Using COBie with Existing Housing Asset Information

Case Study Report

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Research Project 2.46 Whole-of-life Value of Constructed Assets through Digital Technologies

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1 EXECUTIVE SUMMARY

This case study investigates the practicalities of translating the structure of an existing housing asset information database into a COBie format to facilitate the exchange of information with BIM models generated in the procurement of new housing assets. Sustainable Built Environment National Research Centre (SBEnrc) Core Member Queensland Department of Housing and Public Works (QDHPW) manages over 50,000 public housing units and generously provided access to its extensive asset information to facilitate this study.

The study assesses the symantic challenges of data conversion that are likely to arise within any asset-owning organisation considering the adoption of BIM and integration with an existing asset management system. This is just one of many factors to be considered by an organisation contemplating BIM implementation. The QDHPW data allowed a realistic situation to be evaluated; however, consideration of the broader questions pertaining to BIM adoption are beyond the scope of this study and no recommendations are made as to whether or not BIM should be implemented by the Department.

COBie (Construction Operations Building information exchange) is a tool for exchanging digital asset information from a BIM model to a computerised asset management system. The significance of this is the potential saving of many hours of work that are traditionally spent manually transcribing as-built documentation and manuals into the owner's asset management system. COBie can be presented as a spreadsheet workbook containing a suite of linked worksheets or tables. Each table addresses a particular characteristic of a constructed asset including: facility (address), floors, spaces (rooms), zones (groups of spaces), and components and type (the elements of which the facility is built).

BIM (Building Information Modelling) is a rapidly emerging digital technology and activity with the potential to greatly improve the efficiency and effectiveness of the design, construction, operation, maintenance and decommissioning of constructed assets. The implementation of BIM has largely focused on the design and, more recently, construction phases of the asset lifecycle, however the greatest benefits of BIM may lie in the operational phase. Implementation of BIM for asset/facility management, maintenance and operations will present a number of potentially disruptive challenges such as integrating the BIM digital asset information model generated by a new asset with an existing asset management system.

The prevailing practice is to provide as-built asset information in a mix of paper and electronic documents as the delivery phase of the project achieves Practical Completion. This is then manually transcribed into the asset owner's asset information system. Consequently, the BIM digital asset information model is frozen at Practical Completion and the intrinsic value of the model is lost together with any long-term benefits of BIM to the asset management function.

A key step in the implementation of BIM for whole-of-life asset management will be the automated exchange of digital asset information from the BIM model to existing digital asset management systems. To achieve this, the content and structure of asset information in BIM and the asset management system must be aligned. The use of a COBie template may provide a means for asset owners to specify how asset information should be structured. The completed template could then be used to facilitate a digital exchange process between a BIM model and existing asset management system.

The use of BIM for asset management and the associated use of COBie with existing assets and asset owner's information requirements are all areas in which academic research and practical case studies are limited. In the USA, the National Institute of Building Sciences (NIBS) working the US Army Department of Public Works has demonstrated how COBie can be used to record information from an audit of existing constructed assets [1]. While research in Australia has suggested that if BIM is to progress beyond the Practical Completion of new constructed assets then a 'benefits framework' needs to be established [2].

There has been some discussion on professional industry websites as to the value of COBie and suggestions that the integration of BIM and asset management systems will eliminate the need an information exchange tool. While in principle this may eventuate, it will still be necessary for asset owners to define their asset information requirements and to integrate BIM with existing asset management practices for which COBie may provide an appropriate methodology.

An important principle in the use of COBie is to maintain the structure of the COBie asset data tables so that the methodology can be applied repeatedly across many and varied projects and assets. The case study found that the housing asset information did not readily align with the generic COBie workbook tables. The housing asset information has evolved over many years and is structured in a manner that on occasions combines type, component, space, facility and other information in a manner that must be deconstructed to achieve alignment with the COBie tables. In addition the housing asset information focuses on components of interest to the Department for purposes of maintenance and condition monitoring and does not represent all the constitutes of a public housing property - certainly not to the level of detail envisaged in COBie. A key aspect of the Department's work is the management of public housing properties and leases; COBie with its focus on asset operations and maintenance does not address such property management information.

It was not possible to fully overcome the challenges involved in producing a COBie template aligned with the housing asset information lexicon. However, it was found that the use of picklists[1] and attributes as allowed within COBie provides a means for an asset owner to articulate the terminology used in their existing asset management system. The creation of a 'Property Table' based upon the COBie format resolved the need for property management information.

It is concluded that while COBie provides an established international framework for asset information data exchange, its adoption, and by extension the adoption of BIM for asset management, will be disruptive of existing asset management systems. Nonetheless, if the benefits of BIM are to progress beyond design and construction to bring whole-of-life value to asset management then the digital integration of BIM and asset management systems is essential. COBie provides a template by which asset owners can specify their asset information requirements to align with existing asset information systems. To fully realise the value of BIM to asset/facility management COBie may need to further evolve and existing asset management systems further adapted. Consequently, the adoption of BIM for asset management is likely be somewhat disruptive and the use a 'benefits framework' enabling asset owners to clearly focus on end results and whole-of-life added-value will be a critical success factor.

[1] 'Picklst' is a pre-defiend list from which a user can select data for a given field.

2 DEFINING THE PROBLEM

BIM (Building Information Modelling) enables the creation of a digital asset information model of constructed assets. This has the potential to greatly enhance the effectiveness of the design, procurement, delivery and operations phases. Conventionally the exchange of asset information at the end of the design, procurement and delivery phases (Practical Completion) requires a vast quantity of paper, PDF and MS Office files in the form of as-built documentation and operation manuals. The asset owner[2] must then manually transfer the asset information into their asset management system, consuming many hours of labour at great expense. BIM offers the possibility of automating this process. However, this will not be without challenges for asset owners who will need to detail their asset information requirements in a language and structure suited to a digital asset information model [3].

Existing asset owners are likely to have an established asset management system created in a pre-BIM era, complete with their own lexicon of terminologies. Implementing and integrating BIM with existing systems will present a number of challenges. Not least, how to exchange data from a BIM model to an asset management system and align BIM data with the existing lexicon. It is important that these challenges are overcome if the benefits of more seamless process digitalisation through BIM are not to extend beyond Practical Completion.

'the subsequent transfer of the developed model by the project team to the asset owner is the point where 'real' implementation commences.' [2]

The vision of a BIM is of a whole-of-life digital asset information repository continually updated throughout the life of an asset and supporting each lifecycle phase: design, construction, operation and decommissioning [4]. The application of BIM to the design and construction of new constructed assets is developing rapidly. BIM is likely to become 'business as usual' within a few years, particularly in the United Kingdom and parts of Europe where government leadership has promoted and demanded its use.

The use of BIM in asset management and facility management will be the next step of development. This will create a challenge of integrating BIM-based datasets with more traditional approaches:

'The real benefits of obtaining and maintaining computable lifecycle facility data will not materialize until a significant portion of the new and existing facilities managed by DPW are integrated into a coherent digital system.' [1] [3]

While it might be argued that asset management software will develop so as to offer seamless integration with BIM-related software this will not completely nor immediately solve the problem. While BIM-orientated software for design and construction is progressing steadily, the same cannot be said for asset management software. Furthermore, asset owners will still need to articulate their established terminology so that BIM originated asset information uses the same lexicon.

The development of international standards for asset information classification, *ISO 12006-2:2015 Building construction - Organization of information about construction works*, [5] and data transfer, *BS 1192-4:2014 Collaborative production of information Part 4: Fulfilling employer's information*

[2] There are a number of actors in asset/facility management variously described as: client, asset owners, asset managers, facility or facilities manager. The phrase 'asset owner' is used throughout this report to cover all these actors collectively.

[3] DPW – Directorate of Public Works U.S. Army

exchange requirements using COBie – Code of practice, [6] go someway to addressing the methodology of asset information exchange. However, they do not detail an asset information language nor explain how the structure and lexicon of an existing asset management system should be reflected in a BIM model so as to facilitate the exchange of information. The problem presented by bespoke terminology used by individual asset owners is likely to be a bigger challenge to integration of BIM and pre-BIM systems than the technology and exchange process itself.

This case study investigates the challenges of reverse engineering the asset information exchange methodology known as 'COBie' so that the language it requires to be used in generating BIM-based asset information is aligned with an existing asset management system. If this can be achieved, then an asset owner can provide a COBie template as part of the Employer's Information Requirements to their design and construction team confident that the language delivered in a BIM model and transferred via COBie to the asset management system will be consistent with their existing lexicon.

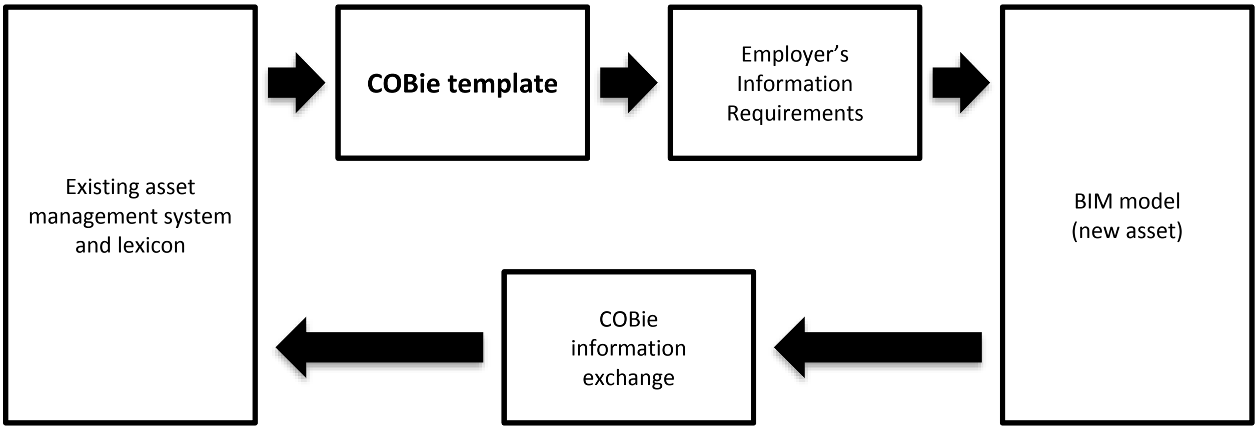


Figure 1: Role of COBie in asset information delivery

The study is timely in an Australian context where the Federal and State Governments are in the relatively early stages of BIM adoption. Both have established working parties to consider the use of BIM and related digital engineering technologies with both new and existing assets. The Queensland Government has established a working party to establish policy and guidelines for the use of BIM on Government projects. One of the objectives set by the Queensland Government for the development of BIM practices is:

> *"To promote consistency and interoperability in the information requirements for state infrastructure projects to facilitate a harmonised approach for industry."[7]*

How to integrate existing asset management systems with the use of BIM on new projects will be an important task for the working party if the State is to avoid inefficiencies of running parallel asset management systems for BIM and non-BIM projects.

To successfully exchange data between a BIM model and an existing asset management system the asset owner must define what information is required, how it is be presented and what language or terminology should be used. This is reflected in the development of 'Asset Information Requirements' and 'Employers Information Requirements' [8] and tools such as COBie (Construction Operations Building information exchange [9].

COBie provides a structured framework to consolidate asset information using a spreadsheet or other electronic database format. In the context of a new constructed asset, designers and contractors add the information progressively, resulting in a complete data set handed to the asset owner prior to Practical Completion. However, it is not sufficient for an asset owner to simply specify in the

Employer’s Information Requirements that information ‘shall be COBie compliant’ – COBie is an information exchange tool, not a specification of information to be provided.

The implementation of BIM for asset and facility management will require asset owners to address the question of information exchange. An understanding of the complexities of establishing an information exchange mechanism will assist asset owners in planning the implementation of BIM for lifecycle asset management and to understand the potential for disruption from this digital technology.

This case study examines the challenges of constructing a COBie template from existing public housing asset information. The intention being that the template is incorporated in the Employer’s Information Requirements document to specify the language and terminology to be used in the provision of asset information by the design and construction teams.

3 LITERATURE REVIEW

3.1 Building Information Modelling

The acronym BIM can be considered to be a product, Building Information Model or a process, Building Information Modelling:

> *"Building Information Model [4] (Product) An object-based digital representation of the physical and functional characteristics of a facility. The Building Information Model serves as a shared knowledge resource for information about a facility, forming a reliable basis for decisions during its lifecycle from inception onward."*
>
> *Building Information Modelling [4] (Process) A collection of defined model uses, workflows, and modelling methods used to achieve specific, repeatable, and reliable information results from the model. Modelling methods affect the quality of the information generated from the model. When and why a model is used and shared impacts the effective and efficient use of BIM for desired project outcomes and decision support." [10]*

In the United Kingdom the definition of BIM has been refined to:

> *The process of designing, constructing or operating a building or infrastructure asset using electronic object-oriented information" [11]*

It is the treatment of information that distinguishes BIM from CAD (computer-aided design) and has the potential to create a single whole-of-life source of asset information. A CAD model contains lines and objects that represent elements and components of an asset, though little or no information about the objects. In a BIM environment an object to which information is attached represents each element and component of a constructed asset.

3.2 BIM and existing assets

BIM is transforming the design phase of the asset lifecycle by enabling architects, structural engineers and building services engineers to work on a single information-rich design BIM. The construction phase of the asset lifecycle has the potential to be similarly transformed by supplementing the design BIM with construction information that will support, for example, modelling of construction processes and elimination of on-site clashes of building elements that can occur when each designer works in isolation. By comparison the potential of BIM for the operational phase of the asset lifecycle is yet to be realised. It can be conjectured that this is because managing existing assets occupies asset and facility managers. Whether or not this true, it is the case that unlike the design and construction professions who can start each asset anew, asset and facility managers will, in all likelihood, require an as-built asset information model to integrate with existing asset and enterprise management applications. However, researchers have largely ignored the application of BIM for asset management and integration with existing business processes.

In four recent and extensive reviews of BIM literature almost no reference is found to existing assets and business processes [12], [13], [14] and [15]. An omission that is highlighted by the paucity of publications and the identification of research gaps:

> *"Most of the selected papers are concerned with 'tracking' and 'generation of an as-built model' at construction stage, while wider applications of BBB [Bridging BIM and Building] at other project stages are yet to be explored" [14]*

"Understanding where BIM resides in a business sense approaching from an organisational view point rather than project view point is an area yet to be explored, and would be relevant to both Infrastructure and buildings domain" [15]

A notable exception is the pioneering development of BIM for facility management carried-out at Sydney Opera House. The case study identified numerous benefits from applying BIM to facility management but noted that:

"In relation to software, it was also identified that a large proportion of the commercial BIM software packages have a specific focus on design and construction phases. However, the asset management and facility maintenance capabilities are seen as lagging" [16]

The literature that is emerging on the use of BIM for existing buildings, tends to focus on the formation of a model through laser scanning and other techniques [17], [18]. A large case study of 32 non-residential buildings on Northumbria University's city campus typifies the perception that BIM for existing buildings begins with the creation of a geometric model from existing data supplemented by new surveys to verify building layout [19].

Although the citied works are invaluable in documenting the BIM implementation process the emphasis is as much on techniques as it is on improving whole-of-life outcomes for constructed assets, leading to the conclusion that:

"the value for BIM and FM has yet to be demonstrated" [19]

Inherent in this statement is an acknowledgement that the adoption of BIM has ignored a basic tenant of effective and efficient change management – beginning with the end in mind [20]. In this instance the end in mind being the operation and maintenance of constructed assets. The operational phase of the asset lifecycle is the longest and most expensive phase, yet there is a significant risk that the BIM model will end at Practical Completion because the information requirements for asset management are not provided for.

3.3 Asset information

In the early days of BIM, the acronym was interpreted as either Building Information Modelling or Building Information Management. Approaching the problem as one of information management rather than information modelling offers the possibility of alternative solutions to the dilemma of how to manage existing asset information data sets in a BIM world.

'Because we too often think of BIM in terms of geometry, we tend to lose sight of the 'I' in BIM, which is information.' [21]

Traditionally asset information (or in the vernacular 'as-built documentation and O&M's') is delivered by the contractor to the asset owner as a mix of paper, PDF, CAD and Microsoft Office documents. The asset owner then has to spend many hours checking the completeness of the information and transcribing it into their asset management system. In a BIM environment it will be possible to automatically check the completeness of information and directly important information into an asset management system.

'BIM offers a technologically driven opportunity for Built-environment stakeholder to break free of the archaic chains of drawings that bind the process, and to revolutionise the system of design, construction and management of the built environment'. [22]

It is possible that the implementation of BIM may enable asset owners to resolve some of the challenges arising from the miscellany of asset information management processes that currently prevail and add whole-of-life value to their constructed assets through digital technologies. Consequently, the integration of BIM with A/FM is likely to be disruptive of existing processes and procedures. Therefore, it is important that appropriate are strategies adopted to ensure the benefits of BIM are sustained beyond the design and construction asset lifecycle phases.

'Fundamentally, the integration of the developed model into the asset owners business will require changes to existing strategic management methods and practices to ensure that benefits are realized. In fact, the model may need to be run in parallel with existing processes unless it is the first asset the owner has ever managed, or they intend to create retrospective BIMs for all their existing stock.' [2]

BIM is not so much a digital technology as business change program aided by digital technologies. Therefore, asset owners need to consider the impact of BIM on their overall business model and the value BIM might bring to their business. Identification of the value or benefits of change and the establishment of a methodology to realize those benefits is seen by some researchers as critical to the successful implementation of BIM:

'For an asset owner the implementation of BIM should not be seen as a discrete information technology (IT) project, but a business change program that can potentially impact the organization's 'value proposition'. Thus, simply identifying and estimating the benefits of BIM are not sufficient as attention should focus on 'how' benefits will materialize and over what period of time.' [2]

Historically limited thought has been given to how asset information should be structured and classified. Asset owners have generally accepted a mix of paper, PDF, MS Office and CAD documents and been reliant upon spine labels and file names as a means of classifying information. The as-built information requirements and guidance on filing published by NATSPEC[4] are indicative of this approach [23].

'owner requirements are represented implicitly and explicitly in a large number of diverse documents …. typically with little formalized structure. In this sense, requirements are often not formalized in a way that matches the content and structure necessary for BIM-enabled project delivery. Existing requirements available from national and international guidelines often fall short in offering a complete set of BIM requirements.' [3]

BIM requires a more robust approach to asset information definition, structure and classification so as to enable the delivery of whole-of-life value to constructed assets through digital technologies.

'The entire theoretical framework of BIM data being used for facilities management is predicated on the assumption that data can be exchanged easily between software programs, specifically BIM and FM.' [24]

The last five to ten years has seen the emergence of standards, industry and academic discussion on the requirements for asset information in a digital environment. The definition of asset information has evolved from 'as-builts and O&M's' to relate the need for asset information to the broader objectives of the asset owning organisation. For example the focus of the ISO 55000 asset management suite of standards is on implementing and maintaining an asset management system so that asset

[4] NATSPEC is an Australian national not-for-profit organisation, owned by Government and industry, whose objective is to improve the construction quality and productivity of the built environment through leadership of information (natspec.com.au).

management practices are aligned with organisational requirements as illustrated in figure 2 [25]. Some two dozen asset management functions are identified in ISO 55000, which recommends that an organisation:

"determine its information requirements to support its assets, asset management, asset management system and the achievement of its organizational objectives" [25]

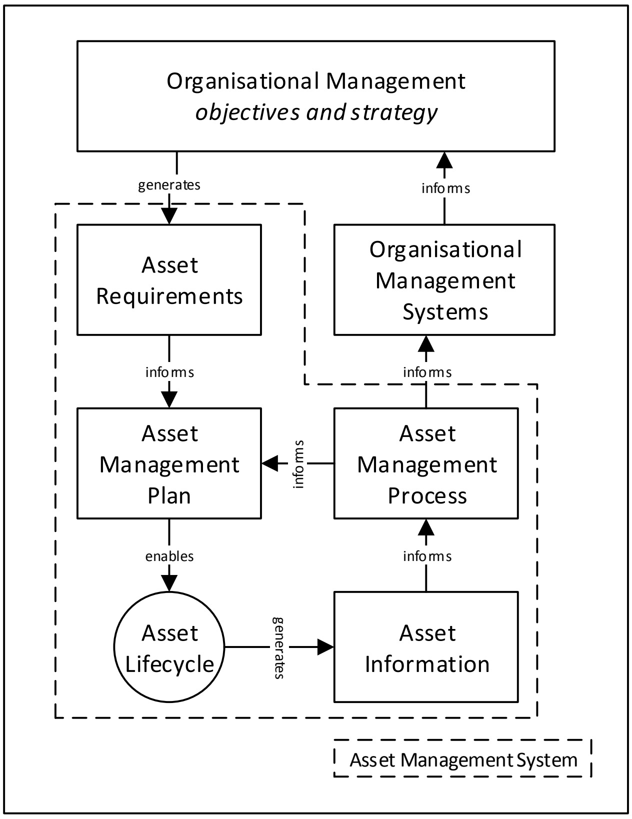


Figure 2: Asset and organisation information requirements

In this model there is no specific place for BIM, though applying the NATSPEC definition of BIM as a product and process then it lies within both 'Asset Information' and 'Asset Management Process'. In the United Kingdom the national BIM implementation strategy envisages the progressive integration of BIM, asset management systems and enterprise (organisational) management systems through information exchange [26]:

- Level 0 - no integration, data exchanged with paper or electronic paper.
- Level 1 - no integration, some data managed by standalone packages.
- Level 2 - integration via proprietary interfaces or 'middleware'.
- Level 3 - full integration via open processes and 'web services'.

The UK Government oversaw the implementation of Level 2 over the period 2011-2016 and is committed to implementing Level 3 progressively between 2017-2025 [11]

In its development of a strategy to improve the efficiency and effectiveness of the delivery and performance of constructed assets the UK Government noted:

“A lack of compatible systems, standards and protocols, and the differing requirements of clients and lead designers, have inhibited widespread adoption of a technology which has the capacity to ensure that all team members are working from the same data” [27].

A sentiment that has been echoed by others:

“owners have not been willing to identify their [information] requirements in a generic way.” [28]

And, included in the objectives set for the Queensland Government BIM working party:

“To promote consistency and interoperability in the information requirements for state infrastructure projects to facilitate a harmonised approach for industry.”[7]

Guidance is emerging from a number of sources on the use of BIM and asset management with the intention of taking BIM usage beyond design and construction and into operations and maintenance. For example: PAS 1192 and BS 1192-4:2014 in the United Kingdom and the ‘National BIM Standard – United Status, version 3’ in the USA [8], [8] [29]. The approach taken in both countries recognises the need for a methodology for identifying, specifying and delivering asset information, a framework for the sharing of asset information between design, construction and operational teams, and clarity with regards to responsibilities. Whilst there are differences between the two nations approaches, there is convergence on the use of COBie (Construction Operations Building information exchange) as an asset information exchange mechanism.

COBie provides a standard framework for the collection and collation of asset information and supports the exchange of asset information between software applications [28]. COBie is an open standard and software neutral, though typically visualised as a suite of linked spreadsheets. It has been shown that COBie can used successfully to exchange asset information between BIM models and computerised asset management systems, potentially saving many hours of labour spent manually entering data [30] [24] [31]. A detailed case study in the USA has demonstrated a viable methodology for using COBie with existing assets through on-site surveys and simple ‘massing’ BIM models [1]. Notwithstanding these affirmations the benefits of COBie have been debated [32], [33] and are considered by some to be unproven:

‘reliable feedback from the market regarding BS 1192-4 standard has not been reported’ [34]

Some scepticism is not surprising given the multi-year gestation period of many constructed asset projects and the fact that BS 1192-4:2014 is less than three year old and BIM Level 2 just a year old. The benefits of COBie may not fully materialise until after Practical Completion whilst the disruption and frustration with implementing a new process is immediate.

Notwithstanding the development of Standards and guides showing how BIM can be applied to the entire asset lifecycle, recent research suggests that asset owners continue to be challenged by the process of specifying asset information requirements [3] [35]. The United Kingdom approach aligns with the ISO 55000 model by proposing the generation of a ‘Employer’s Information Requirements’ specification drawing up the asset information requirements identified within the asset management system. However, whilst the various guides and Standards provide an overview of what ‘asset information requirements’ might be there is no definitive schedule that can be ‘plugged-in’ to a BIM model. What is apparent is that prevailing specifications for ‘O&M’s and as-builts’ do not provide sufficient detail a digital information environment such as BIM and an extensive literature search found only broad, generic, descriptions of asset information.

The Facility Management Association of Australia (FMA) defines facility information as:

> *"data generated in design, construction, operation and demolition of buildings, precincts and community infrastructure; the assets and elements that make up the built environment; and the FM services provided to the built environment." [36]*

And, proposes that information be classified by the purpose to which it is put:

- Strategic aligns quality and quantity of FM services with organisational needs
- Tactical measurable deliverables
- Operational meeting day-to-day needs

A more detailed approach is to view asset information as a pyramid of requirements as proposed by Becerik-Gerber [37]:

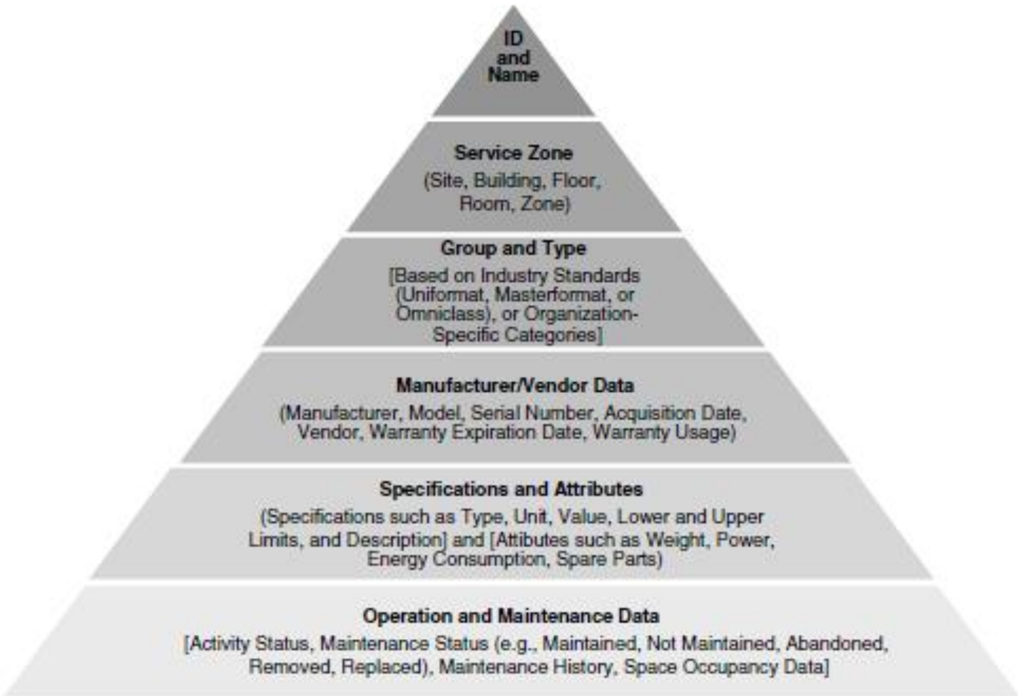


Figure 3: Asset information requirements

A more simplistic approach is taken by Vanier that reduces asset information to that which is required to answer six key questions [38]:

1. What assets do you own?
2. What is the value of these assets?
3. What is the condition of these assets?
4. What tasks are required to maintain asset serviceability?
5. What how long will the asset effectively operate?
6. What is the plan for maintenance of all assets?

Synergies can be seen between the structured approach to information in Becerik-Gerber pyramid and the inter-connected tables used by COBie. Similarly, the COBie framework can be seen to address the questions posed by Vanier. Though others such as Cavka argue that a detailed analysis of work processes and the generation of information flow diagrams is required to identify asset information requirements [3]. Nonetheless COBie provides a means by which asset owners can document their digital asset information requirements.

3.4 Summary

Literature, and particularly case studies, on the use of BIM with existing assets has been found to be limited, causing some to question the value of BIM to asset and facility management. When BIM is used with an existing constructed asset the process of implementation typically begins with the creation of a digital spatial model through laser scanning or other means. This approach is synonymous with the use of BIM in the procurement of new constructed assets that also begins with the creation of a digital spatial model. To a certain extent the focus on creating a digital spatial model is seen in the context of testing laser scanning technology rather than building a data-rich asset information model. A consequence of this is to exclude the possible existence of other digital models such as spreadsheets that can be used with structured data to present the properties of an asset and its elements.

None of the definitions of asset information require a geometric or spatial model as a starting point. In the case of asset owners with an extensive portfolio an obvious starting point is the existing asset management system. This may provide a framework within which to structure asset information and define what asset information is required by the asset owner for operations and maintenance. In this case study asset information data provide by Housing and Homelessness Services within QDHPW provides a starting point from which to investigate the development of an asset information framework that will allow information from both new assets procured using BIM and existing asset information to be integrated through the use of COBie. The QDHPW data allowed a realistic situation to be evaluated; however, consideration of the broader questions pertaining to BIM adoption are beyond the scope of this study and no recommendations are made as to whether or not BIM should be implemented by the department.

4 CONSTRUCTION OPERATIONS BUILDING INFORMATION EXCHANGE (COBIE)

4.1 What is COBie?

COBie provides a standard framework for the collection and collation of asset information and supports the exchange of asset information between software applications. Developed by the United States Army Corps of Engineers and others [28], COBie was implemented in 2007 to improve the transfer of information between the construction and operational phases of the asset lifecycle. A COBie data model provides the core information necessary to manage and operate a facility such as an asset register and preventative maintenance schedule.

COBie is primarily intended for software application-to-application information exchange through digital technologies, rather than an operations manual or asset register read by humans for day-to-day asset management. The data contained in COBie tables can be interrogated to answer a range of questions such as the number of occurrences of an asset type, maintenance frequency and performance parameters. This is best done within a suitable software application such as a property or asset management system that can import the COBie data, rather than by manipulating the tables themselves.

COBie is designed to be application neutral, though is most easily demonstrated in a spreadsheet workbook format such as MicroSoft Excel using a suite of linked tables (worksheets). The suite of COBie tables and their linkages within a workbook is shown in figure 4.

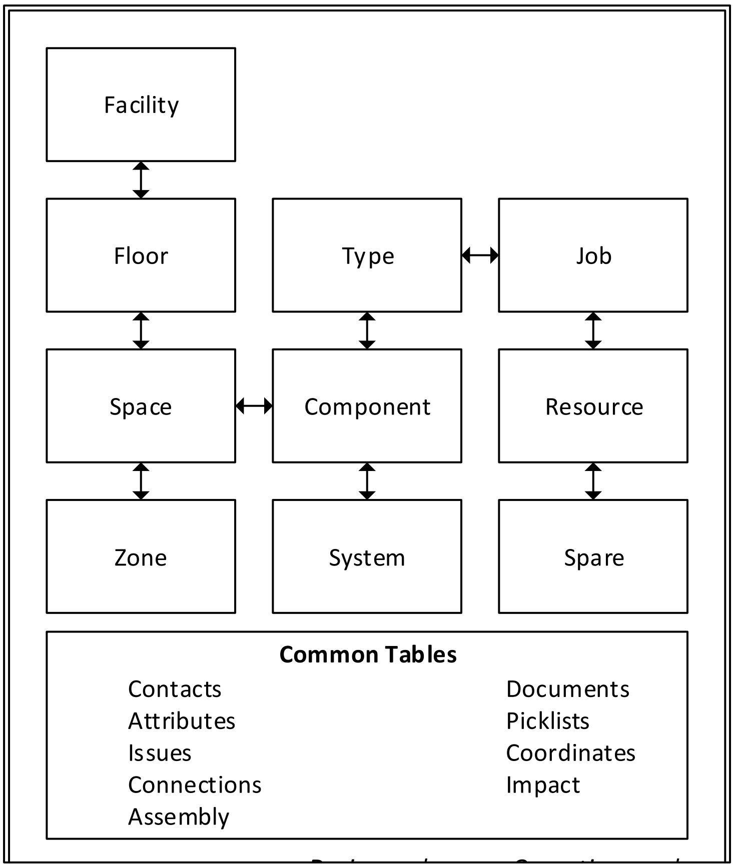


Figure 4: List of COBie tables and linkages

The Facility, Floor, Space, Zone, Type, Component and System tables are used to document the as-built asset information for a facility. The Job, Resource and Spare tables are used to detail maintenance tasks. The common tables provide additional information, and can be used to define data and terminology used in other tables. A brief summary of each table is presented in Figure 5.

COBie Table	Content
Facility	The building or asset that the COBie tables describe
Floor	Each floor, including basements, foundations, external areas, roof space and roof
Space	Defined areas within each floor such as rooms
Zone	A collection of spaces that share a common characteristic such as an air conditioning zone.
Type	Materials, plant and equipment used in constructing the asset
Component	Each occurrence of a 'type' generally located in a specific space
System	A collection of components that form a specific system such as fire detection system
Job	A planned preventative maintenance task
Resource	The resources required to undertake a job
Spare	The spare parts that should be held by the asset owner
Contacts	A schedule of all actors responsible for compiling the COBie tables and other relevant persons
Attributes	Additional characteristics
Issues	A log of issues raised during the design and construction process
Connections	Describes fixing between components and types
Assembly	Aggregation of components and types
Documents	A log of documents required for operations and maintenance
Picklist	Lists of pre-defined entries for fields within other tables
Coordinates	Positional information
Impact	Measures of performance/impact

Figure 5: List of COBie tables (worksheets)

COBie data is captured progressively as a facility passes through the design and construction phases. The design team enters information such floors, spaces and types of materials and plant. The construction team specific information including plant items (Component table), maintenance schedules (Jobs table) and spares to be held (Spare table). The complete COBie tables record the facility at a particular point in time. Typically that point in time would at Practical Completion, however COBie tables could be populated by data obtained during an asset audit or from an asset management system.

COBie is designed to handle information that is largely static or unchanging, for example the address of a facility or the construction of each wall. Dynamic information can be provided for if a static component can be incorporated. For example, asset condition is a dynamic property but is usually measured at a given point in time. By incorporating both condition and date of inspection a static data set is created. Some information held outside the asset information database in other systems such as SAP that HHS uses for financial management. COBie includes fields for creating links to external systems. The information provided for this case study does not identify such linkages and so these fields have been left empty.

COBie has been adopted by national and international organisations as an appropriate framework for asset information exchange. In 2011 COBie was adopted by the US-based National Institute of Building Sciences as part of its BIM standard for the USA. BuildingSmart, a global leader in open data standards for constructed assets, has incorporated COBie into its 'Facility Management Handover Model View for BIM'. The Building Information Modelling [4] Task Group has adapted COBie for use in the UK with a slightly modified set of tables and user guide (**http://www.bimtaskgroup.org/cobie-uk-2012/**). British Standard BS 1192-4:2014 has formalised the use of COBie schema for the production of asset information in a digital exchange model. Guidance on the use of COBie has been published in both the USA [28], [9] and UK [39]. The USA version is referenced in the Australian NATSPEC BIM Guide [10].

4.2 COBie Tables

In each COBie table the columns represent defined fields and each row a data set for a given facet. A typical COBie table is illustrated in Figure 6. The more significant tables are described below and the their fields listed in Appendix

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Name	CreatedBy	CreatedOn	Category	FloorName	Description	ExtSystem	ExtObject	ExtIdentifier	RoomTag	UsableHeight	GrossArea	NetArea
2													
3													

Key		
	required	external reference
	from other sheet or Picklist (required)	if specified as required

Figure 6: Typical COBie table format (extract from Space table)

The first four columns (A-D) in each worksheet generally follow the same pattern:

Column A: Name	a unique identifier (key field) for each row of data and is used as a link between the tables.
Column B: CreatedBy	name of the person updating the row and is drawn from the Contacts table.
Column C: CreatedOn	date of the update for which the ISO format yyyy-mm-dd is recommended.
Column D: Category	link via Picklist table to a national or international classification system such as UniClass1997 in the UK and OmniClass in the USA.

Occasionally compounded keys are used so that linkages can be built from one table to two or more other tables. For example, components are the occurrence of a type in a space and can be identified by a combination of the type and space key fields.

Each field is colour-coded to indicate the source or requirement for data:

Yellow	mandatory field in which data must be entered.
Salmon	mandatory and linked to another table or the Picklist table, must match the source exactly.
Purple	provides information to link to an external system such as BIM.
Green	additional information such as specified by the asset owner (may be mandated and can be linked to a picklist developed for this purpose).

4.2.1 Contact Table

This is the first table to be established as all other tables reference it to validate the name of the person updating a table. During the design and construction phases the Contact table list of all persons likely to be entering data into the COBie tables. The table can also include contacts such as service providers for future reference.

4.2.2 Facility Table

The Facility table sits at the heart of COBie with all other major tables linking through to this table. COBie practice is that each workbook shall contain only one building/facility. Thus the Facility table will typically have only one line of data. Each facility (and hence workbook) requires a unique name so that duplication and conflict does not occur when importing information into an asset management system – the postal address, facility name or other reference could be used for this purpose.

4.2.3 Floor Table

'Floor' is defined broadly as vertical separations and can include substructure, roof and external areas. Once floors are established 'spaces' such as rooms can be linked to their corresponding floor via the COBie Space table. Floor finishes are scheduled in the Type and Component tables and linked to individual rooms as listed in the Space table.

4.2.4 Space Table

The Space table enables identification of functional spaces within a facility including rooms, external spaces and voids.

4.2.5 Zone Table

The Zone table provides for the amalgamation for spaces by function, for example a rental unit, fire compartment or common property. COBie practice stipulates that: every space should be linked to at least one zone, a space may be linked to more than one zone but shall not appear more than once in any zone. A hallway in an apartment block for example could appear in a common property zone and a fire compartment zone. Zones may be nested by structured use of zone names, for example: Fire Compartment – ground floor, Fire Compartment – Level 01. The asset owner may want to specify such structuring in the COBie template.

4.2.6 Type, Component and System Tables

The Type and Component tables work together to identify the products and materials of which a facility is built. The Type table lists details of all the products and materials used. The Component table identifies each use of an item listed in the Type table and records this against the corresponding space in which the item is installed. The System table allows components to be brought together to form a functional system. For example each type of fire detector would be listed separately in the Type table. Each time a given fire detector is used this is identified in the Component table together with the space in which it has been installed. All the smoke detectors in the facility could be brought together as one system named 'Fire Detection System'.

4.2.7 Picklist Table

Picklists play a significant role in standardising terminology between by constraining what can be entered into a field to a pre-determined data list such as floor names, room names and category classifications. Picklists can also be generated by creating a link to the 'Name' field in another table such as in the Component table that includes 'TypeName' from the Type table as a field.

The Picklist table is an exception to the table format, being column rather than row-based. The majority of COBie tables collate information on a particular aspect as a row of data with the content of each individual cell determined by the column heading and consistent for all rows of data. In the Picklist table data is collated in vertical columns with no relationship across a row. Each picklist column heading aligns with a column from another COBie table. Each column contains the data list from which an entry must be picked.

4.2.8 Attributes Table

The Attributes table facilitates the capture of additional information in relation to a row of data in another table. The range of information will depend upon the requirements of the asset owner, design team and contractor. There is no predetermined list of attributes, though suggestions can found in various example COBie workbooks available online such as those listed in the following section. Examples of attributes include design and commissioning data for heating, ventilation and air conditioning equipment, finishes, additional dimensions and spatial descriptors.

4.3 Using COBie

The worksheets within a COBie file provide generic fields for data entry but do not specify the exact information required. The asset owner must be explicit in the information required and detail any particular information parameters used within their existing management systems such as bespoke asset identification taxonomy or a room numbering methodology. This can be achieved by the asset owner creating a Data Dictionary, populating user-definably fields in the COBie worksheets such as picklists and assigning to appropriate the design and construction actors responsibility for providing and inputting asset information.

When using COBie it is not sufficient to simply state: “provide asset information in a COBie compliant format”. A data dictionary or data management plan is required that addresses such matters as what data is to be provided and in what format. Following the standard COBie templates and guides should deliver most core information necessary to manage and operate a facility. However, for data to align with an existing asset information management system, the asset owner must clearly state their requirements in accordance with their internal Asset Information Requirements and documented in the Employer’s Information Requirements as part of the asset procurement contract. Within COBie the asset owner can create picklists of terms to be used with particular fields and thus ensure that their existing asset lexicon is used in the creation of digital models of new assets.

For asset owners with an existing asset management system, information in that system will provide a starting point from which to develop an statement of asset information requirements that can be reflected in the detailed Data Dictionary for COBie via the Employer’s Information Requirements specification. As with a BIM model, there should be only one COBie file in use so as to create a single point of truth and avoid contradictions arising from integrating COBie files from several sources for the same asset.

Asset information is added progressively to the COBie worksheets through the planning, design and construction phases of an asset’s lifecycle. Typically the lead consultant or main contractor coordinates data collation. For example, the designer may specify a particular model of air conditioning unit and enter this detail in the Type and Component tables, the contractor will then add plate number, installation and commissioning data to complete the Component data set. At Practical Completion the completed COBie tables are handed over to the asset owner. This accumulative and collaborative process eliminates duplication and ensures a consistent approach to asset information collection and collation.

An analogy might be made with a painting-by-numbers set. A blank COBie workbook is the canvass and outline, the numbers still need to be added to resolve which colour goes in each shape, this is one role of the Employer’s Information Requirements. The design team and contractor can then fill in the picture with the required colours (information) to complete the COBie workbook.

Blank COBie templates and examples of complete COBie workbooks are available on a number of websites including:

- National Institute of Building Sciences (USA)

  http://www.nibs.org/?page=bsa_commonbimfiles

The Institute website includes a number of COBie guides and reports: https://www.nibs.org

- BIM Task Group (UK)

http://www.bimtaskgroup.org/wp-content/uploads/2012/03/COBie-data-drops-29.03.12.pdf

The Task Group website includes a number of COBie guides and reports:
http://www.bimtaskgroup.org

- The NBS (UK) website includes a number of COBie guides and reports: **https://www.thenbs.com**

4.4 COBie and Case Study

In the following case study, data provided by Housing and Homelessness Services in the Queensland Department of Housing and Public Works is used to examine what may be involved in establishing a COBie-based asset information template based upon information from existing assets.

This case study is a timely exercise in that the Queensland Government has established a working party to establish guidelines for the use of BIM on Government projects. One of the objectives set by the Queensland Government for the development of BIM practices is:

"To promote consistency and interoperability in the information requirements for state infrastructure projects to facilitate a harmonised approach for industry."[7]

If the State is to avoid running parallel systems for BIM and on-BIM projects how to resolve existing asset management systems with the use of BIM on new projects will be an important task for the working party. This study investigates one solution using COBie.

A practical and detailed example of a COBie workbook for housing asset information is available on the US National Institute of Building Sciences website and illustrates the use of COBie with a duplex apartment: **http://www.nibs.org/?page=bsa_commonbimfiles**.

A standardised approach to asset information exchange offers many benefits. It will eliminate reliance upon large quantities of paper documents and duplication between actors. The time consuming manual entry of data from manuals into management systems will be replaced by the exchange of digital information. The ability to check asset information for completeness will greatly enhanced. Software providers will be able to develop information exchange tools for their products confident that data structure and format will be consistent from project to project and one-off bespoke needs will be largely eliminated. Overall, all actors in the design, construction and operation of assets will benefit from greater efficiency and effectiveness in the collation of asset information.

COBie provides a template for collating asset information in a format that can used to exchange data with various software applications. The information collated in a COBie workbook is primarily static as opposed to dynamic, describing what is rather than what happened at a particular point in time, typically at Practical Completion/Handover. Though this need not be the case, for example COBie tables could be populated by a survey of an existing asset or a data dump from an asset management system.

There has been some discussion as to how far COBie tables can be modified before they cease to be COBie and merely something based-upon COBie [32], [33] It is argued that any significant departures from the original COBie framework will lose the versatility of a generic approach to information exchange. If every asset owner develops their own bespoke version of COBie then it will become impossible for software developers to easily design data exchange tools and the process of information will become more rather than less complex. Consistent with this, no changes have been made to the underlying COBie framework. The Queensland Department of housing and Public Works HHS COBie template is used to define information requirements and picklists to establish a lexicon. A table has been created for property management information and while this follows the COBie format it technically sits outside of COBie.

5 CASE STUDY

5.1 Housing and Homelessness Services, Queensland Department of Housing and Public Works

Queensland Department of Housing and Public Works (QDHPW) delivers a range of housing, building and procurement services. The Department has five main areas: Housing and Homelessness Services (HHS), Public Works and Asset Management, Building Industry and Policy, Procurement and Corporate Services. A major focus is on the provision of housing and homelessness services through the management of social housing. In addition, the Department provides advice and delivers asset management services to other government agencies including procurement, asset and facilities management.

Housing services are delivered through 23 service centres in four regions covering all of Queensland. HHS manages more than 50,000 rental properties with almost AU$1 billion of capital and recurrent expenditure per year. In July 2017 HSS completed the transfer of property and asset management services from international software provider SAP to Northgate Public Services[5] software with additional bespoke systems and linkages to the Department's SAP software for financial management.

HHS provided a range of documents and data dumps to support this case study as listed in Figure 7.

Document	Description
Report on Government Services	Report on Government Services - Chapter 18. An annual Australian Productivity Commission report including a comparison of social housing KPI's across the Australian States and Territories [40].
Maintenance Management Framework	Good practice guide for managing the performance of Queensland State assets.
Maintenance Program Development Process	Describes use of the Overall Classification Report to prepare regionally-based annual maintenance programs.
Property Condition Appraisal Process and Requirements Policy	Framework for accurate record keeping and deliver of tri-annual condition appraisals (CA) and annual property inspections of housing stock.
Overall Classification Report (OCR)	An asset condition report tool that identifies building components, systems and spaces.
Property Standard Index (PSI)	A weighted index using asset condition and other data to assess the standard of a property (whereas the OCR is focused on a building's components).
Annual Property Inspection (API) Checklist	Checklist that includes building components, systems, spaces and jobs.
Inspection Information	A schedule of property inspection data fields detailing building components, systems and additional information captured.
Property Condition Data Dictionary and Data Validations (v7.0)	A data dump of building classification information. (Classification refers to an element, component or attribute of a building.)
Housing Service Centre dataset	A data dump of property management information for one Housing Service Centre containing a list of social housing units, addresses and various classifications.

Figure 7: Data and documents provided by QDHPW, HHS

The overall approach to asset management is guided by the Queensland State Government's '*Maintenance Management Framework'* that emphasises the importance of understanding asset condition and the impact that that may have on service delivery. This is reflected in HHS' *Property*

[5] SAP and Northgate are both commercial software providers

Condition Appraisal Process and Requirements Policy and the *Maintenance Program Development Process*, which establish a tactical and operational approach to asset management.

At a strategic level, organisational information requirements are reflected in the Australian Government's annual '*Report on Government Services'* published by the Australian Productivity Commission. The Report includes key performance indicators for social housing services delivered in each Australian State and Territory. A tri-annual asset condition assessment process supplemented by annual inspections enables HHS to make tactical decisions regarding asset maintenance, upgrades and capital works. The importance placed on this process is reflected in the four documents provided by HHS: '*Overall Classification Report', 'Property Standard Index', 'Annual Property Inspection Checklist'* and *'Inspection Information'*. The operational focus is on the management of Rental Units (property management) to ensure the maximum availability of properties and alignment with client needs. The asset management systems, processes and information requirements have been largely in place since 1998. Their longevity reflects HHS' view that systems and processes rank as *good* to *excellent* in supporting efficient and effective asset management, and are used consistently across all service centres.

The two data dumps provided by HHS arise from the key activities of property and maintenance management (*'Property Condition Data Dictionary and Data Validations (v7.0)', Housing Service Centre dataset'*). The structure of this data is significant to investigating the use of COBie to provide an asset information exchange mechanism between new assets delivered using BIM and the existing asset management system.

5.2 General Approach to Case Study

This case study investigates the practicalities of translating the structure of an existing housing asset information database into a COBie template format to facilitate the exchange of information with BIM models generated in the procurement of new housing assets. The study has been undertaken in four steps:

1. Review HHS data requirements and structure.
2. Consider an approach to integrating HHS data requirements with the COBie framework.
3. Establish example COBie template.
4. Consider potential for adoption of BIM and COBie as digital technologies.

The outcome of this case study provides guidance on establishing COBie tables based-upon existing asset information. This will be of benefit to owners of existing assets who are moving to adopt BIM for new assets and require the BIM model data content to align with their existing asset management system. As such, the intention is that this study provides practical benefit to Queensland's Housing and Homelessness Services.

The purpose of the COBie template is to establish a pro-forma into which asset information can be entered using HHS' preferred terminology. This ensures that information created in a BIM model for new assets will align with the existing asset management system. Primarily this is achieved by developing picklists that can be used to define and limit the terms that may be entered into a field in a COBie table. For example floor names can be established in a number of ways (Figure 8). By establishing a picklist of Floor names the asset owner can specify the terminology to be used by the design and construction team.

Ground Floor	**First Floor**	**Floor 01**	**Ground Floor**
First Floor	**Second Floor**	**Floor 02**	**Floor 01**
Second Floor	**Third Floor**	**Floor 03**	**Floor 02**

Figure 8: Various floor name conventions

While ideally a template would be established for every table, that is beyond the scope of this study. It has previously been noted that the HHS data is not well suited to this. The purpose of the study is to illustrate the steps and challenges involved in establishing a COBie template using the existing housing asset information. The case study seeks to develop a general approach to creating a COBie template. The COBie template used for the case study is described in Appendix 2: HHS COBie template

The COBie manuals published in the USA [29] and UK [39] have been used to guide the case study. In accordance with this guidance the structure of the tables has not been changed. Unused fields have been left in place, as these will be required in due course with new construction projects. Picklists have been used to ensure a consistent data lexicon corresponding to HHS established taxonomy. This approach also ensures continuity with the underling COBie framework.

5.3 HHS asset information requirements

In this report's Literature Review, it was established that there is no authoritative approach to asset information requirements. In the case of existing assets, the established HHS housing asset datasets, work practices and reporting requirements provide a starting point from which to develop a COBie template. Applying the FMA's partitioning of information allows HHS asset information requirements to be viewed by usage and the establishment of a hierarchy for both documentation and data (Figure 9). The concept of property management is introduced at both a strategic and operational level, which is not addressed in COBie and may require a new approach. The *Property Condition Data Dictionary and Data Validations (v7.0)* data set details building elements and their characteristics, and so will inform the development of a COBie template for existing housing asset information.

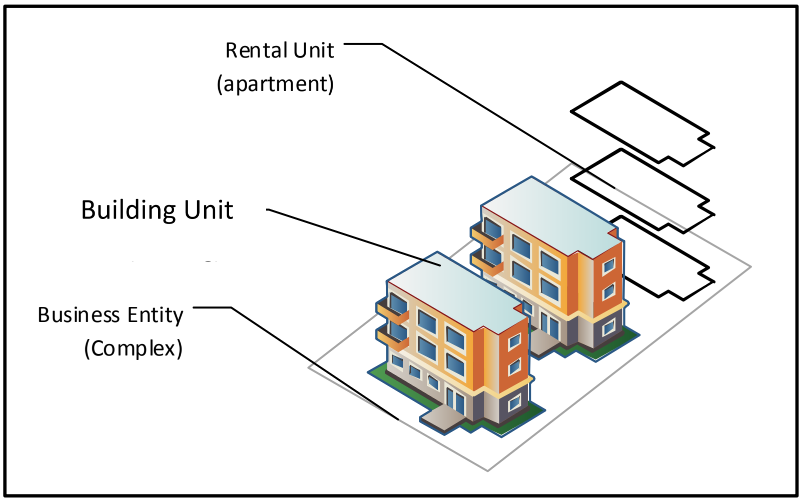
Usage	Document/Data Source	COBie
Strategic Alignment of services (assets) with client needs	Report on Government Services Maintenance Management Framework	COBie asset information can be combined with property and client data from other sources for the *Report on Government Services.* COBie asset information combined with condition data enables compliance with the Maintenance Management Framework.
Tactical Maintenance and capital works planning	Maintenance Program Development Process Property Condition Appraisal Process and Requirements Policy Overall Classification Report Property Standard Index	Condition monitoring process includes building elements that should be mapped to the COBie template if possible.
Operational Maintenance and works delivery Condition inspections Property management (rentals)	Housing Service Centre dataset Property Condition Data Dictionary and Data Validations (v7.0) Annual Property Inspection Checklist Inspection Information	The two data sets provide asset information data characteristics that should be mapped to the COBie template if possible.

Figure 9: HHS data hierarchy

5.3.1 Housing Assets

HHS uses a three-tier hierarchal structure for its housing assets (Figure 10). The principal housing asset is the 'Rental Unit' that forms the basis of tenancies and can take a number of built-forms including detached house, duplex or apartment. A 'Building Unit' represents the building containing one or more Rental Units such as an apartment block. A 'Business Entity' is similar to a plot of land and may contain one or more Building Units and common property such as gardens and car parking.

In some instances a Rental Unit, Building Unit and Business Entity may be one and same thing. For example a detached house and a garden is a single Rental Unit and is also a Building Unit and can be a Business Entity. An apartment block and surrounding common property such as a garden and car park contains multiple Rental Units though only one Building Unit that can also be a Business Entity. A Business Entity may contain several buildings and property common to all buildings, for example a shared car park.



Rental Unit The terms 'Rental Unit' and 'Detached House' are self-explanatory, the latter is a Detached House special case of the former being a standalone building. All other Rental Units form part of a larger building complex such as a duplex, attached houses or apartment block. (References elsewhere to 'Rental Unit' should be taken to include 'Detached House').

Building Unit The physical structure enclosing one or more rental units.

Business Entity The site on which a Building Unit sits. A Business Entity may contain more than one Building Unit if a number Building Units share common areas such as a yard or car parking area.

Figure 10: HHS hierarchy of housing assets

To ensure that information exchange follows a consistent methodology it is necessary to establish rules so Rental Units, Building Units and Business Entities are always handled in the same way within the COBie template. In accordance with COBie practice each workbook should hold only one building (facility). In terms of HHS housing assets this means that Building Unit and not Rental Unit must form the basis of any COBie workbook. Rental Units must be addressed as zones. Each set of rooms forming a Rental Unit brought being together as a zone in the Zone table. Common property unique to a Building Unit, including external areas, can be treated as spaces and zones within that Building Unit's COBie workbook.

A Business Entity may, on occasion, be the same as a Building Unit, containing a single building and the surrounding external areas such as a garden or car park. However, a Business Entity may also contain several buildings and property common to all buildings, for example a shared car park. Since a COBie workbook can contain only one building it is necessary for each Business Entity to be presented in a separate COBie workbook together with the spaces unique to that Business Entity.

To avoid a space or zone appearing in more than one COBie workbook it is necessary to establish additional rules. A space or zone should be wholly contained within the facility detailed in a COBie workbook and uniquely linked to that facility. For example a Business Entity contains two buildings each with a garden but sharing a car park. Each garden would appear in the COBie table for the Building Unit with which it is associated. The car park belongs in the COBie table for the Business Entity because it is unique to the Business Entity but not to either Building Unit.

To accommodate the HHS housing asset structure within the COBie template, rules as described above must be included in the template:

- Each Building Unit must be represented in a separate COBie workbook.
- Each Business Entity must be represented in a separate COBie workbook.
- Each Rental Unit must be identified in the Zone table with the corresponding spaces.
- Each space and zone should be unique to and wholly contained within one facility.

5.3.2 Property Management

A key function of HHS is the property management of Rental Unit assets and tenancies. The purpose of COBie is to manage information for facility operations rather than property management. However, the two activities overlap in that they deal with the same assets and should therefore use the same language.

HHS property-related data is largely found in the *Housing Service Centre dataset* that contains 34 data fields relating to Rental Units and property management - none of which have an obvious home in COBie. To address this issue a new table has been introduced to hold this information, which also satisfies HHS strategic asset information requirements for the *Report on Government Services*. In line with COBie practice of single word names for tables the new table has been called the 'Property Table'.

Although the new table is based-upon the COBie format it has to be treated as an external linkage rather than an additional COBie table. The Property table will provide a source of references between the Facility and Zone tables as explained in the template. This approach avoids disrupting the standard COBie tables and provides a means for owners of large asset portfolios managed centrally such as a university, hospital or government agency to bring together essential property management information.

5.3.3 Asset Information

Assembling a COBie table begins with describing a facility, then its floors and spaces and finally the components and types of product of which it is built. The HHS asset data found in the *Overall Classification Report, Property Standard Index, Annual Property Inspection, Inspection Information,* and *Data Dictionary and Data Validations* between them specify housing asset characteristics that have been identified as relevant to condition assessment and maintenance. The combination of these data sets presents several challenges when attempting to design a COBie template. The mapping process is complicated by only a partial correlation between the *Overall Classification Report, Annual Property Inspection Checklist, Inspection Information,* and *Property Condition Data Dictionary and Data Validations*.

Frequently, data that in COBie would be placed in separate fields if not separate tables is concatenated so that components, systems, spaces, coordinates and jobs become a single characteristic. For example: '*BE front fence*' includes a facility (BE), spatial descriptor (front) and a generic component (fence). Similarly: *'Smoke Detectors: Present, Operational, Tested, Advice sticker present'* from the Annual Property Inspection contains a two generic components and two jobs.

The focus of HHS asset information is on condition monitoring, whereas COBie provides an asset register and operational information. Condition monitoring is an activity that is carried out on assets and therefore it is reasonable to expect alignment between the asset register and condition monitoring process. To achieve this with a COBie template based-upon HHS data, it is necessary to focus on the *'Property Condition Data Dictionary and Data Validations'* report that contains the most detailed breakdown of HHS asset information.

The HHS data dump *'Property Condition Data Dictionary and Data Validations'* contains 9,151 data rows that describe approximately 280 building elements. The data is presented in a 4-tiered structure: Class Group, Class Description, Character Description and Character Value Description.

Class Group — the eight Class Groups describe the general nature of the information, some describe attributes associated with building elements, others data attributes: External, Structure, Services, Internal, Property flag, Core detail, General, Disability.

Class Description — 281 Class Descriptions describe building elements and other housing features such as strata title information and suitability for persons with disabilities. Each Class Description has two parts: housing asset type and description, for example 'BE front fence'. Approximately 50 different building elements (COBie components and type) were identified as many reoccur against different rooms and housing asset types.

Character Description — describes various attributes of the Class Description item such as type, dimensions, condition and location. A Class Description can have multiple Character Descriptions (condition, replacement cost, type, size etc.) that in COBie might be addressed as attributes or included in picklists if not already represented in a table field.

Character Value Description — contains values applicable to a given Character Description, for example a list of various types of fencing.

A term formed from Class Group, Class Description, Character Description and Character Value Description amalgamates fields from several COBie tables and may include information for which there is no immediate COBie equivalent. For example: 'External, BU, Front Fence, Mesh Panels'.

Mapping from HHS asset information to COBie is consequently complex and incomplete as explained below and in Figure 11.

Class Group	**Class Description**			**Character**	**COBie Table(s): Field**
External					No equivalence in COBie
	Rental Unit Building Unit, or Business Entity combined with:				Facility or Zone: Name
		Front, Right, Left Rear			Space: Name or Attribute
			Fence		Type: Name
				Type	Component: Name
				Estimated replacement cost	Type: ReplacementCost
				Condition at last update	Attribute:
				Last updated date	All tables: CreatedOn
				Dimensions	Type: various fields
				Estimated replacement years	Type: ExpectedLife
				Item replacement date	Component: InstallationDate
				Estimated replacement date	Calculated from: Component: InstallationDate and Type: ExpectedLife

Figure 11: HHS asset information and COBie

The *Property Condition Data Dictionary and Data Validations* contains 9,151 lines of data but does not provide sufficient information to fully describe a housing asset to the extent envisaged by COBie. It is beyond the scope of this case study to dissect all data. The following short analysis illustrates some of the steps involved in developing a COBie template based-upon existing HHS asset information and systems.

The HHS asset information focuses on approximately 50 building elements for the purposes of condition monitoring and maintenance. It can be viewed as a sub-set a full COBie workbook. Whilst some Class Descriptions are very specific, others generalise - for example the item *'BU windows'* covers all the windows in a Building Unit. In a full COBie model each window would be individually identified through the Type and Component tables. In COBie terms *'BU Windows'* is a system. Possibly a HHS COBie template could use some means to identify those building elements in which HHS as a condition monitoring and maintenance interest. Information would only be required on those items. However, this approach would result in a partial asset information model, severely limit digital data availability and be likely compromise the benefits from moving to a BIM environment. It is possible the creation of a HHS COBie template aligning with existing HHS asset information may of limited value.

5.4 COBie Template

Having reviewed the HHS housing asset information and given consideration to the challenges of integrating this data with the COBie framework the next task is to develop a COBie template. The approach taken begins by creating the new 'Property Table' the need for which was identified previously (see section 5.2.3). Notes are then provided on each of the critical COBie templates, with illustrations provided in Appendix 2: HHS COBie template where these are considered helpful in explaining the structure. In some instances additional rules are required, these are set-out in the templates.

Of the tables, the Picklist table is the most important in terms of establishing HHS asset information dictionary. For the case study, picklists have been generated from the HHS asset information to illustrate how they are used.

5.4.1 Property Table

The Property table is discussed first as it is a new table. In strict sequence of initiating a COBie workbook the Contact table should be started first as almost all other tables refer back to this table.

The *'Housing Service Centre dataset'* establishes the core housing asset information required for property management and is focused on the characteristics of Rental Units. The standard COBie suite of tables makes no provision for such information. Whilst it might be argued that such information is not part of the construction/operations interface for which COBie is designed, this information is crucial to HHS' business and any digital asset information model that fails to address this will be of limited value. To address this need a Property table has been introduced to contain asset information used in managing Rental Units.

Although the new table uses the COBie format it should not be treated as a COBie table. One of COBie's underlying concepts is that the tables should not be changed. This approach ensures a consistent, industry-wide, format for information exchange. Therefore, the Property table must be treated as an external system and referenced as such from the tables in COBie framework developed in this case study.

In designing the Property table, data fields in the Housing Service Centre data dump have been modified slightly to eliminate duplication and fields that are simply a combination of two or more other fields. Four new fields have been introduced so that all asset information required for the Report on Government Services is contained within the one table (Figure 12). The remaining information required by the Report is drawn from client-related data and is consequently not relevant to COBie.

Organisation Information Requirements	Asset Information Requirements	Property Table Field(s)
KPI: Special needs: Proportion of new tenancies allocated to households with special needs	Dwellings suitable for households with special needs	Count corresponding entries in field: Disability Provision
Match of dwelling to household size Size of household to dwelling size	Number of bedrooms in dwelling	Count corresponding entries in field: BdrmCnt
KPI: Net recurrent cost per dwelling Average cost per dwelling for maintenance and cost of capital	Number of rental units (With SAP financial data)	Count corresponding entries in field: RUCde
KPI: Occupancy rate Proportion of dwellings occupied at 30 June each year	Number of rental units Date vacant Date let (rented)	Calculate from fields: RUCde Date available for let Date vacant Date let
KPI: Turnaround time Average time for vacant stock available to rent to be occupied	Date available for let Date vacant Date let	Calculate from fields: Date available for let Date vacant Date let

Figure 12: Report on Government Services: Asset information requirements

5.4.2 Contact Table

Used with existing asset information the Contact table should hold the names of asset managers, facility managers and service providers, in addition to design and construction team members.

5.4.3 Facility Table

The arrangement of Business Entities and Building Units in the Facility table into separate COBie workbooks with Rental Units described in the Zone table has previously been discussed (5.3.1 Housing Assets). To uniquely name each facility it is proposed to use the HHS allocated code number for each Rental Unit, Building Unit and Business Entity respectively.

5.4.4 Floor Table

'Floor' is defined broadly as vertical separations. Floors are not split between rental units since a floor will span an entire building.

The HHS *'Property Condition Data Dictionary and Data Validations'* contains a Characteristic Description of 'Floor Level' with associated Character Values 'G' and '1-11' with corresponding Character Value Descriptions 'Ground', 'Level 1' to 'Level 11'. From these can be established a picklist of names to be used with the Floor table.

To the floor level picklist has been added 'External' to represent the external area uniquely associated with the Building Unit or Business Entity named in the Facility table. This is compatible with the Class Group 'External' in the *'Property Condition Data Dictionary and Data Validations'* data set that groups together all spaces and components external to a Rental Unit, Building Unit or Business Entity. Sub-divisions of the external space will be treated as 'rooms'.

5.4.5 Space Table

The principal use for the Space table will to identify rooms, which will then be grouped in the Zone table into Rental Units. Three free text fields are available to the asset owner by which to define space information: Name, Description and RoomTag. The proposed usage of each within the HHS COBie template is detailed below.

Resolving space descriptors from the HHS data presented a number of challenges. Space names can be found in four fields in the *'Property Condition Data Dictionary and Data Validations'* data set. By applying filters and uniqueness tests, it was possible to identify 90 potential space descriptors. It may be possible to reduce these further through additional analysis and separation of concatenated terms. For example 'car park' and 'carpark' may be the same. 'Courtyard', 'Courtyard (front)' and 'Courtyard (rear)' are all 'courtyard' spaces with the addition of spatial information in the latter two cases. Other potential spaces names could be classified as components, such as 'Pergola' and 'Driveway' though there may be reasons for treating these as spaces. The ultimate goal of this analysis is to produce a picklist of space names that can be used to populate the 'Description' field.

Name — Space numbering sequences typically use a combination of floor number and sequential space count to create a unique name in the format ##-##, for example GF-01, 02-06. By specifying a space name methodology an asset owner can ensure that all facilities use the same convention.

Description — Generic room descriptors to be selected from a picklist derived from HHS data.

RoomTag — While spaces will collected into Rental zones and other related areas in the Zone table, there are likely to be visualisation benefits in also showing this information in the Space table. Therefore it proposed to populate RoomTag with the corresponding Rental Unit, Building Unit or Business Entity code.

A particular requirement of rental property management is knowing not just how many bedrooms a Rental Unit has but also how many people a bedroom can sleep. This can be treated as an attribute of each bedroom and assigned to the Attribute table.

Additional space names may be needed to cover all possible spaces including external areas. In the HHS data are such spaces as: 'Front yard', 'Back yard', "Left yard' and 'Right yard'. Each can be used as a space name in its current form provided it is understood what is meant by the spatial attribute. It will also be necessary to resolve whether external features such as lawns and paving are separate spaces or components of the yard space.

5.4.6 Zone Table

The Zone table provides for the amalgamation for spaces by function, for example a rental unit, fire compartment or common property. As has been discussed previously each Rental Unit must be represented by a zone. Beyond this, there are no obvious requirements for zones arising from the HHS data. The resolution of naming and coordinate conventions for external areas may necessitate an 'external' zone bringing to together spaces such as 'yard', garage and 'car park'. Further dissection of the space names and other characteristics drawn from the HHS data may identify additional zones.

Each zone requires a unique name. For zones forming a Rental Unit, Building Unit or this is easily resolved by using the corresponding HHS code. Other zones should be named according to their purpose such as 'Common Property' or 'Fire Compartment'. Any further HHS requirements for particular zoning will need to be resolved when implementing COBie and should take into account the needs of designers and contractors.

5.4.7 Type, Component and System Tables

The Type and Component tables work together to identify the products and materials of which a facility is built. The Type lists details of all the products and materials used. The Component table identifies each use of an item listed in the Type table and records this against the corresponding space in which the item is installed. The System table allows components to be brought together to form a functional system. For example each type of fire detector would be listed separately in the Type table. Each time a given fire detector is used this is identified in the Component table together with the space in which it has been installed. All the smoke detectors in the facility could be brought together as one system named 'Fire Detection System'.

Understanding the types and components within the HHS data set is a particular challenge as a definitive list of components is not available (5.3.3 Asset Information). Furthermore, the majority of items that can be identified are generic rather than related to a specific product. For example 24 generic types of fence are identified together with five possible maximum heights and five possible minimum heights. However, it is not possible to determine if every permutation of fence type, maximum height and minimum height exists (24x5x5=600 possible combinations).

The HHS data uses 'type' as a subset of 'Character Type' in the *'Property Condition Data Dictionary and Data Validations'* data set. Filtering the data set for only this subset and further filtering to eliminate duplicates due to supplementary coordinate information (for example 'Front ramp type' and 'Rear ramp type') and other factors reveals approximately 80 types of product, system or building element. Whilst it might in theory be possible to specify a COBie template limited to these particular items that appear in the HHS data, this would result in an incomplete data set that did not describe all the items used to construct a facility and that might require maintenance or condition monitoring.

A possible solution may be derived from the standard COBie framework. Each COBie tables includes a 'Category' field that relates back to whatever classification system the asset owner has specified (Uniclass2015, OmniClass etc.). It would be possible to specify which categories of asset are to be included in the COBie workbook, though the disadvantages of restricting the COBie framework to certain assets would remain.

A review of Uniclass2015 and OmniClass found that neither is specific enough to align precisely with HHS asset 'types'. UniClass2015 is in a continual state of evolution and may in due course be sufficiently detailed to enable a COBie template to specify that only certain categories of asset be included.

The deconstruction of HHS data sufficiently to create COBie Type, Component and System tables is not possible. Nor, is the development of a methodology to specify a subset of assets to be included in a HHS COBie template (an approach that is not recommended). It may be that COBie is not be the solution to asset information exchange or that HHS will need to rethink its approach to asset information management.

5.4.8 Picklist Table

The Picklist table is the possibly the asset owners most powerful tool in specifying the terminology to used in a COBie workbook. Each picklist defines the set of terms to be used in a given field within one of the COBie tables. A number of picklists have been generated from the HHS data to go with fields in the Property, Floor and Space tables. Specific challenges in developing individual picklists are discussed with the table in which the corresponding field is found.

5.4.9 Attributes Table

For the purposes of the case study the Attribute table has been used to specify information on the number of beds a bedroom can accommodate. This is a key piece of information for property management and the identification of rental units for given family sizes. This information, provided by the designer, is then linked to the Property table.

5.4.10 Other Tables

The above discussion addresses the main tables used in COBie and other tables directly relevant to the HHS housing asset information used in the case study. A broader analysis of HHS asset information requirements and State specifications for as-built information would allow the completion of templates for the remaining COBie tables.

5.5 Summary

This case study began with the intention of evaluating the development of a COBie template to enable information exchange from BIM models to an existing asset management system. The study was undertaken using housing asset information provided by Queensland Department of Housing and Public Works, Housing and Homelessness Services. The exercise has been partially successful in developing a COBie template; and has identified major challenges. The structure of HHS data is significantly different from that used in COBie. The development of a dictionary of all terms used by HHS in asset management would seem to be an essential first step.

The analysis of HHS data identified an important requirement for property management information. Property management is closely aligned to the operational management basis of COBie and uses a similar data set. This has led this case study analysis to propose ‘Property Table’ based upon COBie, which may be of value to owners of large built asset estates.

The deconstruction of HHS data and its reassembly into a COBie format was only partially successful. Nonetheless, the use of picklists and attributes was demonstrated. The creation of a generic COBie template for use with existing asset information may be of use to others undertaking a similar task.

6 CONCLUSION

The use of COBie with existing HHS asset information presents a number of challenges. Not least, the need to produce a comprehensive data dictionary and unravel a taxonomy that has developed over many years and been designed to suit software operating in a non-BIM environment. This is likely to be a time consuming task and involve rethinking long-standing practices. Consequently, the task of producing a complete COBie template aligned with existing asset information is likely to be time-consuming and its implementation may become a significant change program for the organisation.

The study focused specifically on the use of COBie with existing housing asset information. This implies that the existing housing asset information is complete and suitable for the implementation of BIM and COBie – which was found not to be the case. With hindsight, there may be more value in initially asking what are the holistic benefits being sought and how well are they delivered at present. An approach such as the benefits realisation framework proposed by Love [2] may produce better overall value than accepting COBie as the single appropriate exchange mechanism.

Mapping the HHS *'Property Condition Data Dictionary and Data Validations'* data to COBie encountered several difficulties. A number of data fields had no direct correlation with COBie, while others concatenated data that in COBie is distributed over several tables and fields. A number of inconsistencies in data structure and definition were identified. None of this should be seen as devaluing the HHS data that is reported to ably serve its purpose, a purpose that does not include alignment with COBie. The study highlights that should it be intended to integrate BIM models with an existing asset management system then a comprehensive review of the HHS lexicon will be required. This conclusion is based upon the assumption that BIM and existing asset information will eventually be amalgamated for which an information exchange tool such as COBie will be required.

This case study has demonstrated an approach to creating a COBie template based upon existing asset information and the use of picklists to ensure terminology remains aligned with the prevailing lexicon. A 'Property Table' has been proposed to align asset management information with asset operational information contained in COBie. These lessons may be of use to others seeking to integrate BIM with an existing asset management system.

It may be that COBie is not be the solution to housing asset management information exchange or that HHS will need to reappraise its approach to asset information management. However, it is clear that the alignment of BIM with an existing asset information lexicon presents a number of challenges. These must be overcome if BIM is to be integrated with existing asset management systems, rather than stop at a project's Practical Completion. It seems likely that asset owners will face some challenges in adopting BIM for asset management and the implementation of an information exchange methodology such as COBie. However, as many authors have identified, the potential benefits of BIM for asset and facility managers are huge.

7 APPENDIX 1: COBIE TABLES – FIELD LISTING

Column	Contact Table	Facility Table	Floor Table	Space Table	Zone Table
A	Name	Name	Name	Name	Name
B	CreatedBy	CreatedBy	CreatedBy	CreatedBy	CreatedBy
C	CreatedOn	CreatedOn	CreatedOn	CreatedOn	CreatedOn
D	Category	Category	Category	Category	Category
E	Company	ProjectName	ExtSystem	FloorName	SpaceNames
F	Phone	SiteName	ExtObject	Description	ExtSystem
G	ExternalSystem	LinearUnits	ExtIdentifier	ExtSystem	ExtObject
H	ExternalObject	AreaUnits	Description	ExtObject	ExtIdentifier
I	ExternalIdentifier	VolumeUnits	Elevation	ExtIdentifier	Description
J	Department	CurrencyUnit	Height	RoomTag	
K	OrganizationCode	AreaMeasurement		UsableHeight	
l	GivenName	ExternalSystem		GrossArea	
M	FamilyName	ExternalProjectObject		NetArea	
N	Street	ExternalProjectIdentifier			
O	PostalBox	ExternalSiteObject			
P	Town	ExternalSiteIdentifier			

Q	StateRegion	ExternalFacilityObject
R	PostalCode	ExternalFacilityIdentifier
S	Country	Description
T		ProjectDescription
U		SiteDescription
V		Storeys
W		Phase
X		
Y		
Z		
AA		

Legend
data entry required
from another sheet or picklist
if specified as required
exterenal reference
Bold text = key field

Column	Type Table	Component Table	System Table	Attribute Table
A	Name	Name	Name	Name
B	CreatedBy	CreatedBy	CreatedBy	CreatedBy
C	CreatedOn	CreatedOn	CreatedOn	CreatedOn
D	Category	TypeName	Category	Category
E	Description	Space	ComponentNames	SheetName
F	AssetType	Description	ExtSystem	RowName
G	Manufacturer	ExtSystem	ExtObject	Value
H	ModelNumber	ExtObject	ExtIdentifier	Unit
I	WarrantyGuarantorParts	ExtIdentifier	Description	ExtSystem
J	WarrantyDurationParts	SerialNumber		ExtObject
K	WarrantyGuarantorLabor	InstallationDate		ExtIdentifier
I	WarrantyDurationLabor	WarrantyStartDate		Description
M	WarrantyDurationUnit	TagNumber		AllowedValues
N	ExtSystem	BarCode		
O	ExtObject	AssetIdentifier		
P	ExtIdentifier			
Q	ReplacementCost			

R	ExpectedLife
S	DurationUnit
T	WarrantyDescription
U	NominalLength
V	NominalWidth
W	NominalHeight
X	ModelReference
Y	Shape
Z	Size
AA	Color
AB	Finish
AC	Grade
AD	Material
AE	Constituents
AF	Features
AG	AccessibilityPerformance
AH	CodePerformance
AI	SustainabilityPerformance

Legend
data entry required
from another sheet or picklist
if specified as required
exterenal reference
Bold text = key field

8 APPENDIX 2: HHS COBIE TEMPLATE

A template has been developed to document the content and format of each field in the COBie tables. The template incorporates COBie requirements and allows the asset owner to specify their information requirements. Whilst it is beyond the scope of the study to build a complete HHS COBie template a number of examples drawn from HHS data serve to illustrate how the template works.

Each template relates to a COBie table and contains a number of sections that establish rules and guidance for use of the table and its fields as explained below.

Notes	details any rules and other essential information for use of the table.
Description	provides a general description of the data field, its source and provides a formatting example when this is needed for clarification.
Key Field	shows which field(s) provides the unique identifier for each row of data.
Mandatory	states whether or not the information must be provided in the completed digital asset information model.
Table Links	identifies which table, if any, a field is linked either because it imports data ‘from’ (such as a picklist) or defines data ‘to’ be used in a table.
External System	identifies an external system data is sourced from or supplied to such as BIM model or asset management system.
Format	defines the format data must take.
Empty Field	explains how any empty field must be dealt with (see Legend included in each template).
Max. Length	establishes maximum number of characters in a field.
Responsible Actor	identifies the person (role) primarily responsible for entering data in a given field. Where the term ‘user’ is inserted this refers to the actor currently updating the row of data. The named responsible actor will need to be reviewed to align with the procurement method being used to acquire a new constructed assets.

The standard COBie colour-coding practice is used throughout. The date format is consistent with the ISO defined format: yyyy/mm/dd.

The template combines the functions of a data dictionary with a COBie-based format. It describes the properties of data within each data field including: format, meaning, origin, usage, structure and relationship to other fields. A data dictionary differs from a data drop in that it defines each data field, it is not the data itself though the data dictionary will contain picklists that limit the contents a given data field to the prescribed set of terms. Compiling a comprehensive data dictionary from existing asset information data sets is an essential step in the composition of COBie tables into a template so that information from new assets aligns with an existing management system.

It is not the intention to produce a complete set of COBie tables, nor is this possible from the information provided by HHS. The case study will analysis sufficient asset information to understand the challenges of creating a COBie-based digital asset information model from existing asset information.

HHS COBie template: Property tTable										
Notes 1. Each Rental Unit detail must be entered in the Property table. 2. Business Entities and Building Units must not be entered in this table. The abbreviations used the Column Name are taken from the HHS 'Housing Service Centre dataset'. Duplicate fields and fields containing an amalgamation of other fields have been omitted. Four new fields have been added to complete the data requirements for the Government Services Report.							Legend			
							Fields	Empty Field		
							data entry required	No	Field cannot be empty	
							from another sheet or picklist	n/a	Use n/a if field not applicable	
							if specified as required	Null	Use Null if data not known	
							exterenal reference	Yes	Field can be empty	
HHS COBie template: Property Table										
Col.	Column Name (field)	Description	Key Field	Mand-atory	Table Links (to/from)	External System Links	Format	Empty Field	Max. Length	Responsible Actor
A	Name	Address: unit number, street number, street name, city	Yes	Yes		To: Zone table	Alphanumeric	No	255	HHS
B	CreatedBy	Email address of perosn most recently updating table linked from Contact table		Yes		From: Contacts table	name@email	No	255	User
C	CreatedOn	Date row most recently updated (ISO format yyyy/mm/dd)		Yes			yyyy/mm/dd	No	10	User

D	Category	UniClass2015, OmniClass or other Classification system		Yes		From: Picklist table	Alphanumeric	n/a	255	Designer
E	QuarterlyArea	See Picklist table		Yes		From: Picklist table	Alphanumeric	No	255	HHS
F	RR	See Picklist table		Yes		From: Picklist table	Alphanumeric	No	255	HHS
G	Site	See Picklist table		Yes		From: Picklist table	Alphanumeric	No	255	HHS
H	BECde	Business Entity Code issued by HHS (see note explaining BECde, BldgCde, RUCde)		Yes			Numeric	No	8	HHS
I	BldgCde	Building Code issued by HHS (see note explaining BECde, BldgCde, RUCde)		Yes			Numeric	No	8	HHS
J	RUCde	Rental Unit number issed by HHS, unique to each rental unit (see note explaining BECde, BldgCde, RUCde)		Yes			Alphanumeric	Null	6	HHS
K	StNo	Street number		Yes			Alphanumeric	No	5	HHS
l	StName	Street Name		Yes			Alphanumeric	No	255	HHS
M	City	City, town or suburb		Yes			Alphanumeric	No	255	HHS
N	Pcde	Post Code		Yes			Numeric	No	4	HHS
O	BldgType	See Picklist table		Yes		From: Picklist table	Alphanumeric	No	255	Designer

P	BdrmCnt	Count from Space table		Yes		From: Space table	Numeric	No	2	Designer
Q	Beds	Total number of beds that can be accomodated in the bedrooms		Yes			Numeric	No	2	Designer
R	Stry	RU/DH: number of stories in the RU/DH. BU number of stories to the building. BE always has 0 stories. (Count ground floor as 1 and include roof space if it includes habital rooms).		Yes			Numeric	No	2	Designer
S	BusArea	See Picklist table		Yes		From: Picklist Ttble	Numeric	No	3	HHS
T	StatElec	See Picklist table		Yes		From: Picklist table	Alphanumeric	No	255	HHS
U	LoclAuth	See Picklist table		Yes		From: Picklist table	Alphanumeric	No	255	HHS
V	YrBlt	Format yyyy		Yes			yyyy	No	4	Contractor
W	DateCapOn	Date asset information first captured. ISO format yyyy/mm/dd		Yes			yyyy/mm/dd	No	10	HHS
X	UsageType	See Picklist table		Yes		From: Picklist table	Alphanumeric	No	255	HHS
Y	ABSStatDvn	See Picklist table		Yes		From: Picklist table	Alphanumeric	No	255	HHS

Z	ABSLocalArea	See Picklist table		Yes		From: Picklist table	Alphanumeric	No	255	HHS
AA	WaitListArea	See Picklist table		Yes		From: Picklist table	Alphanumeric	No	255	HHS
AB	LotNum	Unit number not registered land title lot number		Yes			Alphanumeric	No	255	HHS
AC	SHProgram	See Picklist table		Yes		From: Picklist table	Alphanumeric	No	255	HHS
AD	OwnedManaged	See Picklist table		Yes		From: Picklist table	Alphanumeric	No	255	HHS
AE	Disability Provision	RU/DH only. See Picklist table, use n/a with BU and BE (New field to idenfity rental units suitable for people with disabilities)		YES		From: Picklist table	Alphanumeric	No	255	Designer
AF	Date available for let	Date on which rental unit is in condition to let		Yes		From: Letting System	dd/mm/yyyy	Null	10	HHS
AG	Date vacant	Date on which rental unit is vacated by previous tenant		Yes		From: Letting System	dd/mm/yyyy	Null	10	HHS
AH	Date let	Date on which incoming tenant lease begins		Yes		From: Letting System	dd/mm/yyyy	Null	10	HHS

HHS COBie template: Facility table

Notes	Legend		
1. Each Business Entity and Building Unit must be represented in a separate COBie workbook. 2. Each Rental Unit must be represented on the Zone table.	Fields	Empty Field	
	data entry required	No	Field cannot be empty
	from another sheet or picklist	n/a	Use n/a if field not applicable
	if specified as required	Null	Use Null if data not known
	exterenal reference	Yes	Field can be empty

HHS COBie template: Facility table

Col.	Column Name (field)	Description	Key Field	Mand-atory	Table Links (to/from)	External System Links	Format	Empty Field	Max. Length	Responsible Actor
A	Name	Business Entity or Business Unit Code.	Yes	Yes			Numeric	No	8	HHS
B	CreatedBy	Email address of perosn most recently updating data set		Yes	From: Contact		name@email	No	255	User
C	CreatedOn	Date row most recently updated		Yes			dd/mm/yyyy	No	10	User
D	Category	UniClass2015, OmniClass or other Classification system		Yes	From: Picklist. CategoryFacility		Alphanumeric	n/a	255	Designer
E	ProjectName	For design and construction phases only		No			Alphanumeric	n/a	255	HHS

F	SiteName	Concatenate (Street No + Street Name + City)		Yes			Alphanumeric	No	255	Contractor
G	LinearUnits	Millimeters		Yes			Alphanumeric	No	255	HHS
H	AreaUnits	Squaremeters		Yes			Alphanumeric	No	255	HHS
I	VolumeUnits	Cubicmeters		Yes			Alphanumeric	No	255	HHS
J	CurrencyUnit	Pounds		Yes			Alphanumeric	No	255	HHS
K	AreaMeasurement	Indicative area for BU: building footprint; BE site area		No			Numeric	Yes	255	Architect
I	ExternalSystem	Use if link to an external system is required		No			Alphanumeric	n/a	255	
M	ExternalProjectObject	Use if link to an external system is required		No			Alphanumeric	n/a	255	
N	ExternalProjectIdentifier	Use if link to an external system is required		No			Alphanumeric	n/a	255	
O	ExternalSiteObject	Use if link to an external system is required		No			Alphanumeric	n/a	255	
P	ExternalSiteIdentifier	Use if link to an external system is required		No			Alphanumeric	n/a	255	
Q	ExternalFacilityObject	Use if link to an external system is required		No			Alphanumeric	n/a	255	
R	ExternalFacilityIdentifier	Use if link to an external system is required		No			Alphanumeric	n/a	255	
S	Description	Free text		No			Alphanumeric	Yes	255	
T	ProjectDescription	For design and construction phases only		No			Alphanumeric	Yes	255	
U	SiteDescription	See Picklist table		Yes		Picklist table	Alphanumeric	No	12	HHS
V	Storeys	Number of above ground stories counting ground level as 1		No			Numeric	0	2	Designer
W	Phase	See Picklist table (covers whole-of-life)		No		Picklist table	Alphanumeric	No	255	User

HHS COBie template: Floor table

Notes

Each facility must have at least one floor.

Legend

Fields	Empty Field	
data entry required	No	Field cannot be empty
from another sheet or picklist	n/a	Use n/a if field not applicable
if specified as required	Null	Use Null if data not known
exterenal reference	Yes	Field can be empty

Col.	Column Name (field)	Description	Key Field	Mand-atory	Table Links (to/from)	External System Links	Format	Empty Field	Max. Length	Responsible Actor
A	Name	Gerneic floor names to be selected from HHS terminology as per Picklist table	Yes	Yes	From: Picklist		Numeric	No	3	Designer
B	CreatedBy	Email address of perosn most recently updating data set		Yes	Contacts Table		name@email	No	255	User
C	CreatedOn	Date row most recently updated (ISO format yyyy/mm/dd)		Yes			yyyy/mm/dd	No	10	User
D	Category	UniClass2015, OmniClass or other Classification system		Yes	Picklist.Category-Floor Type		Alphanumeric	n/a	255	Designer

E	ExtSystem	Use if link to an external system is required						n/a		
F	ExtObject	Use if link to an external system is required						n/a		
G	ExtIdentifier	Use if link to an external system is required						n/a		
H	Description	Free text					Alphanumeric	n/a	255	Designer
I	Elevation	Dimensions in mm					Numeric	n/a	10	Designer
J	Height	Dimensions in mm					Numeric	n/a	10	Designer

HHS COBie template: Space table				
Notes	Legend			
	Fields	Empty Field		
	data entry required	No	Field cannot be empty	
	from another sheet or picklist	n/a	Use n/a if field not applicable	
	if specified as required	Null	Use Null if data not known	
	exterenal reference	Yes	Field can be empty	
HHS COBie template: Space table				

Col.	Column Name (field)	Description	Key Field	Mand-atory	Table Links (to/from)	External System Links	Format	Empty Field	Max. Length	Responsible Actor
A	Name	Formant: ##-## abbreviated floor name-room number e.g.GF-01, 02-06 Number rooms clockwise from front right corner of building	Yes	Yes			Alphanumeric	No	5	Architect
B	CreatedBy	Email address of person most recently updating data set		Yes	Contacts table		name@email	No	255	User
C	CreatedOn	Date row most recently updated		Yes			dd/mm/yyyy	No	10	User
D	Category	UniClass2015		Yes	Picklist. Category-		Alphanumeric	n/a	255	Architect
E	FloorName	Name from Floor table		Yes	Floor table			No		Architect
F	Description	See Picklist table		Yes	Picklist Description-Space					Architect
G	ExtSystem	Use if link to an external system is required		No			Alphanumeric		255	
H	ExtObject	Use if link to an external system is required		No			Alphanumeric		255	
I	ExtIdentifier	Use if link to an external system is required		No			Alphanumeric		255	
J	RoomTag	Rental Unit, Building Unit or Business Entity name to which the Space is uniquely linked		Yes	Zone table or Facility table		Alphanumeric	n/a	255	Architect
K	UsableHeight						Numeric			Architect
I	GrossArea						Numeric			Architect
M	NetArea						Numeric			Architect

HHS COBie template: Zone

Notes

Composite key field of Name and SpaceNames.
Every space must belong to at least one zone, a space may belong to more than one zone, a space shall appear only once in a zone. A zone shall be created for each Rental Unit, Building Unit and Business Entity. Zones may be nested by using structured names.

Legend

Fields	Empty Field	
data entry required	No	Field cannot be empty
from another sheet or picklist	n/a	Use n/a if field not applicable
if specified as required	Null	Use Null if data not known
exterenal reference	Yes	Field can be empty

Col.	Column Name (field)	Description	Key Field	Mand-atory	Table Links (to/from)	External System Links	Format	Empty Field	Max. Length	Responsible Actor
A	Name	Rental Unit, Building Unit and Business Entity shall use their corresponding HHS code. Other zones shall be named by the user as appropriate.	Yes	Yes			Alphanumeric	No	255	HHS
B	CreatedBy	Email address of person most recently updating data set		Yes	Contacts table		name@email	No	255	User
C	CreatedOn	Date row most recently updated		Yes			yyyy/mm/dd	No	10	User
D	Category	UniClass2015, OmniClass or other Classification system		Yes	Picklist. Category-		Alphanumeric	No	255	Designer

E	SpaceNames	Link to Space table: Name field	Yes	No	Space table		Alphanumeric	n/a	255	Designer
F	ExtSystem	Use if link to an external system is required		No			Alphanumeric	n/a	255	
G	ExtObject	Use if link to an external system is required		No			Alphanumeric	n/a	255	
H	ExtIdentifier	Use if link to an external system is required		No			Alphanumeric	n/a	255	
I	Description	For Rental Unit zones enter postal address. For Building Unit and Business Entity zones enter street address.		No			Alphanumeric	n/a	255	Designer

<table>
<tr><td colspan="4">HHS COBie template: Attribute table</td></tr>
<tr><td rowspan="6">Notes

The Attribute table allows the Asset Owner to specify additional information that they require with respect to any item list on the other tables. The actor responsible for populating the table will vary with the attribute. For example the Architect would be responsible for populating the attribute 'Number of occupants per bedroom' and the services engineer 'Hot water system capacity'. The Key field is a composite of the Name, SheetName and RowName fields beause an attribute may apply to more than one item.</td><td colspan="3">Legend</td></tr>
<tr><td>Fields</td><td>Empty Field</td><td></td></tr>
<tr><td>data entry required</td><td>No</td><td>Field cannot be empty</td></tr>
<tr><td>from another sheet or picklist</td><td>n/a</td><td>Use n/a if field not applicable</td></tr>
<tr><td>if specified as required</td><td>Null</td><td>Use Null if data not known</td></tr>
<tr><td>exterenal reference</td><td>Yes</td><td>Field can be empty</td></tr>
</table>

HHS COBie template: Attribute table										
Col.	Column Name (field)	Description	Key Field	Mand-atory	Table Links (to/from)	External System Links	Format	Empty Field	Max. Length	Responsible Actor
A	Name	Brief name of attribute	Yes	Yes			alphanumeric	No		HHS
B	CreatedBy	Email address of perosn most recently updating data set		Yes	Contact		name@email	No	255	User
C	CreatedOn	Date row most recently updated		Yes			yyyy/mm/dd	No	10	User
D	Category	UniClass2015		No	Picklist		alphanumeric	No	255	HHS
E	SheetName	Name of table to which attribute relates	Yes	Yes	Any table		alphanumeric	No	255	User
F	RowName	Name of row in table to which attribute relates	Yes	Yes	table named in row E		numeric	No	255	User
G	Value	To be entered by responsbile actor		Yes			alphanumeric	Null		User
H	Unit	Unit of measure to be for Value		Yes			alphanumeric	No	255	HHS
I	ExtSystem	Use if link to an external system is required		No			alphanumeric	n/a		
J	ExtObject	Use if link to an external system is required		No			alphanumeric	n/a		
K	ExtIdentifier	Use if link to an external system is required		No			alphanumeric	n/a		
I	Description	Describe attribute if not apparent from name		No			alphanumeric	Yes		HHS
M	AllowedValues	Link to picklist or describe allowed values (e.g. numeric)		No	Picklist if used		alphanumeric	Yes		HHS

HHS COBie template: Attribute table, example												
Name	CreatedBy	CreatedOn	Category	SheetName	RowName	Value	Unit	ExtSystem	ExtObject	ExtIdentifier	Description	AllowedValues
Number of beds per bedroom				Space			no.				Maximum number of single beds that can be accommodated in a bedroom	Numeric only

Property Management: QuarterlyArea	Property Management: RR	Property Management: BldgType	Property Management: UsageType	Property Management: ABSStatDvn	Property Management: ABSLocalArea	Property Management: WaitListArea	Property Management: SHProgram	Property Management: OwnedManaged	Property Management: Disability	Floor: Name	Space: Name	Phase
PH Rental Stock	Regional Australia	Attached Housing	Rental General Stock				01, Public Rental Housing	Government Owned and Managed		EXTERNAL	Back	Feasibility
ATSIHP Rental	Rural Australia	Cluster Housing	Senior Accommodation				02, ATSI Housing Rental Program			GROUND	Balcony	Concept Design
		Detached House	ATSIHP General Accommodation							LEVEL 1	Bathroom 1	Design Development
		Dual occupancy	Dem/Remove after Settlement							LEVEL 2	Bathroom 2	Approval Submission
		Duplex Apartment								LEVEL 3	Bedroom	Detailed Design
		Senior Unit								LEVEL 4	Bedroom 1	Construction
		Senior Unit Studio								LEVEL 5	Bedroom 2	Handover
										LEVEL 6	Car park	Rental Stock
										LEVEL 7	Communal Room	Maintenance
										LEVEL 8	Entrance	Demolition
		From HHS property data		Picklist ABS Statutory Divisions	Picklist ABS Local Areas	Picklist Wait List Area			Picklist to be devised to describe	From HHS Class Description	From HHS Class Description (partial listing)	

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