attributes;
- **Configuration:** Physical and functional data identify and provide static references of manufacturer details, asset construction, asset procurement and technical characteristics;
- **Condition:** Past and current condition data, such as information on residual life;
- **Operational:** Operational data related to usage, tonnage, restrictions and criticality;
- **Maintenance:** Data defining maintenance management and recording of activities;
- **Organisational:** Organisational data illustrates the framework referring to responsibilities of the owner, operator and maintainer;
- **Financial:** Financial data records costing of the whole project lifecycle from capital acquisition, operation and maintenance through to disposal.

The full suite of asset documents consists of manuals, plans, photos, drawings, models, certificates, licences and schematics.

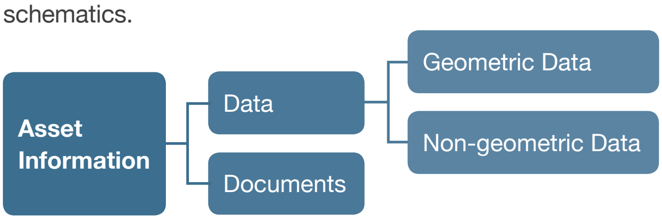


Figure 4: Asset information categories

The following summary is from a transport infrastructure case study of the Forrestfield Airport Link Project, Perth, Western Australia, (see P2.51 *Case Studies Report*) that illustrates a clear approach to identifying and defining asset information requirements:

1. Western Australia's Public Transport Authority (PTA) Asset Management Team developed 30 Asset Details (as shown in Table 1) that are required to be submitted by the design/construct contractors during project design, construction, commissioning and handover stages.
2. A series of Asset Information Templates were developed to facilitate the information handover, such as
   - *Asset Maintenance Information Template - Control System*
   - *Asset Maintenance Information Template - Traction Power*
   - *Asset Maintenance Information Template - Track and Structures*
   - *Asset Maintenance Information Template - Signals*
   - *Asset Maintenance Information Template - Overheads*
   - *Asset Maintenance Information Template - Facilities and Infrastructure, and*
   - *Asset Maintenance Information Template - Communications*

   Figure 5 illustrates the *Asset Maintenance Information Template - Traction Power* as an example.
3. These asset details and templates were checked and agreed by the project designers, contractors and suppliers.

No.	Asset Details
1	Asset Label/Tagging
2	BIM Globally Unique Identifier (GUID) Code (asset ID)
3	Contract/PO Number
4	Exact Location
5	Sub-location

No.	Asset Details
6	Manufacturer Details
…	
28	Completion Date
29	Commissioning Date
30	Warranty Expiration Date

Table 1: Condensed asset details list for Forrestfield Airport Link Project, Perth, Western Australia

ELECTRICAL TRACTION POWER MAINTENANCE BRANCH				
PROJECT NAME:			Enter Project Name Here	
Responsible Maintenance Branch	Code	Description	Description of Equipment Included	Applicable to Project Y/N
Elec. Traction Power	BZ	HV Bus Section	25KV Switchboard	
Elec. Traction Power	CA	Cable	Cable	
Elec. Traction Power	CB	Circuit Breaker	Circuit Breaker	
Elec. Traction Power	CF	Current Transformer	Current Transformer	
Elec. Traction Power	CY	Circuit Breaker Bay	Bay (EG. SUMTF1)	
Elec. Traction Power	EE	Electification System	Electification System	
Elec. Traction Power	FD	Feeder Station	Feeder Station	
Elec. Traction Power	IE	25KV Isolator/Earth Switch (Traction)	Bus Section Isolator, 25KV Isolator, Earth Switch, 25KV Bus Riser	
Elec. Traction Power	IH	132KV Isolator (Traction)	Earth, Isolator	
Elec. Traction Power	RY	Relay (IED)	Relay (IED)	
Elec. Traction Power	SU	Sub Station	Sub Station	
Elec. Traction Power	SV	Static VAR Compensator	Static VAR Compensator	
Elec. Traction Power	TI	Track Section Cabin (TS)	Track Section Cabin	
Elec. Traction Power	TV	Rail Traction Transformer	Spare Transformer, Trans Volt, Transformer	
Elec. Traction Power	VF	Voltage Transformer	Voltage Transformer	

Figure 5: Example of an Asset Maintenance Information Template – Electrical Traction Power

2.3 **Step 3:** Mapping Asset Information to Open Standards

This step is focused on mapping the Asset Information identified in Step 2 to open standards such as Asset Data Exchange Standards, Asset Classification Standards and Asset Location Referencing Standards. Mapped asset information is critical to the success of the asset information transformation, sharing, searching, and maintenance. Detailed open standards and their explanations can be found in the P2.51 *Research Report*: Asset Data Exchange Standards (Section 3); Asset Classification Standards (Section 4) and Asset Location Referencing Standards (Section 5).

The following summary is from a case study of the Armadale Road Upgrade Project in WA (see P2.51 *Case Studies Report*) illustrating how to map road asset information to the Austroads Data Standard. The mapping work was conducted by the Project Digital Engineering Team, Main Roads Western Australia (MRWA), and the SBEnrc Research Team. Mapping road asset data to a common standard will make the management and sharing of that data more efficient and effective.

The Master Data Management Standard (as shown in Figure 6) was developed based on the *Data Standard for Road Management and Investment in Australia and New Zealand: Version 2*. The standard covers the following eight key data types:

- Inventory
- Infrastructure Performance
- Works and Costs
- Access
- Demand
- Classification
- Condition
- Customer Levels of Service

Asset data items presented in this Standard cover the whole-of-life management of assets required to support and substantiate decisions made over the lifecycle. These decisions include, but are not limited to, the following:

- Investment management requirements including asset capitalisation and whole-of-life costs;
- Asset handover requirements including asset acceptance information; and
- Asset configuration change requirements including asset approvals or sub-component approvals, new assets, configuration and operational changes including changes in asset strategy and concessions to Standards.

Austroads Data Standard for road management and investment – Version D2V2 – Data items

Function	Group	Document Section	Document Subsection	Document Unique Ref	Document Combined Ref	Data Item Category	Data Item Category Rank	Sophistication Level	Design Team	Construction Team	Hand Over	MRIA	Armadale Rd Dual	Appendix A & B Code & Function Lists			
FUNCTION	GROUP					PURPOSE		SOPH						Code	Name	Function	Ref
Inventory	Vehicle Crossings	8.3	32	1	8.3.32.1	D	2	1				Y		cross_mat	Vehicle crossing material	Inventory-Vehicle Crossings	8.3.32.1
Inventory	Vehicle Crossings	8.3	32	2	8.3.32.2	D	2	1				Y		cross_typ	Vehicle crossing type	Inventory-Vehicle Crossings	8.3.32.2
Inventory	Vehicle Crossings	8.3	32	3	8.3.32.3	D	2	2				Y		cross_dep	Vehicle crossing depth	Inventory-Vehicle Crossings	8.3.32.3
Inventory	Vehicle Crossings	8.3	32	4	8.3.32.4	D	2	2				Y		cross_reo	Vehicle crossing reinforcing mesh present	Inventory-Vehicle Crossings	8.3.32.4
Inventory	Vehicle Crossings	8.3	32	5	8.3.32.5	D	2	2				Y		cross_wid	Vehicle crossing width excluding splays	Inventory-Vehicle Crossings	8.3.32.5
Inventory	Vehicle Crossings	8.3	32	6	8.3.32.6	D	2	3				Y		crs_b_dep	Vehicle crossing basecourse depth	Inventory-Vehicle Crossings	8.3.32.6
Inventory	Vehicle Crossings	8.3	32	7	8.3.32.7	D	2	3				Y		crs_b_typ	Vehicle crossing base course type	Inventory-Vehicle Crossings	8.3.32.7
Inventory	Vehicle Crossings	8.3	32	8	8.3.32.8	D	2	3				Y		crs_s_dep	Vehicle crossing subbase course depth	Inventory-Vehicle Crossings	8.3.32.8
Inventory	Vehicle Crossings	8.3	32	9	8.3.32.9	D	2	3				Y		crs_s_typ	Vehicle crossing subbase course type	Inventory-Vehicle Crossings	8.3.32.9

Figure 6: The Master Data Management Standard

2.4 **Step 4:** Developing an Asset Information Delivery Plan

This step is focused on developing an Asset Information Delivery Plan which is used to manage the delivery of information during the project lifecycle. It is typically developed by the project delivery manager in collaboration with the task team managers and then used by the project delivery manager to assist in the delivery of project information during the project.

Essentially the Asset Information Delivery Plan is a collation of Individual Task Information Delivery Plans, prepared by other team members, and includes details of when project information is to be prepared, who is responsible for producing the information and which protocols and procedures for each stage shall be followed.

Information deliverables which may be listed in the Asset Information Delivery Plan include (but are not limited to):

- Models
- Drawings
- Specifications
- Certificates
- Licences
- Manuals
- Reports

Table 2 illustrates an Asset Information Delivery Plan Template.

Asset Information Delivery Plan Template

Project Number	
Project Title	
Author	
Date Created	
Date Last Updated	
Document Reference	

Originator | Levels and locations | Role | Number | Revision (Meta-data)

SC1-SFT-V1-01-M3-A-30_10_30-0001-S1-P02 — Example file name

Project | Volume or system | Type | Classification (Optional) | Suitability (Meta-data)

			Refer to file naming convention doc for info							OPTIONAL		DATA EXCHANGE #01		DATA EXCHANGE #02	
			FILE NAME									STAGE:	BRIEF	STAGE:	CONCEPT
												PROGRAMME REF:		PROGRAMME REF:	
DELIVERABLE (TITLE)	DES.	EXCHANGE FORMATS	PROJECT CODE	ORIGINATOR CODE	VOLUME / SYSTEM*	LEVEL/ LOCATION	TYPE	ROLE	NUMBER	CLASSIFICATION	NRM1 CODE	OWNER	DATE REQUIRED TO ISSUE	OWNER	DATE REQUIRED TO ISSUE
MODELS															
DRAWINGS (CUT FROM MODEL)															
REPORTS															
SPECIFICATIONS															
OTHER															

Table 2: Example of an Asset Information Delivery Plan template

2.5 **Step 5:** Reviewing and Evaluating

This step is focused on reviewing and evaluating the performance of Steps 1-4, and continually improving the proposed Digital Asset Information Model according to the feedback from real implementation cases. A joint team including the Asset Operator and Digital Engineering Team should lead the reviewing and evaluation process.

3 Capturing Information on Existing Assets Lacking Documentation

Gathering information for assets for which there are no previous digital records is a challenging task. Starting with the end requirements in mind is critically important, so as to avoid the gathering of unnecessary information. The capture of 3D information can be performed in three different ways:

1. Taking onsite measurements and creating a BIM model directly from the measurements. This works well for simpler structures and rectilinear geometries;
2. Using photogrammetry. Taking many overlapping photos and using photogrammetry software to build the 3D geometry through complex geometric calculations.
3. Using a laser scanner, for which there exist several technologies.

3.1 Photogrammetry

Photogrammetry produces surface models of the asset, which consist of many connected triangles with textures applied to the triangles to produce the desired appearance. Figure 7 and Figure 8 are views of a photogrammetry model showing textures and the underlying surface geometry, respectively.

Figure 7: University of Sydney main building facade captured using photogrammetry – showing textures

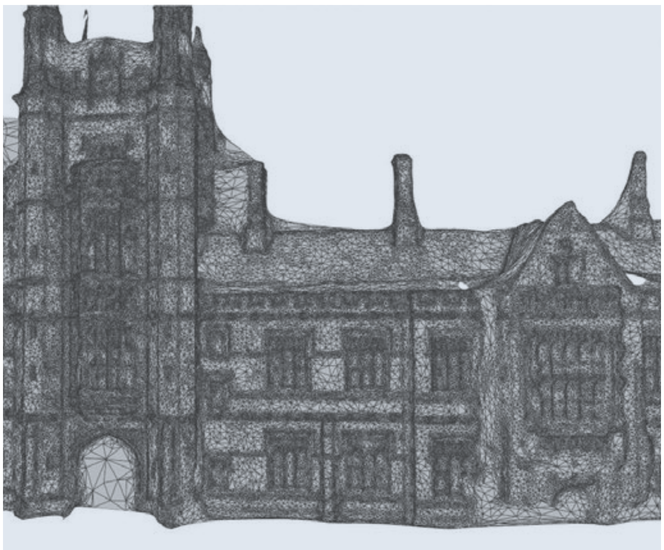


Figure 8: University of Sydney main building facade – showing triangles forming surface model

3.2 Laser Scanning

Laser scanners produce point clouds. These consist of thousands, up to millions of points, each of which is independent of all other points. Various meshing algorithms can be used to generate a surface model from a point cloud. Figure 9, Figure 10 and Figure 11 show various images of a masonry railway bridge captured using a laser scanner. Laser scanning can be accurate to within several centimetres over the 155 m length of this bridge.

A problem with all scanning methods is that a line-of-sight is required to generate accurate results. Unmanned Aerial Vehicles (UAVs) can be used to access tall or inaccessible locations. This is a simple process externally, but scanning interiors can be more problematic. UAVs can be used in larger interior spaces to provide full coverage.

The major issue for occupied spaces is the furniture and fittings within the space. Scanning is simple if these can all be removed, but the time and effort to do this may mean that relying on more traditional sketches and annotations is more efficient.

Figure 9: Yerrondilly Viaduct – raw laser scan

Figure 10: Yerrondilly Viaduct – cleaned laser scan

Figure 11: Yerrondilly Viaduct – scanner stations to produce laser scans

Photogrammetry and laser scanning can produce surface models of a structure. However, a user then needs to generate more detailed geometry by bringing these representations into BIM software so that attributes can be attached to the geometry.

Additional non-geometric data can be gathered using an app or a web page on a mobile device (Figure 12).

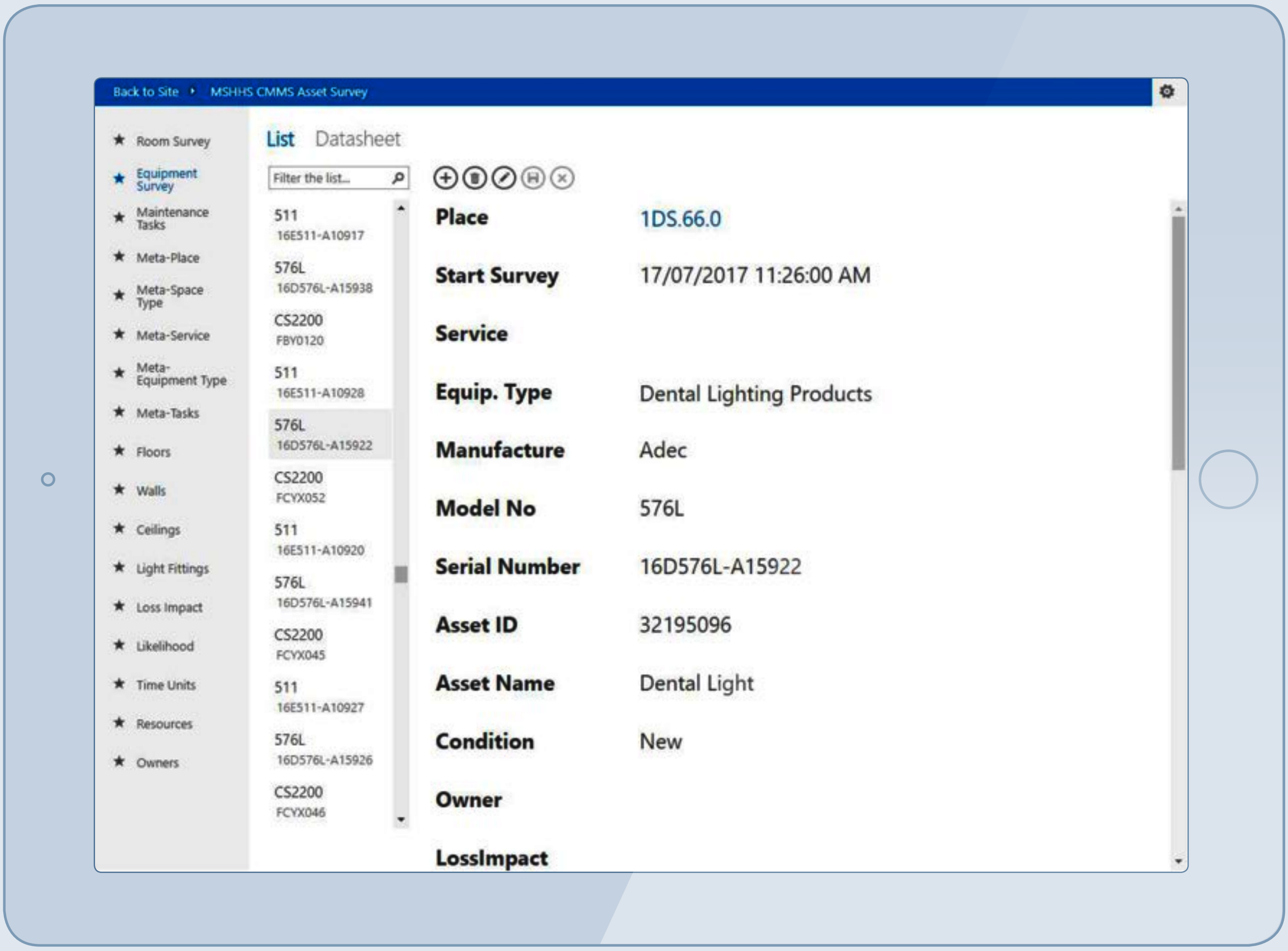


Figure 12: Example of a web page used to capture textual asset data

4 Traditional Documentation as an Asset Information Source

Traditional documentation (drawings, specifications, As-built) will continue to be a major part of asset management processes for a long time due to the large amounts of information that have been stored in these formats. Most of these will either be stored as paper documents, or scanned from paper documents. This places all of the load of interpreting the documents to extract the information required by an asset management system on the people entering the data into the asset management system.

When paper or scanned documentation provides the only information available for a project then the necessary asset information can be extracted from this. However, extraction is a time consuming and error prone process which relies on the skill of the people extracting the information.

Data can be extracted more readily from documents prepared in CAD or other drawing software, if the software supports ‘blocks’ as library objects. The counting and locations of these can be extracted from the electronic drawings using simple computer programs to automate at least some of the process.

Information on the location and type of an asset needs to be extracted from the drawings (see the example from the P2.51 Sydney housing case study in Figure 13) and then combined with the non-geometrical information from the specification to complete the asset schedules. If the only available documentation is the contract documentation, then a great deal of onsite work will be required to accurately capture the specific products, serial numbers, and so on, from the building itself. This is due to the normal practice of using generic or non-specific names in the drawings and specifications to allow the contractors to source products from a range of manufacturers.

The information extraction process is sped up if reliable As-built documentation is available. Random checks of the accuracy of the information captured in the As-built documentation against individual pieces of installed equipment can be used to demonstrate reliability or otherwise.Even if the As-built information is accurate and reliable, some onsite validation will be required to obtain necessary information that was not recorded by the contractors that installed the components.

The amount of effort required to gather asset data from traditional documents and onsite inspections means that a strategic approach should be taken in deciding what asset data is essential and what data is not worth collecting. There will be some data which would not be worthwhile collecting for its own sake, but will be relevant to a component that has some essential data. This additional data can be gathered during the onsite data capture process for the essential data, as the cost of collecting the additional data will be small.

Another mechanism for gradually capturing additional lower value data is to gather this additional data during maintenance, repair or replacement activity on co-located equipment. If, for example, someone has to enter a service duct or ceiling space to do a piece of work, then they could be asked to gather additional data while they are in the location. This requires a reasonable degree of planning and willingness to gather data that may not be directly relevant to the person performing the work.

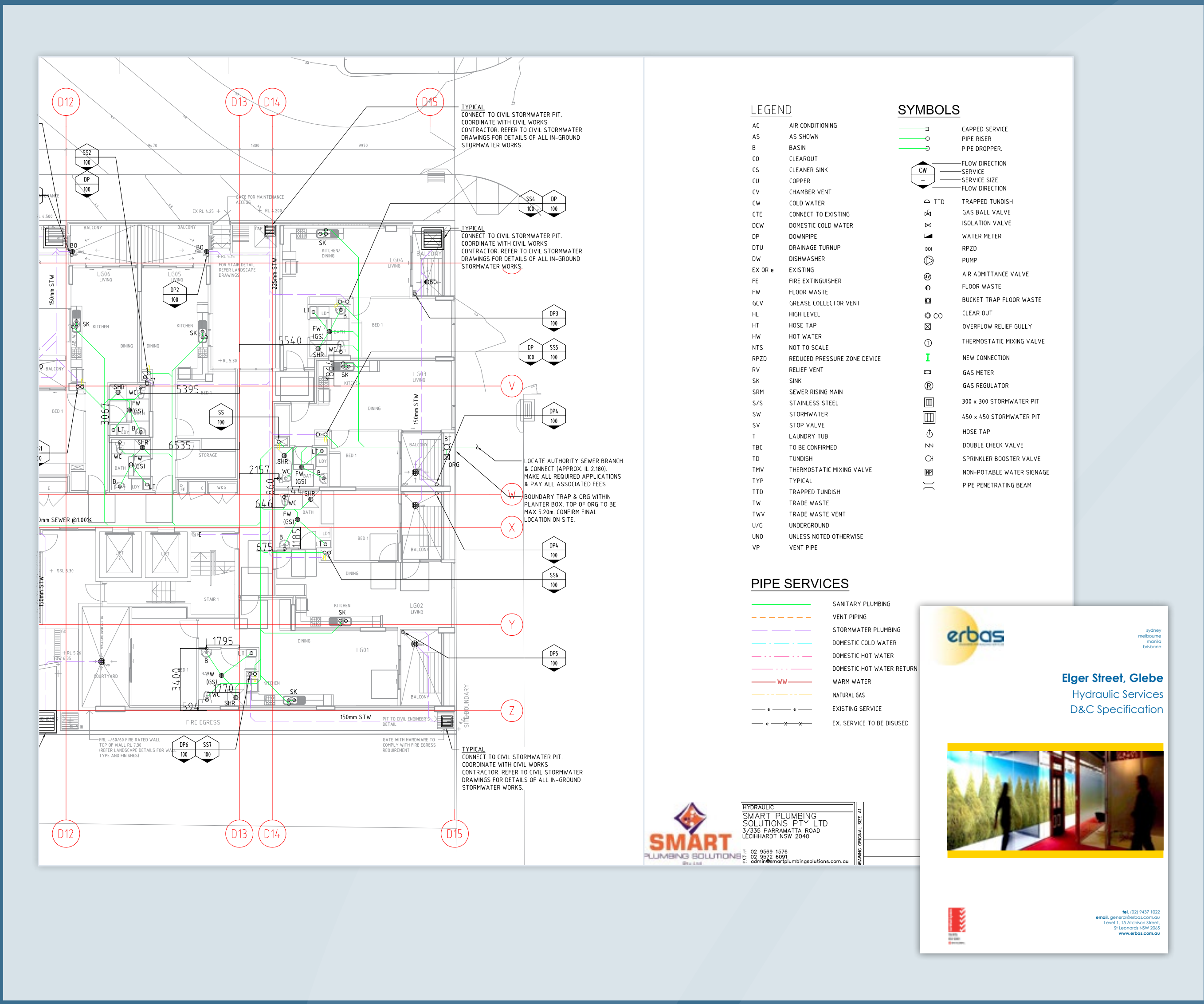


Figure 13: Partial hydraulic floor plan, schedule and specification for Elger Street, Glebe, Sydney

5 Adapting BIM Models as a Source of Asset Management Information

The potential of BIM to support asset management was recognised early in the development of BIM technology. The US GSA (General Services Administration) published their initial BIM strategy in 2003. The current GSA FM guidelines are available on the GSA website[3].

The US Army Corps of Engineers developed the Construction Operation Building Information Exchange (COBie) system to support their needs in capturing BIM data. The work commenced in 2007 and was formally ratified in 2011. COBie is currently being further developed and maintained by the BuildingSMART Alliance.

The GSA delivers federal work spaces through managing government buildings, leasing commercial real estate and providing a suite of related services. It also provides standards and guidelines for setting up BIM models to be used for the design, construction and operation of buildings. It also provides a project folder structure in an attempt to improve the productivity of BIM teams. Templates hold default object line weights and styles, system definitions, view templates, plotting defaults and browser organisation configurations. A well-defined template (or group of templates) dramatically reduces the time required to setup and run a project[4].

In their Technical Standards, the GSA provides minimum attributes for COBie data. The table in Appendix 3 of the Standards represents the minimum attributes for COBie, data types and the responsible parties[5].

The naming standards from the GSA can be found on the GSA website[6]. They include BIM file naming, National Compliance Services (NCS) compliant discipline codes and standard equipment abbreviations.

The COBie guide document[7] provides guidelines on what information should be delivered at different stages of design and construction. It also points out the parties responsible for the deliverables and the possible ways of specifying the responsible entity. As one would expect, this information should be obtained from BIM models regardless of the software platform. Hence, the guideline provides deliverable evaluation criteria in which the issues arising from incorrect software configurations are discussed. The following recommendations are made in setting a BIM file to be compliant for COBie export:

- One facility per COBie file;
- Unique asset naming;
- Component spatial containment: all COBie.Component records shall be identified in the COBie.Space in which the asset is found or the COBie.Space from which the asset is operated;

[3] https://www.gsa.gov/real-estate/design-construction/3d4d-building-information-modeling/bim-guides
[4] https://www.gsa.gov/real-estate/design-construction/3d4d-building-information-modeling/bim-guidelines-for-revit/downloads/templates)
[5] https://www.gsa.gov/real-estate/design-construction/3d4d-building-information-modeling/bim-guidelines-for-revit/guidelines/technical-standards/bim-technical-standards-minimum-attributes
[6] https://www.gsa.gov/real-estate/design-construction/3d4d-building-information-modeling/bim-guidelines-for-revit/guidelines/technical-standards/bim-technical-standards-naming#
[7] The COBie Guide: a commentary to the NBIMS-US COBie standard. https://www.bimpedia.eu/static/nodes/1010/COBie_Guide_-_Public_Release_3.pdf

- Component spatial placement: a COBie.Attribute named 'SpatialPlacement' shall be provided for each COBie.Component;
- Site spatial containment: for each facility compound or campus with shared site work, a separate COBie Site file shall be submitted;
- Facility geo-location: longitude, latitude, elevation and rotation should be provided for each COBie.Facility record;
- Categories: appropriate classification systems should be used for Contact, Facility, Space, Type and System worksheets;
- Zones: zones shall be identified by zone type and characteristics;
- Systems: systems shall be identified by building service, floor and wing;
- Units of measure: COBie models require a single standard set of units of measure for linear, area and volumetric measures;
- Use of commercial software: the software vendor's set-up instructions should be followed prior to the use of any commercial software;
- Multiple-model merging: it is recommended that when preparing a COBie deliverable from multiple models that a 'pre-flight' check of model merging operations be conducted to determine if assets are duplicated in different models.

There is a need for communication between different disciplines so that common features are addressed in a consistent way, because one COBie file merged from different files is going to be delivered and used. For instance, naming of the spaces and rooms should be consistent between architects and mechanical engineers.

The way that objects and their properties are set up in a BIM model plays an important role in the presentation of information in a final COBie file. For instance, the Revit model for the P2.51 Jellicoe Street, Toowoomba case study is a very complete model and the objects in this model contain sufficient information for COBie. However, this information does not transfer to COBie properly since it is not structured appropriately for the COBie export process. In the Jellicoe Sreet model, most of the information related to objects is presented in the name field rather than their own specific field.

In contrast, the model obtained from the US National Institute of Building Sciences (NIBS[8]) is developed in a way to be COBie compatible. This model contains similar information; however, all of this information can be properly transferred to COBie since it is entered in the relevant fields in the model. A demonstration of the differences between these two models is presented below. Figure 14 (see page 30) represents the data presentation in an object property and COBie outcome from the Jellicoe Street model. Figure 15 (see page 30) presents the same information for the model obtained from the NIBS.

[8] https://www.nibs.org/page/bsa

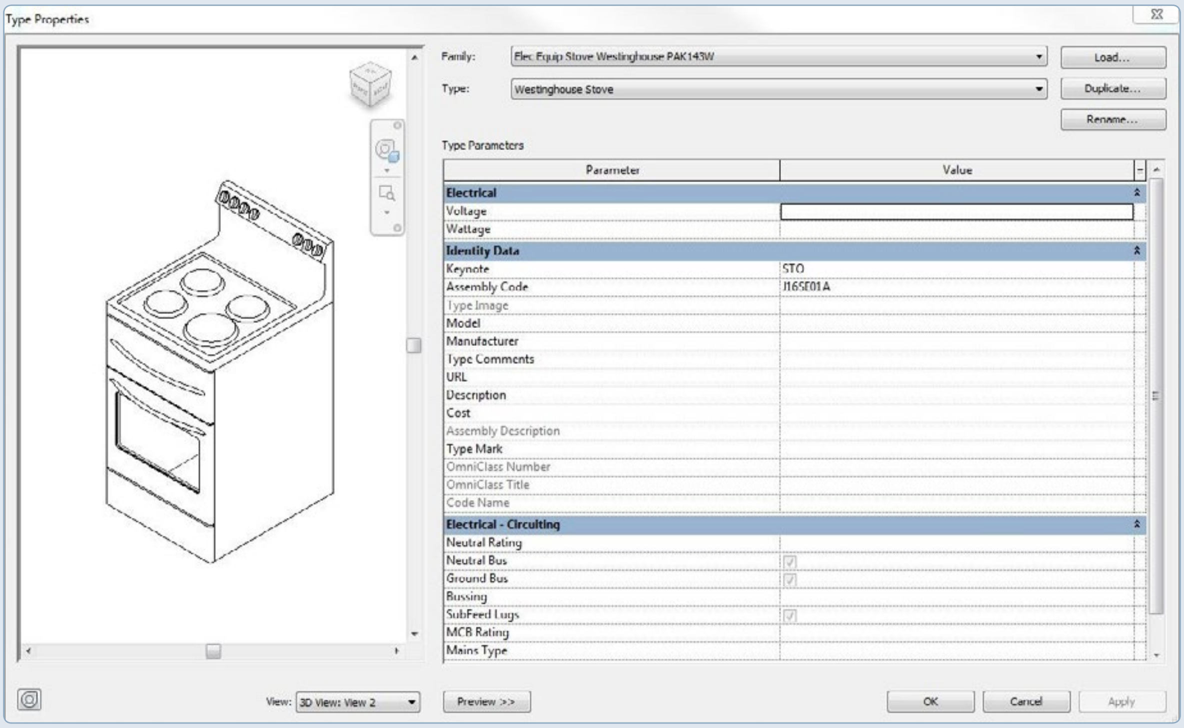


Figure 14: Standard object data in BIM software for Jellicoe Street housing case study

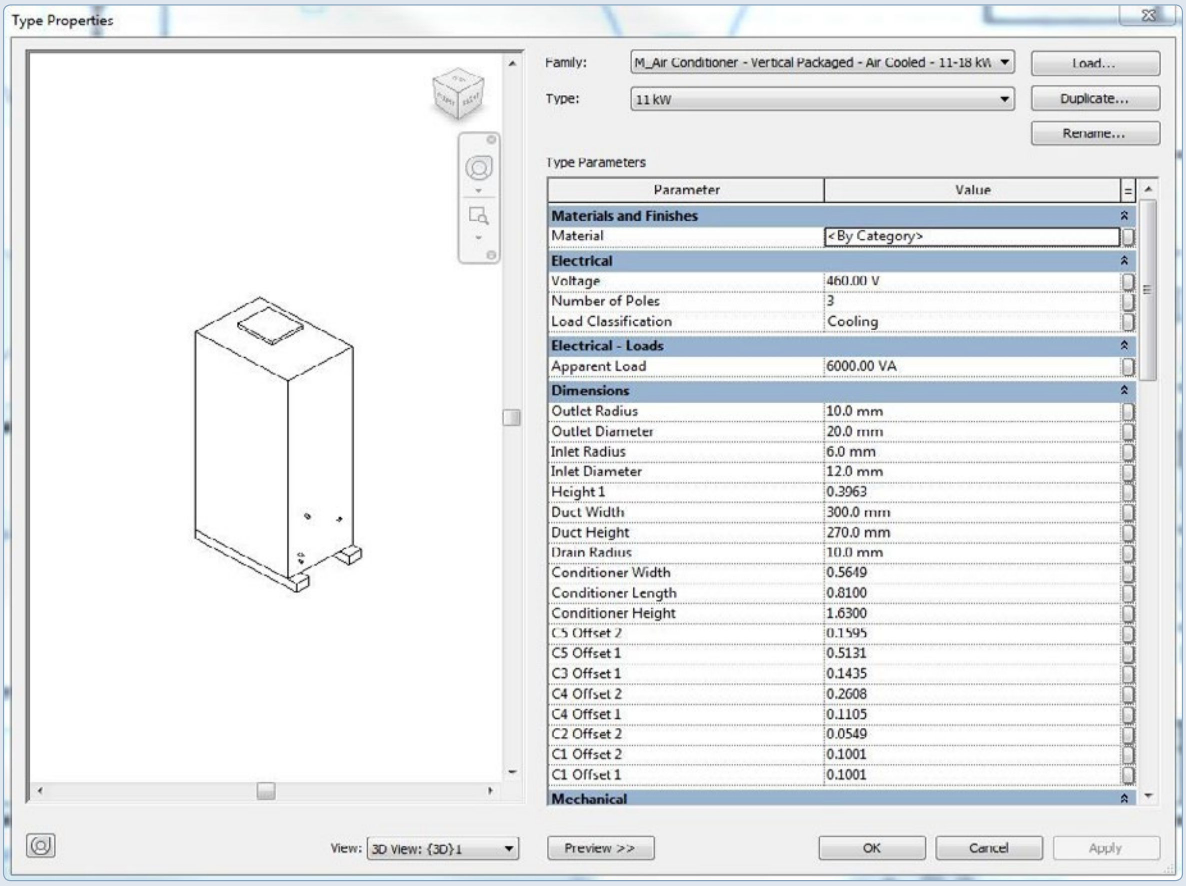


Figure 15: Object data supplemented with NIBS specification for Jellicoe Street housing case study

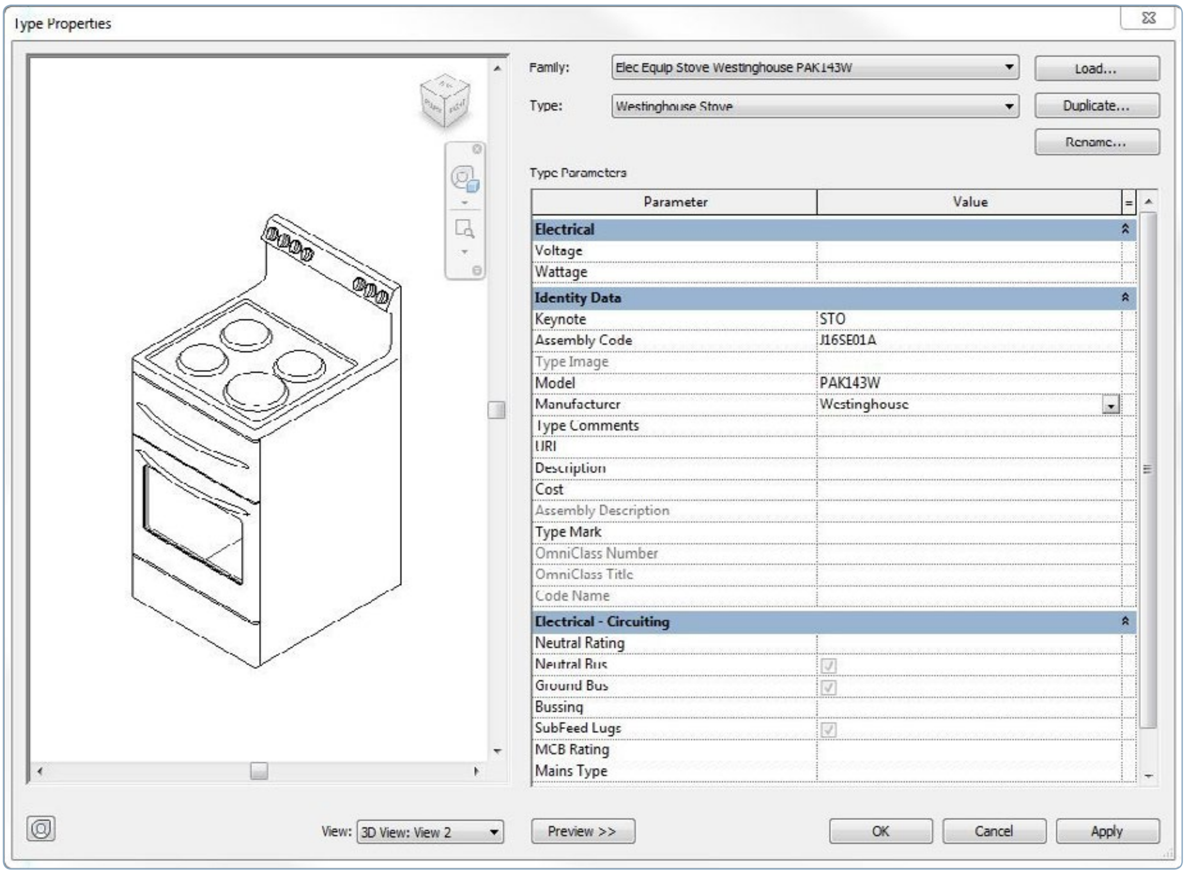


Figure 16: Stove library data from Figure 14 edited to support COBie export

This specific issue with the Jellicoe Street model, however, can be resolved relatively easily. Since all the objects included in the model are exported from a library, updating the library in a COBie compatible way should fix this problem. Figure 16 provides an example where the information for the same object presented in Figure 14 is inserted in the relevant COBie fields rather than the family name field.

The GSA provides a COBie2 tutorial in which the Revit implementation of COBie is explained. This process mainly uses GSA Standard Revit Templates for different disciplines[9]. Although these templates are very useful, they are only developed for Revit; other software platforms are not currently covered by the GSA.

Regarding BIM models and their intended use throughout a building's lifecycle, a number of conclusions can be drawn[10]:

- Good tools (e.g. software) do not guarantee the model quality;
- Double entries within a discipline can happen in the case of poor models;
- Double entries across disciplines can occur when information does not carry across to the other discipline; and
- Multiple entries across multiple phases will also result in information communication deficiencies.

[9] https://www.gsa.gov/real-estate/design-construction/3d4d-building-information-modeling/bim-guidelines-for-revit/tutorials/cobie2-tutorial
[10] https://www.youtube.com/watch?v=MKdjdc2IxfE&feature=youtu.be)

6 Maximising BIM for Asset Management

6.1 The Modelling Gaps between Architecture, Engineering, Construction and Facilities Management

One of the challenges that building owners implementing lifecycle BIM face is the difference between the Building Models created for design and construction and the Building Models needed for operational use. However, with planning and proper procedures, building data can and should flow from one phase to the next. It is useful to identify at least four types of Building Models as seen below in Figure 17.

BIM Design Models
Developed by the design team with a level of development to relay design intent and generate documentation and details used during construction

BIM Construction Models
Contains a high level of detail used before and during actual construction to reduce uncertainty, improve safety, eliminate conflicts and simulate real world outcomes

BIM As-built Model
Contains both construction and fabrication data with detailed geometry and multiple disciplines that facilitates turnover from AEC to owners

BIM FM Model
Is derived from the BIM As-built model removing details, sheets, and other extraneous information, and defining rooms, spaces, assets by unique identifiers. The BIM FM model is then linked with the facility management system for ongoing management.

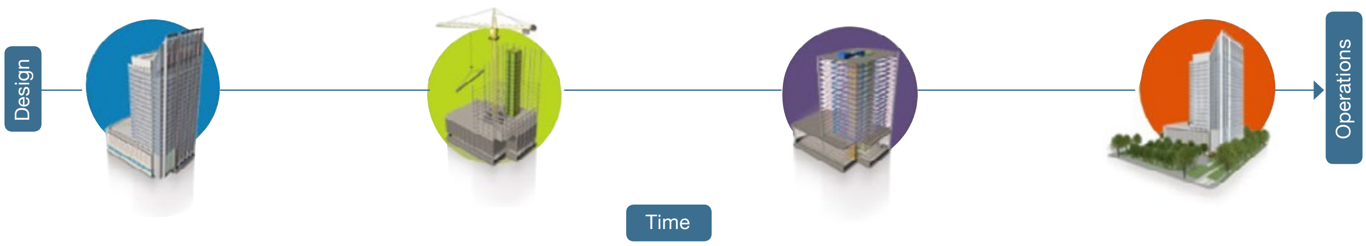


Figure 17: Building models from design through to facility management (Source: Ackerman et al. 2017[11])

[11] Ackerman, A., Gibbs, B., Lowe, J., Saliba, M., Williams, J. and Wong, K. (2017), Building information modelling: asset management in civil infrastructure, Roads Australia Fellowship, Working Group 4.

6.2 Evolution of BIM from Design to Facilities Management

6.2.1 BIM Design Models

BIM design models are created by architects and engineers with the objective of first defining the conceptual design and ultimately producing more detailed construction documents. Materials and equipment for buildings or infrastructure are defined generically, allowing the contractor the freedom to competitively bid and price equivalent alternatives. For example, air handling units are described by general dimensions and performance requirements by the engineer without knowledge of who the selected manufacturer will be.

6.2.2 BIM Construction Models

Contractors and subcontractors will use these models to aid in staging and detection of potential conflicts using clash detection before encountering the issues in the field, as well as for material take-offs (estimating) and procurement. BIM Construction Models typically contain a high level of detail used before and during construction to reduce uncertainty in the construction process. Additional benefits include enhancing safety on the job, limiting conflicts and the simulation of real world outcomes.

6.2.3 BIM As-built Model

This is created by the building construction contractor, subcontractors and suppliers. Traditionally this information has been provided as a set of paper working drawings that were annotated to reflect change orders and field changes and was accompanied by equipment cut sheets and shop drawings depicting specific equipment selection.

In the BIM era, this information needs to be entered back into the BIM Model by the contractor or a specialist in building commissioning. Information in the BIM As-built Model will include details, annotations, dimensions, building or infrastructure sections, schedules and elevations. The BIM As-built Model will also include material and equipment properties as determined during the construction process. The BIM standards are critical for defining the information that is required.

The building or infrastructure project's owner should retain the As-built model as the authoritative source and a reference for the building as–constructed. Figure 18 shows an example of a floor plan of an As-built drawing for the P2.51 Warren District Hospital case study in Western Australia.

Figure 18: Floor plan of Warren District Hospital in a Construction Model with annotation, equipment and dimensions providing as-built information.

6.2.4 BIM-FM Model

The BIM-FM Model is derived from the BIM As-built Model. Additional information is included later in Section 6.9. When creating the BIM-FM Model, the following modifications are made:

- Extraneous information is removed, including construction details and working drawing sheets. This information can be obtained from the 'As-built' model if needed, but otherwise encumbers the BIM-FM Model.
- Where linked models have been used to separately represent building core, building shell and tenant improvements, these are merged into a single model.
- If practical, linked models representing architectural, mechanical, electrical, fire protection and specialised equipment are merged. For large buildings, this may not be practical with current technology, so there may be the need to maintain multiple models that are linked.
- Occupancy room numbers are derived from construction room numbers, with numbers matching building signage.
- For office spaces, workstations and offices are defined separately from rooms and are numbered with an occupancy numbering system. This is key to matching office occupants to desks, cubicles and offices and is also essential for management of work orders.
- Building equipment items are numbered with unique asset IDs.
- The BIM-FM Model is linked to the facility management system, which tracks ongoing work orders, maintenance operations, occupancy information, equipment and material replacement costs and other data related to building operations. Figure 19 shows an example of a floor plan of a BIM-FM Model for the P2.51 Warren District Hospital case study.

Figure 19: Floor plan of Warren District Hospital in a BIM-FM Model without annotation, but with space definition

6.3 Integration with Facility Management Systems

The BIM Model is the authoritative source for the physical aspects of a building or infrastructure project including the structural system, walls and doors, room finishes, lighting, power, plumbing, fire protection and HVAC systems. It is not designed to manage data for ongoing operations and occupancy; this information is best handled by a facility management system. In this document, we use the general term ‘facility management system’, but this might alternatively be known by one of the following designations:

- Computer–Aided Facility Management (CAFM) System: These are systems integrated with CAD or BIM and are used to track space and maintenance.
- Computerised Maintenance Management System (CMMS): These are systems designed to track remedial and scheduled maintenance.
- Integrated Workplace Management Systems (IWMS): These are systems that manage space, maintenance management, real-estate information and leases, move management, strategic planning, project management, room bookings and other facility functions and are deployed on an enterprise rather than departmental basis.

6.4 Organisation of Information

Although information can be tracked from both the Building Model and the facility management system, it is critical to determine the authoritative source for each set of data. As an example, Table 3 illustrates the guidelines used by Advanced Spatial Technologies (ASt)[12] for the P2.51 case studies on buildings.

[12] Advanced Spatial Technologies
https://www.advancedspatial.com.au/about-us

BIM-FM Model is Authoritative	Facility Management System is Authoritative
Building structure and base building architecture including structure, walls, doors, stairs, elevators and building core areas.	Real estate information including property records and lease information.
Interior architecture including walls, doors, floors and ceilings.	N/A
Rooms with ‘as–occupied’ room numbers consistent with building signage. Room numbers should be unique by building.	N/A
Workspace areas which include closed–wall offices but also include open–plan workstations. Areas should include space ID numbers that are consistent with occupancy management systems for occupant workspace assignment. Workspace numbers should be unique by building.	Occupants with unique occupant ID’s and referencing workspace numbers. Move management information including from, to, move date, move project and move details. Department or cost centre codes.
Building equipment by general type and dimensions with unique asset ID numbers for reference by other systems. The Building Model should also carry the model, manufacturer and serial number for major equipment. BIM is typically authoritative when an item of equipment exists in the model. In other words, it is placed in BIM first and if removed from the building, deleted from the Building Model.	Equipment warranty information, information on date placed in service, replacement costs, asset values, depreciation schedules and service contracts. Equipment preventative maintenance schedules and inspection results. Work requests and work orders. Service level agreements by activity.
Furniture panels, desks and work surfaces but not fittings, components, shelves or drawers.	N/A
Electrical outlets and switches with circuit information.	N/A
Lighting fixtures with circuit information.	N/A
Plumbing fixtures and piping.	N/A
Fire sprinklers and fire protection systems.	
Special equipment such as food service equipment and lab equipment.	N/A
N/A	System user information including system privileges.
N/A	Project management schedules and costs.
N/A	Sustainability information including certifications and resource initiatives.
N/A	Strategic plans.
N/A	Lifecycle management information including service life by system, replacement costs, annual upkeep costs and capital budget forecasts.

Table 3: Advanced Spatial Technologies (ASt) Guidelines used in P2.51 case studies on buildings

For infrastructure assets, in 2018, buildingSMART International Infrastructure Room published a technical report on *Infrastructure Asset Managers BIM Requirements*[13]. The report provided guidance to asset owners/operators to manage their infrastructure assets (as shown in Table 4). It is designed as a list that gives headers for the information attributes required and to be fulfilled against detailed object descriptions. It uses the MoSCoW rating system for priorities, specifically:

- M – Must have information
- S – Should have information
- C – Could have information
- W – Would eventually have information if time and money available

Note that most owners and asset operators will choose to manage the information in the above lists that is most critical for effective asset operations. Very few owners track all of the information above and owners should consider a phased and prioritised approach when implementing a system.

[13] Infrastructure Asset Managers BIM Requirements Technical Report: https://www.buildingsmart.org/wp-content/uploads/2018/01/18-01-09-AM-TR1010.pdf

Subject	MoSCoW Rating	Notes
Asset Inception and Lifecycle	Must begin life as it is conceived not when it has been built and handed over after or during construction.	To satisfy lifecycle information requirements, the development and collection of data about an asset must be instantiated at conception and be progressively managed and added to throughout its lifecycle.
An Asset	**Must have:** • A unique identification • A reference to type of object • Managed revision identifier.	As an asset is conceived in the planning and design process it should be uniquely referenced and from that point on version controlled.
	Should have information related to its: • Currency • Suitability for information use • Function • Technical performance specification.	Date of information currency. Suitability of use of information including quality and accuracy. The function the asset performs. The technical performance specification for the asset.
	Could have: • A location – Geospatial, Linear & Space • A topological relationship and location • Geometric construction • Dimensions • Relationship to other assets and groupings such as Network, Entities, Facilities, Systems, and Assemblies.	Geometry and topology are not essential attribute requirements. This breaks with IFC tradition which currently mostly relies upon construction geometric components and use cases. However, these will generally be required attributes for locational and context purposes.
	Further could have: • Reference to Work Breakdown Structure • Material • Energy embedded • Energy of installation • Volume or other quantification measure related to a method of measurement • Manufacturer • Installation date and time • Performance criteria of installed product.	An extendable list which will be dependent on the type of asset being described and captured.
	Could have (operational and maintenance): • Inspection frequency • Condition • Criticality • Risk	Information that gives support to day-to-day operation and maintenance of the asset.

Table 4: Guidance on Infrastructure Asset Information Requirements

6.4.1 Classification of Model Data and Standards

Organisations that own and operate facilities portfolios can increase the accuracy and integrity of their data by implementing modelling and data standards enterprise-wide. It is strongly recommended that each organisation implement and enforce the adoption of well-defined standards. This can provide stronger, more accurate reporting and ease of high quality data integration. It also provides a method for communicating expected results to architecture, engineering and construction partners and consultants, who may be providing modelling and data collection services for new construction, renovations or retrofit projects.

Standards can include naming conventions, formats and classifications. Several industry data standards already exist (e.g. OmniClass or Uniclass) and can be used as is or adjusted for each building owner as necessary. Examples of standards and classifications systems are covered in the following sections.

The usage of classification systems should be considered on their merits on a case-by-case basis. For example, some building facility management applications may favour OmniClass; whereas an infrastructure asset application may favour Uniclass classification system (e.g. Uniclass 2015).

6.4.1.1 OmniClass

The OmniClass Construction Classification System is recognised by the construction industry as one authoritative source for classification of information related to building construction. OmniClass Tables 21 (Elements) and 23 (Products) are beneficial to the building owner and using both may be required as they each serve a different purpose.

OmniClass Table 21–Elements (Figure 20) is one useful general framework for structuring BIM information. Elements are systems or major assemblies and as such lend themselves to the migration of information from conceptual design through construction and facility operations. Table 21 is based on the Uniformat system that was developed in the 1980s for conceptual cost estimating.

OmniClass Table 23–Products (Figure 21) is also relevant as a classification for final building equipment items and manufactured products. Product manufacturers are beginning to provide downloadable BIM content which is typically referenced by Table 23. These tables are also used in the Construction Operations Building Information Exchange (COBie) standard. More detailed information on OmniClass tables is available on the OmniClass website[14].

[14] www.omniclass.org

OmniClass™ **Table 21 - Elements**

OmniClass Number	Level 1 Title	Level 2 Title	Level 3 Title	Level 4 Title	Table 22 Reference
21-04 30 70			Special Purpose HVAC Systems		
21-04 30 70 10				Snow Melting	22-23 83 00
21-04 40		**Fire Protection**			
21-04 40 10			Fire Suppression		22-21 00 00
21-04 40 10 10				Water-Based Fire-Suppression	22-21 10 00
21-04 40 10 50				Fire-Extinguishing	22-21 20 00
21-04 40 10 90				Fire Suppression Supplementary Components	
21-04 40 30			Fire Protection Specialties		22-10 44 00
21-04 40 30 10				Fire Protection Cabinets	22-10 44 13
21-04 40 30 30				Fire Extinguishers	22-10 44 16
21-04 40 30 50				Breathing Air Replenishment Systems	22-10 44 33
21-04 40 30 70				Fire Extinguisher Accessories	22-10 44 43
21-04 50		**Electrical**			22-26 00 00
21-04 50 10			Facility Power Generation		
21-04 50 10 10				Packaged Generator Assemblies	22-26 32 00
21-04 50 10 20				Battery Equipment	22-26 33 00
21-04 50 10 30				Photovoltaic Collectors	22-26 31 00
21-04 50 10 40				Fuel Cells	22-48 18 00
21-04 50 10 60				Power Filtering and Conditioning	22-26 35 00
21-04 50 10 70				Transfer Switches	22-26 36 00
21-04 50 10 90				Facility Power Generation Supplementary Components	

Figure 20: A part example of OmniClass Table 21 (Source: OmniClass Development Committee)

23-25 69 13	**Laboratory and Scientific Equipment**			
23-25 69 13 11		Microscopes		
23-25 69 13 11 11			Acoustic Microscopes	
23-25 69 13 11 13			Binocular Microscopes	
23-25 69 13 11 13 11				Phase Contrast Binocular Microscopes
23-25 69 13 11 13 13				Binocular Light Compound Microscopes
23-25 69 13 11 15			Bore scope Inspection Equipment	
23-25 69 13 11 17			Combination Electron And Light Microscope	
23-25 69 13 11 19			Dark field Microscopes	
23-25 69 13 11 21			Digital Image Varityping Microscopes	

Figure 21: A part example of OmniClass Table 23 (Source: OmniClass Development Committee)

6.4.1.2 Uniclass 2015

Uniclass 2015[15] is a unified classification system for the UK construction industry covering all sectors of the industry. Uniclass 2015 is divided into a set of tables which can be used to categorise information for costing, briefing, CAD layering, and so on, as well as when preparing specifications or other production documents. These tables are also suitable for buildings and other assets in use, and for maintaining asset management and facilities management information.

The suite of tables are broadly hierarchical, and allow information about a project to be defined from the broadest view of it to the most detailed. The Complexes table describes projects in overall terms and can be thought of in terms of the provision of an Activity. Complexes can be broken down as groupings of Entities, Activities and Spaces, depending on the particular use. Entities can also be described using the Spaces and Activities tables if required.

There are seven main tables developed within Uniclass 2015:

1. *Complexes:* This describes a project in overall terms. It can be a private house with garden, drive, garage and tool shed, or it can be a highway with bridges and tunnels.
2. *Entities:* These are discrete things such as buildings, bridges and tunnels. They provide the areas where different activities occur.
3. *Activities:* These define the activities to be carried out in the complex, entity or space. For example a prison complex provides a detention activity at a high level, but can also be broken down into individual activities such as exercise, sleeping, eating and working. The Activities table also includes surveys, operation and maintenance, and services.
4. *Spaces/Locations:* In buildings, spaces are provided for various activities to take place. In some cases, a space is only suitable for one activity, for example a kitchen, but a school hall may be used for assemblies, lunches, sports, concerts and dramas. Also classed as spaces are transport corridors that run between two locations, such as London Kings Cross to Newcastle stations, or the M1 from London to Leeds.
5. *Elements:* Elements are the main components of a structure, such as a bridge (foundations, piers, deck) or a building (floors, walls and rooves).
6. *Systems:* Systems are the collection of components that go together to make an element or to carry out a function. For example, a signal system for a railway has a number of components and products; and the scum removal system is part of a wastewater treatment entity.
7. *Products:* The individual products used to construct a system can be specified, such as joist hangers, terrazzo tiles and gas-fired boilers.

Uniclass 2015 provides:

- A unified classification system for the construction industry. For the first time, buildings, landscape and infrastructure can be classified under one unified scheme.
- A hierarchical suite of tables that support classification from a university campus or road network to a floor tile or kerb unit.
- A numbering system that is flexible enough to accommodate future classification requirements.
- A system compliant with ISO 12006-2 and which supports mapping to other classification systems in the future.

[15] https://toolkit.thenbs.com/articles/classification#classificationtables

6.4.1.3 ISO 12006-2: 2015

ISO 12006-2:2015[16] (Building construction -- Organization of information about construction works -- Part 2: Framework for classification) defines a framework for the development of built environment classification systems. It identifies a set of recommended classification table titles for a range of information object classes according to particular views, such as by form or function, supported by definitions. It shows how the object classes classified in each table are related, as a series of systems and sub-systems, such as in a building information model. ISO 12006-2:2015 applies to the complete lifecycle of construction works, including briefing, design, documentation, construction, operation and maintenance, and demolition. It applies to both building and civil engineering works, including associated engineering services and landscaping.

Two types of hierarchy have been defined by ISO 12006-2:2015: Classification Hierarchy ('type-of') and System/Composition Hierarchy ('part-of'). The purpose of Classification Hierarchy is to distinguish between objects in a collection based on properties of interest. Classes are defined by attributes representing the properties of interest, and ordered in levels determined by the relation 'type-of', where specific classes are types of more general classes. The System/Composition Hierarchy allows a designer to handle wholes (as distinct from parts).

By identifying related systems, the relationships among these can be determined, and monitored; for example to ensure that all systems operate correctly. Examples of relationships are input to or output from a system to its environment. Systems can consist of sub-systems in different compositional levels. By subdividing or structuring a system in sub-systems, using 'part-of' relations, any large sets of information in a complex design can be handled in smaller parts.

[16] https://www.iso.org/standard/61753.html

6.5 Information Transfer versus Integration

Much has been written about the ‘handover’ of information between design, construction and operations phases. There are two basic approaches to transferring information from construction to facility management:

- Direct integration of the BIM and the facility management system.
- Transfer of data using a standard data format, typically the COBie standard.

The advantages of direct integration between the Building Model and the facility management system are as follows:

- Better validation of data. With the BIM and facility management systems linked, data is validated upon entry and there is no need for a ‘data scrubbing’ activity on handover; however, the data held in the As-built Building Model should be QA checked for accuracy and completeness before integration with the FM System.
- Better access to BIM data. Facility management systems that provide floor plan and model viewing functionality open the Building Model access up to anyone with a Web browser.
- Better ongoing updates to the building. By maintaining a working Building Model throughout building occupancy, the owner has an accurate record of the building as a base for future remodelling and expansion.

The advantages of using a transfer method such as COBie:

- Owners using facility management systems without direct BIM integration have a means to acquire information from the Building Model.
- Design and construction consultants who don’t have access to the BIM authoring system or the facility management system can contribute BIM data.

6.5.1 COBie Standard

Where a direct integration between BIM and the facility management system is not available, the COBie standard is recommended to transfer information. It provides a framework for the information attributes required for major building systems. A number of BIM and facility management software developers have developed interfaces for importing and exporting COBie data. Users should be aware, however, that data will need to be validated after import since the source system is not integrated with a target system.

The COBie standard is also a useful reference for attributes to track various types of building equipment. However, users should use their judgment in determining the subset of attributes that can be kept accurate. A ‘lean’ approach to BIM data, tracking the information that is deemed essential for ongoing maintenance, will be more successful than tracking every possible attribute of all equipment items.

Figure 22 shows an example of COBie air conditioning system data for a building.

Name	Created By	Created On	Type Name	Space	Description	Ext System	Ext Object	Ext Identifier	Serial Number	Installation Date	Warranty Start Date	Tag Number	Bar Code	Asset Identifier
AC Unit Type	danielle.r.	2011-09-1	AC Unit Type 1	1B21	AC Unit	n/a	Ifc Energy Conversion Device	n/a	n/a	n/a	n/a	n/a	n/a	n/a
AC Unit Type	danielle.r.	2011-09-1	AC Unit Type 1	1C13	AC Unit	n/a	Ifc Energy Conversion Device	n/a	n/a	n/a	n/a	n/a	n/a	n/a
AC Unit Type	danielle.r.	2011-09-1	AC Unit Type 1	2B12	AC Unit	n/a	Ifc Energy Conversion Device	n/a	n/a	n/a	n/a	n/a	n/a	n/a
AC Unit Type	danielle.r.	2011-09-1	AC Unit Type 1	2C15	AC Unit	n/a	Ifc Energy Conversion Device	n/a	n/a	n/a	n/a	n/a	n/a	n/a
AC Unit Type	danielle.r.	2011-09-1	AC Unit Type 2	2D04	AC Unit	n/a	Ifc Energy Conversion Device	n/a	n/a	n/a	n/a	n/a	n/a	n/a
AHU-1	danielle.r.	2011-09-1	AHU	2D05	M_Air HandLING Unit - Split Sys	Autodesk Revit MEP	Ifc Flow Moving Device	OJGTSjcSn7	n/a	n/a	n/a	n/a	n/a	n/a
AHU-2	danielle.r.	2011-09-1	AHU	2D05	M_Air HandLING Unit - Split Sys	Autodesk Revit MEP	Ifc Flow Moving Device	1gn$K6jVP	n/a	n/a	n/a	n/a	n/a	n/a
Air Compre	mariangel	2013-01-2	Air Compressor - D	1E15	Duplex Packaged Assembly w	n/a	Ifc Medical Device	n/a	n/a	n/a	n/a	n/a	n/a	n/a
ACC-1	danielle.r.	2011-09-1	Air Cooled Chiller	1F01	M_Screw Chiller - Air Cooled -	Autodesk Revit MEP	Ifc Energy Conversion Device	379JtJEeXD	n/a	n/a	n/a	n/a	n/a	n/a
ACCU-5	danielle.r.	2011-09-1	Air Cooled Condenser	2R02	Air Cooled Condensing Unit	n/a	Ifc Energy Conversion Device	n/a	n/a	n/a	n/a	n/a	n/a	n/a
ACCU-1	danielle.r.	2011-09-1	Air Cooled Condenser	Site	Air Cooled Condensing Unit	n/a	Ifc Energy Conversion Device	n/a	n/a	n/a	n/a	n/a	n/a	n/a
ACCU-2	danielle.r.	2011-09-1	Air Cooled Condenser	Site	Air Cooled Condensing Unit	n/a	Ifc Energy Conversion Device	n/a	n/a	n/a	n/a	n/a	n/a	n/a
ACCU-3	danielle.r.	2011-09-1	Air Cooled Condenser	Site	Air Cooled Condensing Unit	n/a	Ifc Energy Conversion Device	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Figure 22: An example of COBie air conditioning system data for a building.

6.6 Benefits of Cloud–based BIM and Facility Management Systems

Organisations implementing facility management systems typically have these choices for installing the software:

- On-premise, meaning the system is in the organisation's private data centre and behind the organisation's firewall
- Cloud-based, meaning the system is in a data centre provided by the software vendor and not behind the organisation's firewall

Although many organisations have traditionally preferred the on-premise option, this has changed dramatically in the past three years, with the trend moving strongly to cloud-based deployment. This is being driven by better security for cloud-based applications and significant reduction in IT management costs for cloud-based systems. Some organisations will still choose on-premise deployment due to IT preferences or the need for complete security control. Cloud-based facility management systems with real-time bi-directional integration to a Building Model enable the subject matter experts, who are closest to the data and have been given an appropriate level of secure access, the ability to update information in the model quickly and easily. Most organisations depend on a number of specialists to plan, manage and operate their buildings. BIM skills in particular, are often outsourced by owners and facility managers rather than staffed in-house. Cloud-based systems provide the IT environment that is needed to support essential collaboration.

Figure 23 shows what a basic BIM-based lifecycle management solution can look like when coupled with a facility management system.

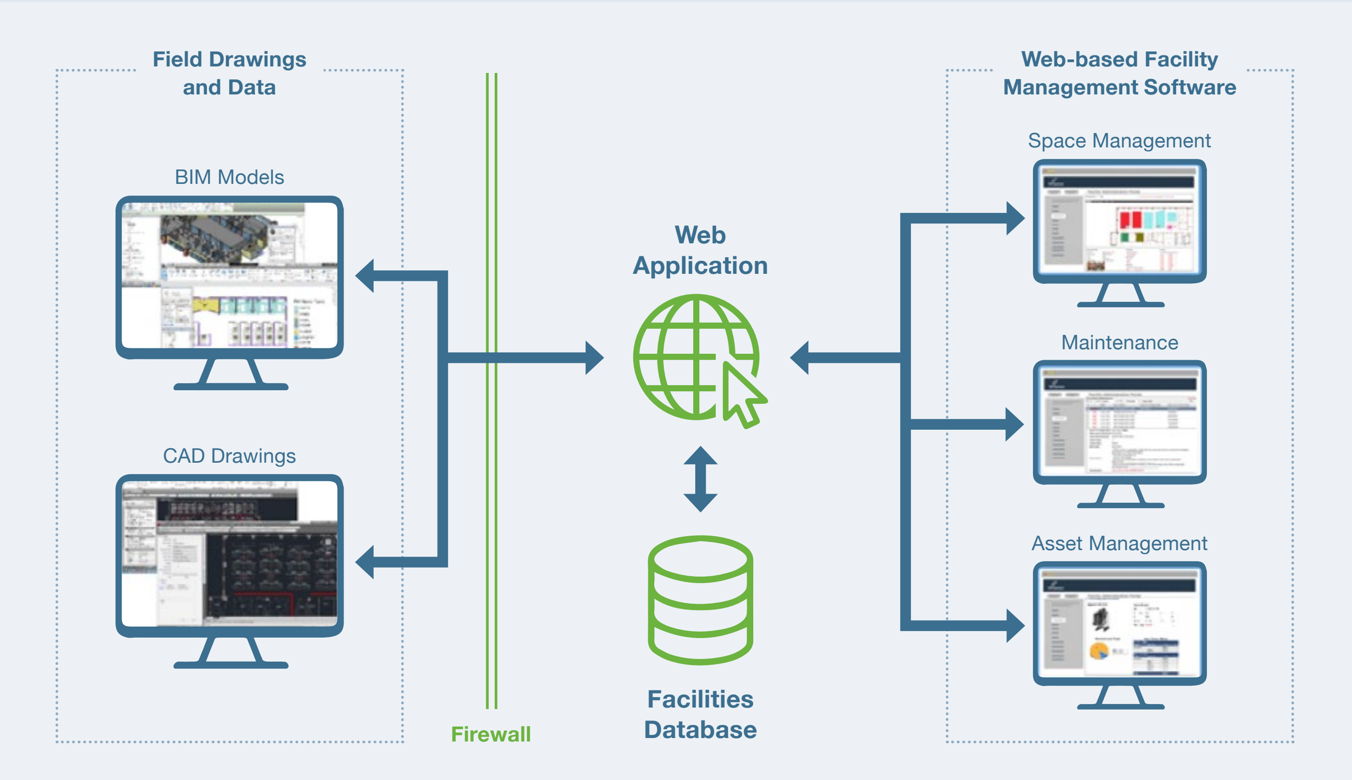


Figure 23: Lifecycle example of BIM coupled with a facility management system

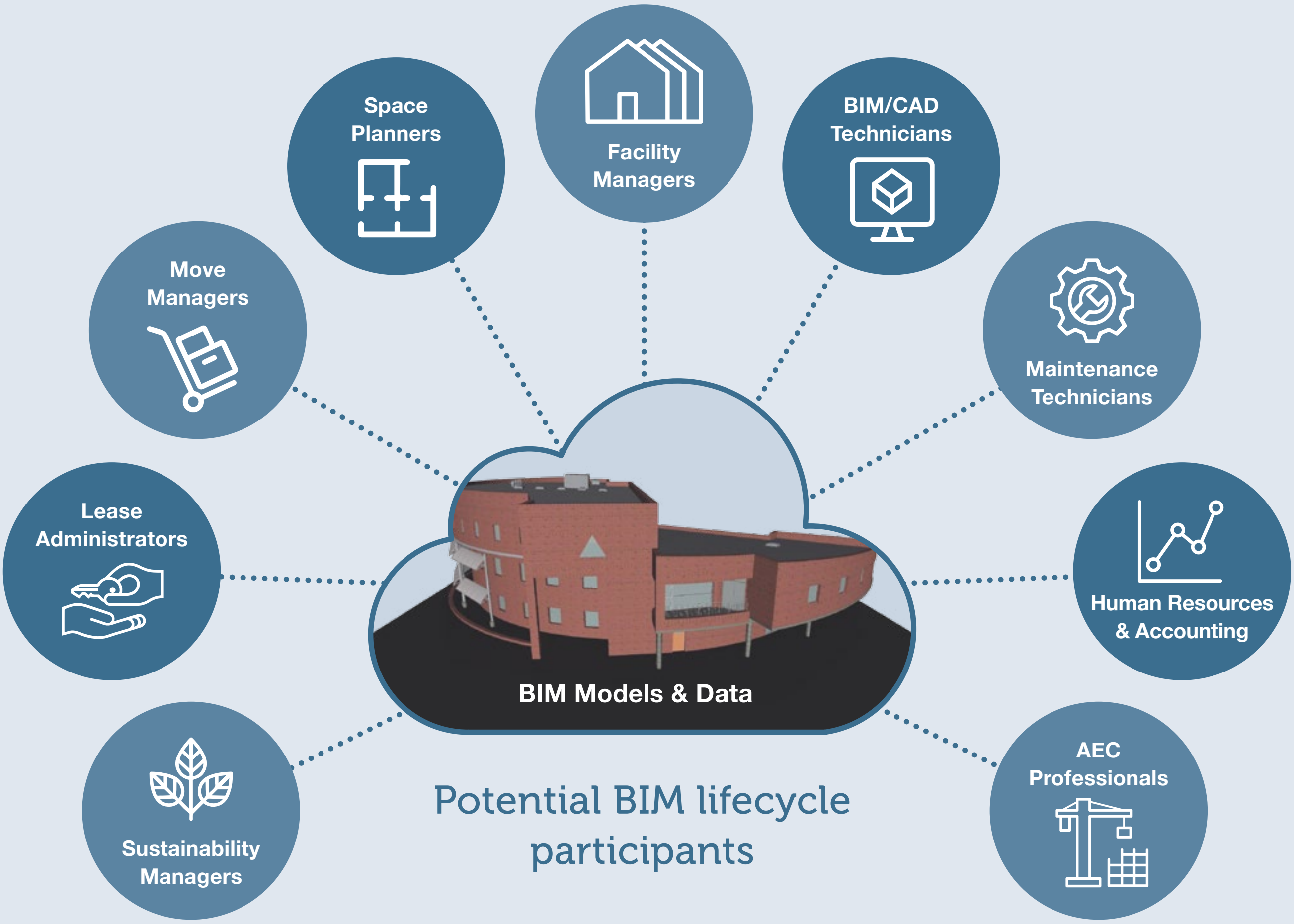


Figure 24: Collaboration enables lifecycle BIM

The most basic use case is when a maintenance technician spends their time in the field completing both preventive and corrective maintenance tasks. Their view of BIM data may be as limited as seeing asset details or maintenance information on a handheld device, such as a smart phone, and may not even interact with a 2D floor plan as they go about their daily maintenance tasks. They could also be performing additional tasks such as barcode scanning assets and logging their conditions through a limited data-driven form. This type of very specific access is distributed broadly to staff who interact with facilities data every single day, anytime and anywhere. This allows them to quickly and easily access and update a Building Model, which is the key to high quality lifecycle maintenance of the model. In this example, there is no actual experience with the building modelling authoring tool needed, for the majority of the lifecycle BIM tasks required to maintain a healthy model.

A facility management system that has a live bi-directional connection to the Building Model is the best way to ensure that a model continues to live on and provide value to building owners through the lifecycle of a building. A primary method for achieving this is by providing distributed secure access to AEC and facilities management professionals in a way that allows those specialists to provide the services needed to ensure the continued accuracy and security of the model. Figure 24 illustrates potential BIM lifecycle participants for a facility.

6.7 Space as the Basic Organiser of Facilities Data

To successfully track and report on facilities data, a method to reference ‘places’ in the building is needed, particularly with respect to occupants and assets. Tracking systems should be established at two levels: rooms and spaces. For linear infrastructure asset, there are three different types of methods to define Space or Location: topological, geospatial, and geometric. Topological methods including linear referencing and network referencing describe locations along discrete but interconnected networks of features. Geospatial method provides a way to describe locations on the Earth’s surface in real-world coordinates. Geometric method is based on digital models that provide coordinate geometry within local model coordinates. Detailed explanation of these three methods can be found in the Project *Research Report*.

6.7.1 Rooms

Rooms are divisions of a building floor typically enclosed by interior walls and defined as ‘room’ elements within the Building Model, although there may be some cases of rooms that are defined by space separations rather than walls.

It is critical that a room numbering system be established that corresponds to building signage and is coordinated with room finish schedules. Establishing this system may require a workflow step transition between construction room numbers used for the building construction process and occupancy room numbers used for the operations phase of the building’s lifecycle.

Room numbers should be unique by building so that the combination of a building ID and a room ID defines only one location (Figure 25).

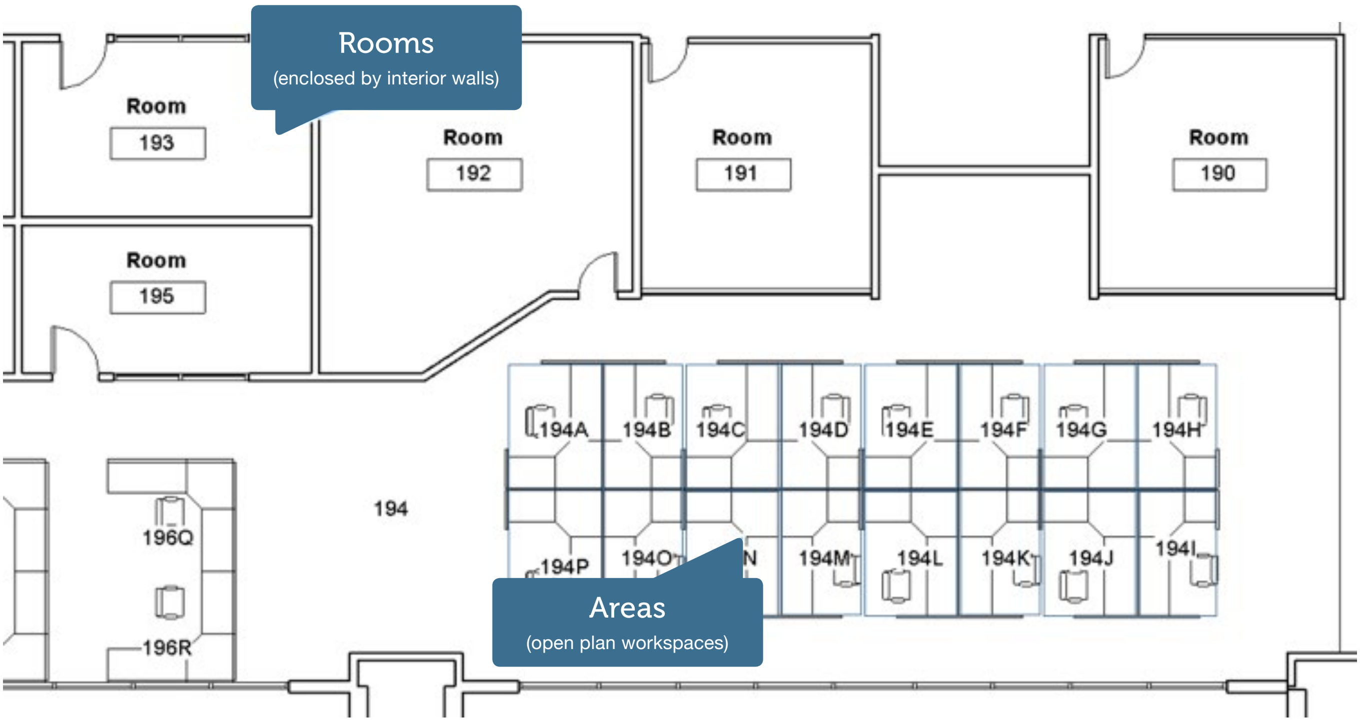


Figure 25: Example of rooms and spaces

6.7.2 Workspaces

In office buildings, and buildings where occupancy tracking is important, it is essential to establish a system for tracking workspace areas (spaces). Where workspaces are closed offices, these will be identical to rooms, but for open plan workspaces multiple areas will exist within a single room. For that reason, a separate system is needed for these (Figure 26).

All spaces should be identified with space ID numbers that are unique by building, correspond to building signage and are used as the primary reference in the facility management system for occupancy management, move management and facility maintenance.

Spaces in BIM are available in the Cloud Facilities Management

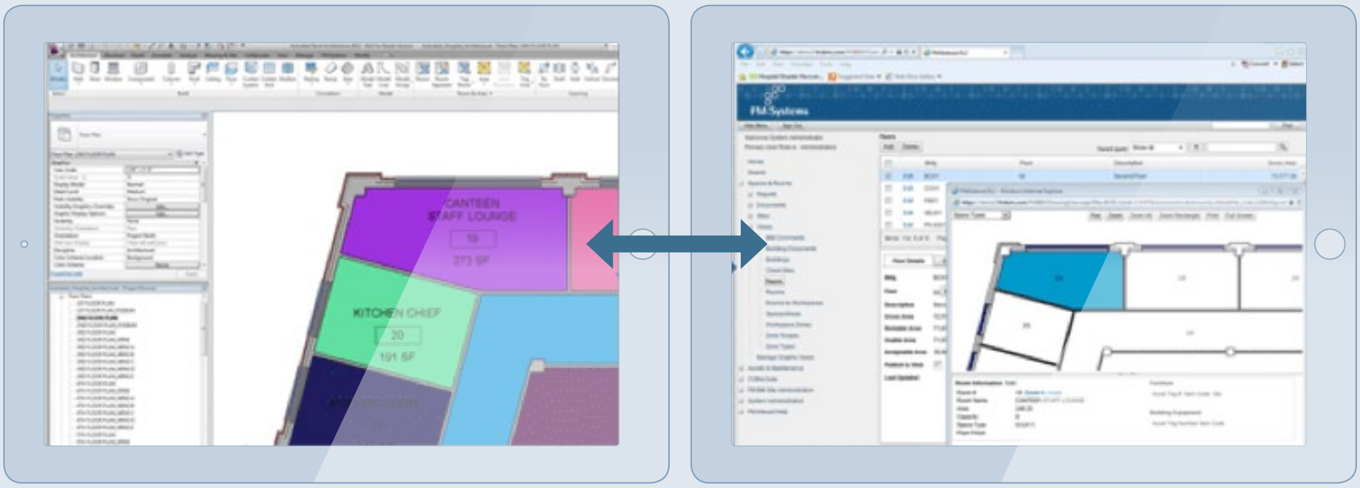


Figure 26: Space in BIM with identifiers for FM

6.8 Assets as a Cornerstone of BIM and Facilities Maintenance

Once an asset owner's space is organised and optimised they can begin the task of tracking their assets. Typically, the types of assets that are initially most important to owners are ones that need to have maintenance performed on them on a regular basis and are required for the functional operation of the building and infrastructure. Examples include the main components of HVAC systems and traffic systems, or key components of safety systems. The assets in these types of systems include air handling units, chillers and pumps that require maintenance technicians to perform both routine preventive maintenance as well as corrective maintenance when components malfunction. As maintenance is performed, several pieces of information begin to be compiled on each asset including its maintenance history, warranty status and possibly asset replacement as it goes beyond its useful life.

6.8.1 Classification of Equipment

Not all equipment has moving parts, or needs regular maintenance, but it may still require information beyond location. For example, an electrical disconnect that uses Residual Current Device (RCDs) or fuses for 'over–current' protection may only require attention occasionally. Immediate access to the RCD or fuse type and size for that disconnect, and the equipment that it protects, can not only save time, but may also save costs.

Another example of a static type piece of equipment would be a 'ball valve' that is used to shut off domestic water to a section of an asset. That item may never need maintenance, but will definitely need to have a location findable in a BIM-FM model. In order to properly classify the equipment for maintenance and other requirements, the Facility Manager must understand the data needed to populate the BIM for use for an asset and maintenance solution. There are several sources of information for the equipment: manufacturers' data sheets, equipment submittal packages, recommended maintenance schedules and nameplate data, some of which are explained in the following paragraphs.

6.8.2 Equipment Nameplates

Mechanical, electrical and plumbing (MEP) equipment will most often have a stamped nameplate that is permanently attached to the component. Common information for a nameplate is manufacturer, manufacturer's address, model number, serial number and certification marks. In addition, electrical data will include voltage, amperage, frequency and phase requirements; motors may include information on horsepower, efficiency and RPMs; and pumps may have rated flow, head pressure, maximum flow and pump type. The more complex the machinery, the more information necessary to relay the required operating conditions. Including the nameplate data of equipment in the BIM for FM model would be an excellent resource for the Facility Manager. For existing buildings or infrastructure assets without a BIM, the nameplate data may be the only available source of information for a piece of equipment.

6.8.3 Submittals

The submittal process is intended to guarantee that the contractor installs the equipment as specified in the contract documents. Like the nameplate, the submittals include manufacturer information, model details and other relevant data. As part of the submittal process, the design/bid team must approve the documentation submitted by the contractor. If specific attributes are identified ahead of the process, then the designer can include them as part of the data collection process in a standardised way that matches an asset owner's data standard. This will, in turn, allow for extraction of data sets that will make it much easier to bring the data into a technology solution such as IWMS, CAFM or CMMS software (described earlier).

Unlike the nameplate data, the submittals will include the datasheets for equipment, and can list replacement parts and maintenance schedules. The submittal process occurs relatively early in the construction process, as approval is required before ordering equipment. This approval time period will require the Facility Manager to have input during

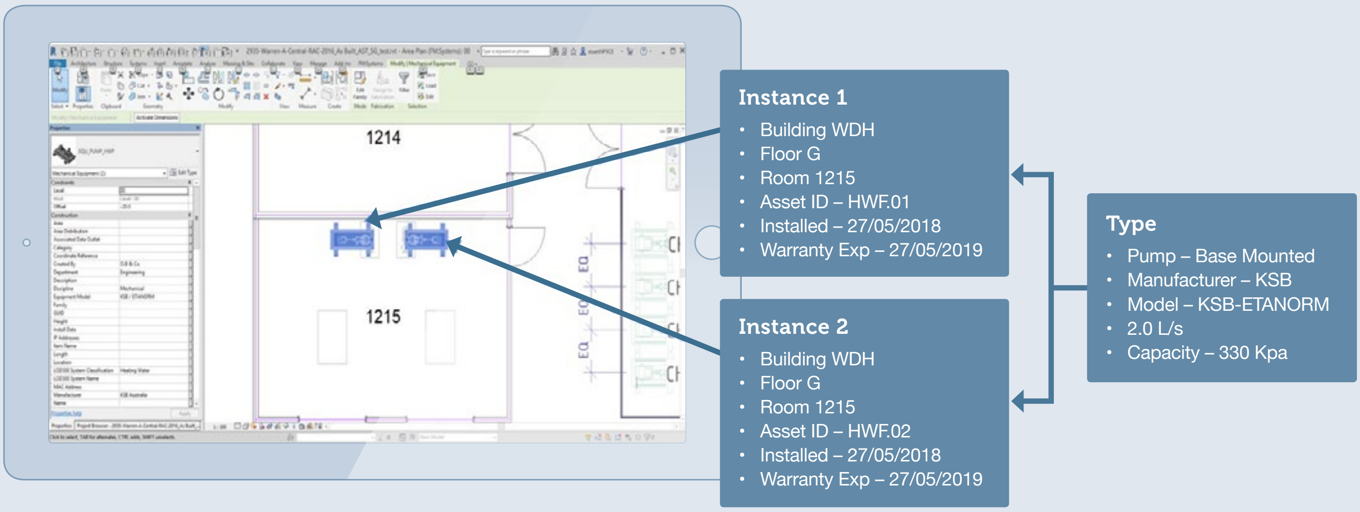


Figure 27: Type and instance properties for pumps in a building

the preconstruction phase and coordinate the data input responsibility with the designers. Many large contractors utilise document management software systems (DMSs) that may be able to automatically populate the design model with equipment data that can migrate to the BIM-FM model.

6.8.4 Control Sequences

In some instances, the key piece of data for a component will be the control information in relation to the overall system. For example, as described earlier, a ball valve that is identified as controlling a specific area of an asset may need to include that information as an attribute. Likewise, listing the electrical panel that provides power to equipment is not only required for workers, but it is also a safety requirement. The Facility Manager will need to fully understand the system as a whole in order to ensure that the correct data is used.

6.8.5 Type versus Instance Properties

Efficiencies in data acquisition and use, can be gained by distinguishing between ‘type’ properties and ‘instance’ properties. Type properties are attributes of a component that are true for all occurrences of that type of item. For example, a building or infrastructure asset might use the same model of a pump or air handling unit in ten locations. The model number and basic specifications for the pump would be identical and should therefore be tracked as part of the ‘type’.

Other properties will be unique to each occurrence. For example, each pump would serve a different zone of the asset, so the zone would be an ‘instance’ property. Examples of type and instance properties are shown in Figure 27.

Finally, information related to ongoing repair, maintenance and operations would be maintained in the facility management system with a reference to the BIM-FM Model.

6.9 FM Data Requirements for As-built BIM Models

6.9.1 Purposes of the As-built Model

The As-built BIM Model serves three main purposes:

1. It provides the source data from which the BIM-FM Model will be built.
2. It is the source of record for the building or infrastructure. As such it will serve as a reference throughout the asset's life when materials or equipment need to be repaired or replaced.
3. Portions of the model may be used as essential reference data for future renovation and expansion projects.

6.9.2 BIM As-built Model Requirements

As-built models should be delivered standalone by discipline, with discipline models linked unless otherwise specified. The following types of models are examples of the models an asset owner should expect to receive as part of the As-built modelling package:

1. Architectural and structural
2. Mechanical, plumbing and control systems
3. Electrical power and lighting
4. Civil
5. Fire protection
6. Special equipment

6.9.3 Data Requirements for Assets

The owner should create a document that specifies the information required for each type of asset. The following principles are recommended:

1. Standard naming conventions to exist across all facility information ranging from file names to object attribution names, to ensure consistency, cross software scalability and accurate reporting. File names for models and drawings should follow: asset number – year – discipline designations.
2. All assets to have as a minimum, the properties of manufacturer, description, model and serial number.
3. All assets to be accompanied by their appropriate specification sheets, installation manuals and operation and maintenance manuals in PDF format.
4. All assets to be placed in the model with dimensional accuracy; assets not directly bound within a room/location will be captured via the nearest room/location's area boundary.

6.9.4 Guidelines for Creating BIM-FM Models

The BIM-FM Model will serve as the 'live' data source used throughout the life of the building and infrastructure. As such, it is important that there be enough information to support building and infrastructure asset maintenance and operations, but not so much as to become burdensome. Attempting to track more data than can be practically updated can result in data of uncertain accuracy, making the entire system untrustworthy.

Attention should also be given to the need many owners have to manage a portfolio of real estate or a jurisdiction, not just a single building or a road infrastructure. Modelling guidelines should be followed to ensure the accuracy and consistency of lifecycle BIM data across the entire facilities portfolio. This information should be compatible with existing CAD-based facilities data in a way that ensures all facilities information is available and usable by an asset owner's team, regardless of whether the information was created in a BIM Model or generated from traditional facilities data and drawings.

The list of general modelling guidelines below will help to ensure consistency through the lifecycle of all buildings in the portfolio. For infrastructure assets such as roads, bridges, tunnels, and rail, detailed asset information requirements are developed, respectively (refer to the Project *Research Report*).

1. Information that should be retained includes the following:
    - Floor and roof plans
    - Reflected ceiling plans
    - Mechanical ductwork and piping plans
    - Lighting plans
    - Electrical power plans
    - Electrical panel diagrams and schedules
    - Fire protection plans
    - Data system plans
2. The following information should be removed to facilitate a more workable model:
    - Details
    - Annotation pertaining to installation or construction
    - Building sections and elevations
    - Working drawing sheets
    - Unnecessary views
    - Unused Families
    - All phases but 'existing'
    - Data fields (parameters) that are no longer needed
3. Information from the following disciplines should be included:
    - Architectural
    - Mechanical, Plumbing and Control Systems
    - Electrical Power and Lighting
    - Fire Protection
    - Special Equipment

4. Standard naming conventions should exist across all facilities information ranging from file names to object attribution names to ensure consistency, cross software scalability and accurate reporting.
5. Specific guidelines are as follows:
   - File names for models and CAD drawings should follow: Building number – discipline designations;
   - All assets should have unique identifiers and should adhere to the following:
     - All assets to have at minimum a detail level of: Manufacturer, model and serial number.
     - All assets to be placed dimensionally accurate; assets not directly bound within a room will be captured via the nearest room's area boundary;
   - Room numbers, room names and room finish;
   - Space numbers for office areas with workspace name and space type.
6. BIM-FM Models should be delivered standalone with multiple models combined to the extent practical, though consideration should be given to large files size and performance.

6.9.4.1 Systems

Systems include components, assemblies and systems which are a part of the overall asset. Asset owners should create a list of standardised systems that will be used across all of their facilities as this will ensure better reporting results and greater integrity of information. Examples are HVAC systems, civil and structure, traffic control system, fire protection, electrical power and lighting.

6.9.4.2 Object Type

Object type is the name of the components that make up a system. These are typically the components that need to be directly maintained by facility teams either through preventive maintenance programs or by corrective maintenance requests. Object types are also usually at the 'catalogue item' level when facilities teams need to track inventory and do not represent individual instances (inventory) in a system or on a floor.

6.9.4.3 Type Attributes

The specific attributes or properties tracked and maintained in the BIM-FM Model vary by system, but in general should include the information required for ongoing asset maintenance. For building or infrastructure equipment, essential type attributes are manufacture, description, model number and relevant information on maintenance procedures.

6.9.4.4 Instance Attributes

Equipment items should be identified with a unique asset ID. This ID should also be clearly labelled on the item of equipment with a durable label, generally showing the ID number and a barcode. Equipment items should also have the serial number tracked and any performance properties essential to operations.

Judgment should be used to avoid attempting to track more information than can be maintained in an accurate state. Information of uncertain accuracy is worse than the absence of information. It is possible to have dozens of attributes associated with an object but this guide recommends that asset owners begin by tracking information that is likely be used for the day-to-day operations and maintenance of the equipment and space within the facility. Additional attributes can be added over time as necessary.

6.9.4.5 Required

It is important to understand data priorities in terms of required versus optional information at the object or attribute level. This can help to create a very basic rule that says whether or not the specified piece of information is required and can aid in enforcing standardisation around which elements will be tracked across a facilities portfolio.

6.9.4.6 Data Source

In the context of this guide, data source is used to describe where the authoritative source lies for individual attributes. The two primary locations in lifecycle BIM are either the relational database in the facility management system or the BIM Model. Consideration for which data source is authoritative, is important, so that an owner knows which data location controls the ability to update or change information associated with individual attributes. An example would be ‘space type’ for an individual space, area, corridor, segment or room in a facility.

Space type is typically managed in the space management module of the facility management system and is linked to the BIM Model for viewing purposes only within the modelling environment. Conversely, attribute level information about airflow or power requirements might be more appropriately maintained and updated in the BIM Model and linked to the facility management system for viewing and reporting.

6.9.4.7 Model Element

Model element simply means whether or not the object or attribute has been physically modelled as either a 3D or 2D element in a BIM Modelling platform. In general, each element will be modelled according to its size, shape, location, orientation and quantity. At the early stages of the project, element properties are more generic and approximate, but become more specific and increase in accuracy as asset data is gathered.

6.9.4.8 Data Only

Similar to model element, ‘data only’ means it is the object or attribute simply being tracked from a data perspective and is not required to be modelled in the modelling platform.

6.9.4.9 Source Model

Often a complete BIM Model may contain multiple individual models with each model representing a specific trade, system or approach to modelling. Example models that might be included are:

- Architectural
- Mechanical, Plumbing and Control Systems
- Electrical Power and Lighting
- Civil and structure
- Traffic control system

6.9.4.10 Responsibility

This part is used to track the party's responsibilities for maintaining the specific systems, object or attribute. This can either be a named member of the facilities management team, BIM partner, or more simply, it could be the name of the role associated with maintaining this information.

Figure 28 provides an example of a spreadsheet as a starting point for tracking each of the individual items described above in the Lifecycle BIM data recommendations section of this document.

BIM FM Models									
System	**Object Type**	**Type Attributes**	**Instance Attributes**	**Required** Yes/No	**Authoritative Data Source** Model/Data	**In Model** Yes/No	**In Data** Yes/No	**Source Model** Arch/MEP etc.	**Responsibility**
HVAC									
	Air Handler								
		• Manufacturer							
		• Model							
		• Description							
			• Asset ID						
			• Air Handler Number						
			• Serial Number						
			• Cooling Capacity						
	VAV Boxes								
		• Manufacturer							
		• Model							
		• Description							
			• Asset ID						
			• VAV Box Number						
			• Serial Number						
			• Air Flow Capacity						
	Pumps								
		• Manufacturer							
		• Model							
		• Description							
			• Asset ID						
			• Pump Number						
			• Serial Number						
			• Flow Capacity						

Figure 28: Example of a requirements document for a BIM-FM Model

6.10 Issues Encountered with BIM Models Supplied for Conversion to BIM-FM

Some of the common issues that have been found through the process of conversion, including re-using assets held in design/construction BIM models for use in the facilities systems, are as follows:

- Assets such as wall mounted A/C units entered into models during design/construction modelling phase, may be related to a wall by the designer, for the purposes of scheduling, and location and install in construction. The same A/C unit asset needs to also relate to the floor level in the model for facilities purposes. Note that FM software technology would normally recognize and transfer assets related to a floor level in Revit.
- The horizontal plane used to generate plan views from the model also should be placed directly underside of the floor slab to ensure all assets on that floor are discovered by automatic pick up in the software. Note assets located on a wall above a cut line may not be found by automatic software that detects the assets.
- BIM Models contain assets that have been inserted from various BIM libraries (e.g. Revit family libraries). These are normally downloaded from BIM libraries and/or manufacturers catalogues, or created by design offices. Whilst the family libraries have been constructed with accurate geometry, standards and conventions in mind (e.g. OmniClass or COBie2) there are bound to be variations or even unique objects constructed by the designer; where no such object could be found in a library. FM software has naming mapping tools to match field names and parameters found in the Revit family object, to the target field names of the assets in the FM database schema, for the case where they don't already match.
- Mapping may be set up as a template for an Asset owners' specific building or infrastructure; however, the mapping template will need to be reviewed and modified if required for another BIM model, which may have been constructed by an entirely different deign/construct team. This issue highlights the importance of having consistent, usable, industry wide standards, such as are being established by organisations such as NATSPEC in Australia and New Zealand.

6.11 Pre-flight Preparation of BIM for Better Data and Operational Use in the FM System

The experience of ASt and their customers (e.g. Warren Districts Hospital Case Study and James Cook University Biosecurity Building Case Study) has been that even following the traditional As-built process carried out by the contractor, there is still missing data, incorrect data and duplicate data in the BIM model. This issue is enough of a problem to disrupt the excellent concept of using BIM for FM. The data needs to be checked before linking the BIM Model to the FM System.

To prepare BIM Models for ongoing use in the facilities system, ASt and their customers use quality checking software technology to pre-flight quality assurance (QA) the model data, to ensure models have no missing data and correct data. An example would be to ensure that the BIM Model has the correct 'Space number' and no duplicate Room or location IDs. The BIM Assure software technology (Figure 29) uses rules and analysis algorithms, to both check/update the data in the cloud and synchronise updates back to the Revit model on the desktop. Similarly, BIM Assure can provide an easy method to directly enter data into the BIM Models and verify. All relevant members of the BIM team can access and check the model in the cloud.

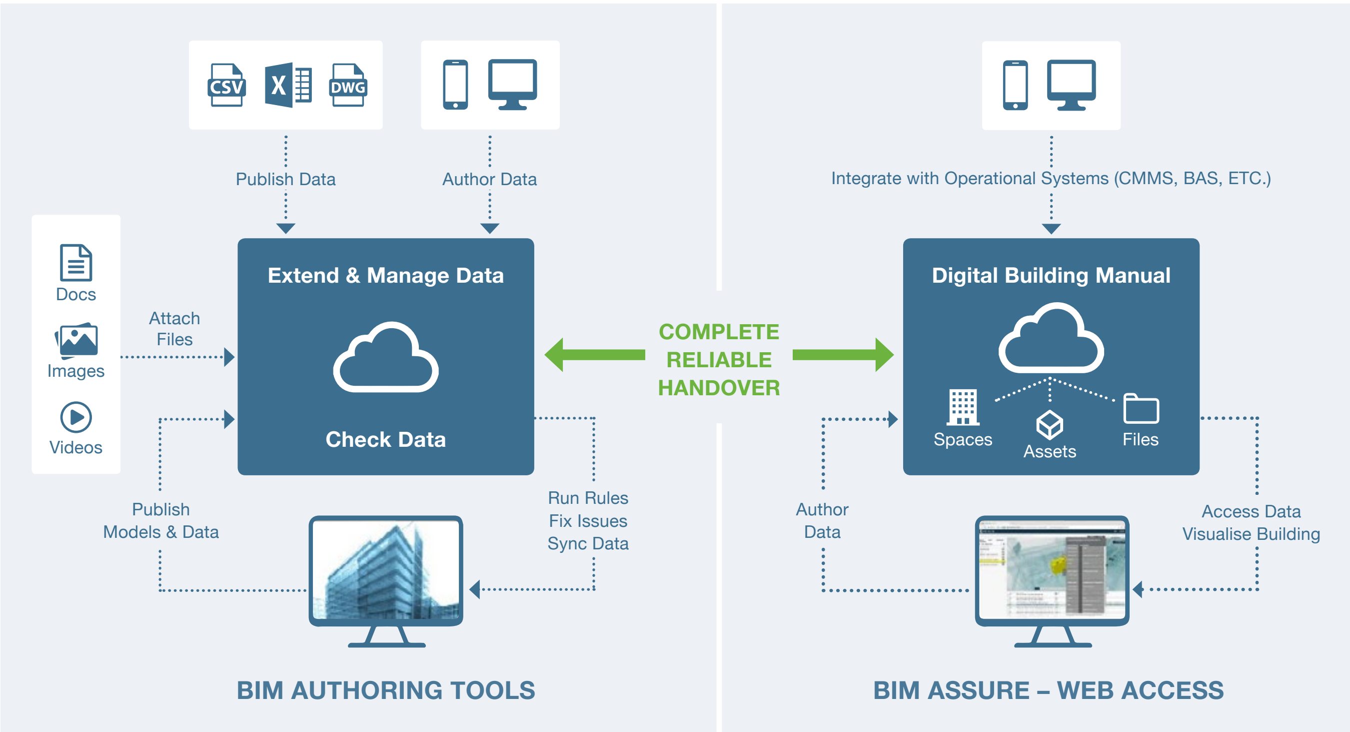


Figure 29: BIM Assure cloud access

7 Recommendations and Conclusions

This concluding section provides guidance on whether to ‘BIM or not to BIM’ (Table 5). Rather than use ‘housing’, ‘buildings’ or ‘transportation infrastructure’ as divisions as per other sections in this project including the case studies, the recommendations have been divided into ‘internal’ and ‘external’ assets, for reasons elaborated in the following section.

Full BIM is considered as containing both geometrical and non-geometrical information. However, a digital model containing only non-geometrical data is still considered BIM.

The following recommendations are general. Each potential use of BIM for asset management should be considered on its merits and specific requirements, with the information in the recommendations available as a guide.

Available Information	Internal assets	External assets
No existing documentation	Gather non-geometrical data using mobile devices and store in the asset database keyed against AssetID, ContainingSpace and System. A staged approach, with high value, high maintenance assets or those with legislative requirements as the first priority. Lower value, lower maintenance items could then be tackled in a staged manner.	Use unmanned aerial vehicles (UAVs), photogrammetry and post-processing to generate GIS representations for locational referencing. Add high value, high maintenance assets or those with legislative requirements as the first priority. Lower value, lower maintenance items could then be tackled in a staged manner.
Existing 2D design documentation	Use existing documentation as a starting point for data gathering as per above. Use existing documentation as the basis for 2D locational interfaces.	Use existing documentation, with UAVs used to validate critical 'As built' data. Use existing documentation to add non-geometrical data to the asset database.
Existing BIM	As per above, but edit BIM to suit data export/import constraints.	As per above, but edit BIM to suit data export/import constraints.
New project	Set up contractual requirements to ensure that both required geometric and non-geometric data is provided by the entities best able to provide it. Ensure there are incentives for providing reliable information. The COBie approach provides a good basis for this.	Set up project contractual requirements to ensure that both required geometric and non-geometric data is provided by the entities best able to provide it. Ensure there are incentives for providing reliable information. The COBie approach provides a good basis for this.

Table 5: Recommendations for BIM in asset management

At first glance, it may appear that there is little in common between a house, multi-storey office building and a road or railway facility. Some of the differences between the types of asset are shown in Table 6 below.

	Housing and Buildings	Transport Infrastructure
Ownership	Single title.	‘Ownership’/responsibility may be divided between multiple parties, for example: Road Authority; Water Authority; Electrical Authority.
Location	Internally, referenced to containing space.	Geo-spatial location system.
Systems	Potentially complex, inter-related services.	Simpler, linear systems.

Table 6: Comparison of buildings and transportation infrastructure characteristics

However, while the physical detail of assets can vary significantly, Table 7 illustrates some significant commonalities. This report has defined a single process that supports various levels of use of BIM to support asset management for housing, buildings and transport infrastructure. The asset owner or manager needs to consider a range of factors before deciding to what extent BIM should be used within their asset portfolio. However, it is clear from this report’s findings that BIM, even in its simplest application, has a valuable role to play across the facility asset management spectrum.

	Housing and Buildings	Transport Infrastructure
Range of sub-assets	Buildings are located within sites, often with significant external assets.	Transport systems often include buildings, such as stations and shelters.
Services	Contain a wide range of services.	Normally, power, water and communication systems parallel transport corridors.

Table 7: Commonalities between building and transportation infrastructure assets

This project grew from the need of industry partners of the Sustainable Built Environment National Research Centre (SBEnrc) for asset management systems that spanned across housing, buildings and transportation infrastructure assets. An international review of the state of BIM-based asset management indicated that existing asset management frameworks were not comprehensive enough to meet the identified needs of industry partners.

While the research within this project progressed, a number of other asset management initiatives commenced, in Australia, New Zealand and overseas. Due attention has been taken of relevant other initiatives to ensure that the approaches are harmonised as much as is appropriate. However, as far as we are aware, the results of this project are positioned in a leadership standpoint in digital asset management activity.

It is expected that future research will be necessary to:

1. Expand the range of infrastructure asset types;
2. Embed the learnings from additional implementations of the approaches defined in this report; and
3. Exploit the additional capabilities of both BIM and asset management software systems, as the industry and its processes continue to mature.

Together with the associated *Digital Asset Information Management: Case Studies* report, it is trusted that this Guide and Manual will aid in the wider adoption and consistent curation of digital information for maintaining and operating assets across the built environment supply chain. Expected outcomes from this SBEnrc initiative, together with other aligned projects, are greater efficiency in managing community assets and returns on investment, and improvements in sustainability, facility resilience and safety.

This research would not have been possible without the ongoing support of our industry, government and research partners:

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