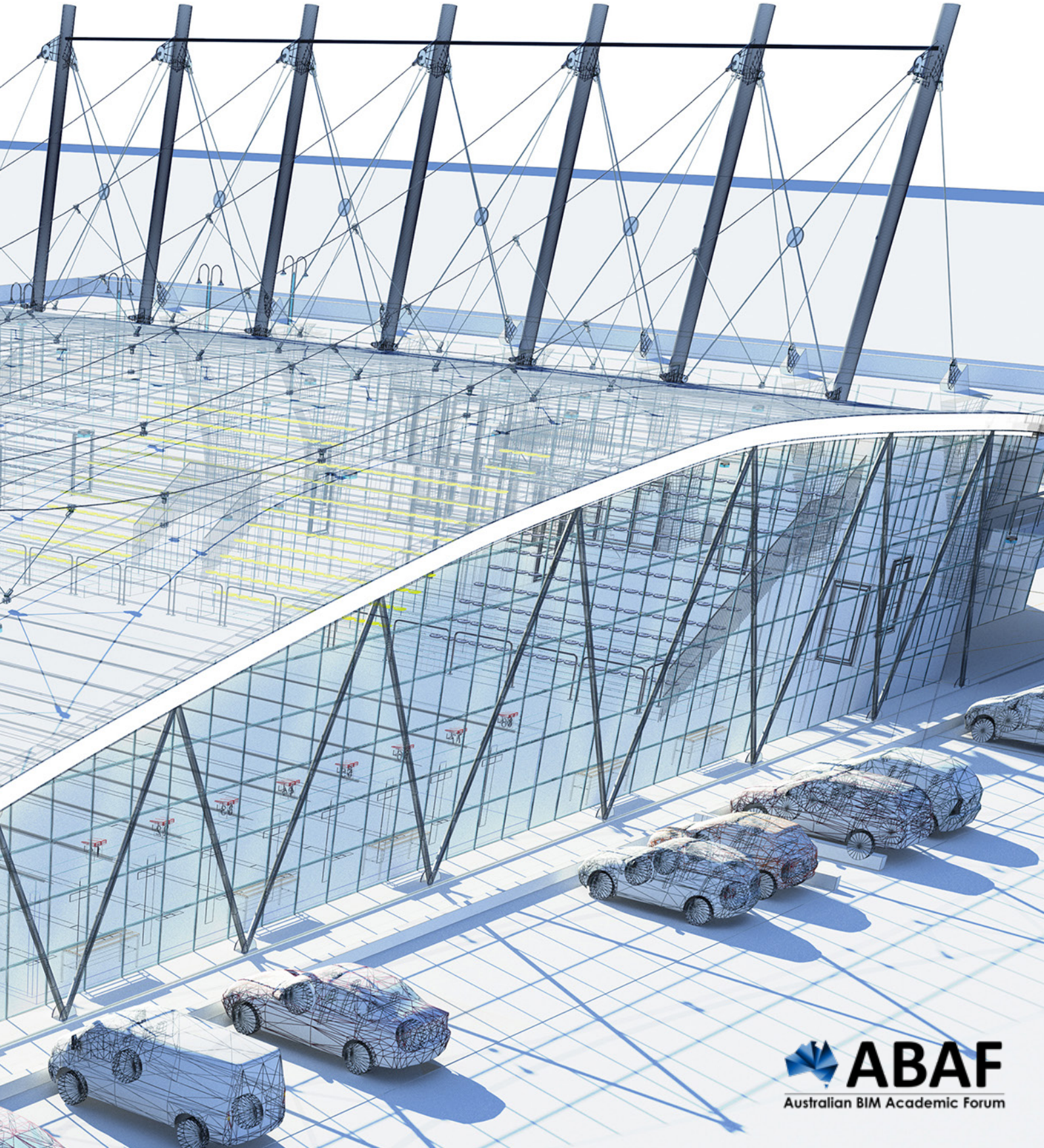
BIM Competency Framework for Australian Universities



ABAF
Australian BIM Academic Forum

BIM Competency Framework for Australian Universities

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Executive Summary

Building Information Modelling (BIM) has been widely praised as a new paradigm and the next digital transformation in the architecture, engineering, construction and owner/operator (AECO) industry, moving towards a more productive and agile industry.

Global scholarly and industry works provide evidence that replacing conventional non-digital practices with the integrated management of data throughout the life cycle of projects can resolve many of the cited challenges that affect the AECO industry. Building Information Modelling (BIM) and its broader, more recent version "digital engineering" (BIM/DE) present a significant opportunity to bring a paradigm change to the construction sector.

The framework presented here is an attempt by the Australian BIM Academic Forum (ABAF) to fulfil two key ABAF objectives by:

1. collectively promoting BIM education and learning across Australian universities and
2. developing the minimum requirements for BIM-related curricula, with the objective of bridging the gap between BIM university education outcomes and workplace performance requirements. Driven by the needs of the Australian AECO industry, this framework is the first in Australia to set minimum requirements for BIM/DE education across Australian universities, with the aim of creating a sustainable pipeline of graduates in AECO-related courses, who possess the knowledge, skills and abilities required by the Australian AECO industry.

The ABAF's aspiration, as reflected in this framework, is devoted to gaining higher and consistent levels of student competence in BIM/DE in tertiary education in Australia. This goal is to be achieved through outlining the minimum intended learning outcomes (ILOs) for raising the standards and baselines of BIM-related curricula, as set out in the framework. The framework therefore establishes the links between BIM Uses and ILOs and, in doing so, translates the requirements of the AECO industry into minimum learning requirements to inform the design of BIM/DE-related subjects and courses at Australian universities.

Although the prime targets of this framework are courses related to the built environment, it is recognised that BIM/DE issues may appeal to academic disciplines outside the Built Environment discipline. The framework therefore recognises the need to cover the education of BIM/DE-ready graduates across wider generic fields to address issues throughout the whole asset life cycle.

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Abbreviations

3D	three-dimensional, relating to 3D geometry and model authoring BIM Uses
4D	four-dimensional, relating to construction simulation BIM Uses
5D	five-dimensional, relating to cost analysis BIM Uses
ABAB	Australasian BIM Advisory Board
ABAF	Australian BIM Academic Forum
ACIF	Australian Construction Industry Forum
AECO	architecture, engineering, construction and owner/operator (industry)
AIM	Asset Information Model
APCC	Australasian Procurement and Construction Council
BEP	BIM execution plan
BIM	Building Information Modelling
CAFM	computer-aided facility management
CAGR	compound annual growth rate
CBS	Cost Breakdown Structure
CDE	Common Data Environment
CMMS	Computerised Maintenance Management System
CNC	computer numerical control (machining)
CoBie	Construction Operations Building Information Exchange
CPM	Critical Path Method
DE	digital engineering
DfMA	design for manufacture and assembly
GIS	geographic information system
IFC	Industry Foundation Classes
ILO	intended learning outcome
IoT	Internet of Things
JTA	job task analysis
KSAOs	knowledge, skills, abilities and other characteristics
LIDAR	light detection and ranging
LOD	Level of Development
LOI	Level of Information
PIM	Project Information Model
RFID	radio-frequency identification
SOLO	structure of the observed learning outcome (taxonomy)
USD	United States dollar/s
WBS	Work Breakdown Structure
WHS/OH&S	work health and safety/occupational health and safety

Introduction

Building information modelling (BIM) is at the forefront of digitalisation in the architecture, engineering, construction and owner/operator (AECO) industry.

The BIM market is projected to grow at a compound annual growth rate (CAGR) of 14.5%, from USD4.5 billion to USD8.8 billion during the forecast period of 2020–2025. This growth has resulted in new work practices, with the roles and responsibilities related to BIM gradually becoming established professional positions within the AECO industry [1].

Leaving the question of BIM benefits aside, this development presents the AECO industry with challenges on multiple fronts. Chief among them, in seeking to increase BIM adoption, is the need for companies to recruit employees with requisite skills to work on BIM-enabled projects, hence the ever-present and always vexing demand for "BIM-savvy professionals" [2]. In the short term, construction companies can resort to outsourcing BIM tasks to fulfil their immediate needs. From a long-term, strategic perspective, the most viable solution to the lack of professionals with BIM capabilities is to provide an ongoing pipeline of BIM-ready graduates, most of whom would be from universities. Industry sources recommend BIM education as a foundational activity, a critical need for both industry and academia and a priority due to the apparent skill shortage. Therefore, BIM training is placed among the top three priority areas of investment by the AECO industry [3].

Despite significant advancements in the development of BIM education in Australia, only restricted offerings are available from universities and training institutions [4]. Evidence shows existing curricula, if any, remain in their infancy. The available programs vary significantly in quality and content across universities and disciplines. The variety in standards for BIM pedagogical delivery and assessment methods across institutions could lead to different perceptions among graduates in terms of their learning and behaviours when in actual BIM practice. It is also questionable whether intended learning outcomes (ILOs) are aligned with the needs of the industry. Thus, even the best BIM programs might fail to provide BIM-ready graduates [3].

Given this scenario, a coalition of BIM practitioners, educators and service users joined together to form a community under the umbrella of the Australian BIM Academic Forum (ABAF). The formation of ABAF is a response to address the disparity in BIM education by reaching convergence on consistent content, while embracing the needs and requirements of the industry in terms of access to BIM-ready graduates. What follows in this framework is the outcome of many meetings, two job task analysis (JTA) workshops and ongoing discussions with a wide range of educators and practitioners across the AECO industry in Australia.

Terminology

Building Information Modelling (BIM): the framework adopts a broad definition of BIM, as a central element of "digital engineering (DE)" in Australia. The acronym "BIM" encompasses the core component of digital engineering (DE).Digital engineering (DE) is defined as a combination or a set of BIM-oriented technologies and organisational solutions that are expected to increase inter-organisational and inter-disciplinary collaboration in the AECO industry and improve productivity and quality in the design, construction and maintenance of constructed facilities [5].

The BIM competency model: this model refers to an inventory of knowledge, skills, abilities and other characteristics (KSAOs) needed for effective performance in BIM-related functions and job families [6, 7].

BIM purposes: these reflect the goals of the project and project teams in using BIM, namely, the specific objectives to be achieved when applying BIM during a facility's life cycle [8, 9]. These also offer a frame of reference for defining the information requirements of owners and clients (see Australasian BIM Advisory Board (ABAB) in ABAB [10]).

BIM Uses: these are derived from the common "use case" terminology and refer to a method of applying BIM during a facility's life cycle to achieve at least one BIM purpose [11]. BIM Uses can be the basic building blocks of common understanding and agreement on how BIM processes and deliverables will be used in project delivery, including within the BIM execution plan (BEP).

Competency: in this framework, competency is defined as a "combination of skills, abilities, and knowledge needed to perform a specific task" [12]. The term "competency" here does not focus on personal traits, such as behaviour or attitude: it also does not refer to "transversal competencies", defined as a set of competencies that can be applied in any professional situation or task and that are required for all types of jobs. Therefore, competencies, such as leadership, communication, problem-solving, teamwork and creativity, among others (see Care and Luo in Care and Luo [13]), are not discussed here. "Competency", as used in this framework, solely concerns professional and technical capabilities, derived from integrative learning experiences that predict future performance [12, 14]. In this framework, verbs that describe competencies (see Table 1) reflect the intended learning outcomes (ILOs), according to the structure of the observed learning outcome (SOLO) taxonomy [15].

Individual BIM competency: this is the aggregation of professional knowledge and technical abilities required by an individual to perform a BIM activity or deliver a BIM-related outcome [12].

Theoretical Underpinnings

The intention is to take a methodologically rigorous systemic approach towards identifying, classifying and maintaining a generic BIM competency model, required for modelling, collaboration and integration activities and applicable across project life cycles, industry sectors, disciplines and specialities [12]. The considerations below have informed the development of the competency model:

- Competency models must be presented in a manner that facilitates ease of use. Therefore, a finite number of competencies are identified here to be applied across multiple BIM-related functions and job families. Building the competency model for this framework therefore takes the "one-size-fits-all" approach [16], for the sake of ease of use.
- Individual competency, as opposed to competency at group, team and organisation levels, is taken here as the primary unit of analysis. The reason is that individual competencies underpin the performance and improvement of competency at all other unit levels – groups, teams and organisations [12].
- BIM Uses and associated competencies are developed here by looking into the future. The best possible estimate of the future is used, with all elements of the competency model kept under review.
- The competency framework is to be reviewed on an annual basis, in alignment with rapid developments in the field. When changes occur, an updated competency framework will be accordingly released.
- The competency framework draws from existing models, particularly the model developed by Pennsylvania State University [17]. Nevertheless, the BIM Uses considered here are validated and contextualised for the Australian context, as discussed next.

From BIM Uses to a Competency Model

Across the construction industry, BIM job titles and descriptions continue to evolve and emerge. Therefore, a common lucid description of competencies pertaining to BIM remains inaccessible for the industry [18-20]. Agreement is not even universal on the required BIM roles, their descriptions and associated responsibilities [2, 21]. Moreover, significant variance exists in knowledge sharing, skill set availability and standardisation of jobs between various countries, under disparate technological, socio-economic and cultural contexts [18, 22].

With these points in mind, a comprehensive list of context-specific BIM Uses can provide a firm starting point, one that is considered as the most reliable basis, for developing a BIM competency model for the Australian construction industry. The reasons are as follows:

- BIM is a technological innovation with high reliance on advanced technologies and software applications. For software-oriented methodologies, "use cases" link the information from experience in the field with the functional requirements of systems and training needs of personnel [23, 24].
- Discussion on competencies requires a detailed analysis and an inventory of associated tasks and activities [25].
- Empirical evidence of BIM project applications, related discipline-specific BIM innovations and best practices pertaining to BIM are all reflected in the list of BIM Uses [18, 26].
- BIM Uses inform construction companies in recruiting future BIM talents; that is, applicants with competencies to perform the day-to-day job tasks built into BIM Uses are regarded as being BIM-proficient [18].
- BIM Uses are the driving force behind the emergence of new BIM career paths within the construction industry [18].
- Relying on BIM Uses as the springboard for discussions on developing a BIM competency model is an acceptable approach in the literature, as adopted by the leaders in BIM research [18, 26].

Input for developing a list of BIM Uses across the industry, along with identifying the competency requirements for each BIM use, can be drawn from discussions among subject matter experts, in the form of workshops, focus groups and survey questionnaires [12]. Facilitating job task analysis (JTA) workshops is an acceptable approach [18, 26] and is the method of choice here, as discussed next.

Job Task Analysis (JTA) Workshops

A job task analysis (JTA) workshop is a formal discussion among a group of subject matter experts to validate the inventory of BIM Uses, associated tasks and their required competencies, with this to form the basis for education/training planning and curricula development [18, 25]. With training and education requirements as the ultimate goal, JTA is an appropriate and valuable method for providing insight into development of the BIM competency model [18, 25]. Several JTA workshops were arranged, with attendance by practitioners and BIM experts from the industry, along with BIM educators and key policy makers in the BIM domain from government organisations. The outcome of these JTA workshops was deemed to be directly applicable to the Australian context, given that JTA workshops result in evaluating jobs and their essential competencies. In addition, they ensure compliance with legal and quasi-legal requirements for creating customised curricula to meet students' learning requirements [27, 28]. The procedure for conducting the JTA workshops was undertaken in four stages, as illustrated in Figure 1, and is discussed next.

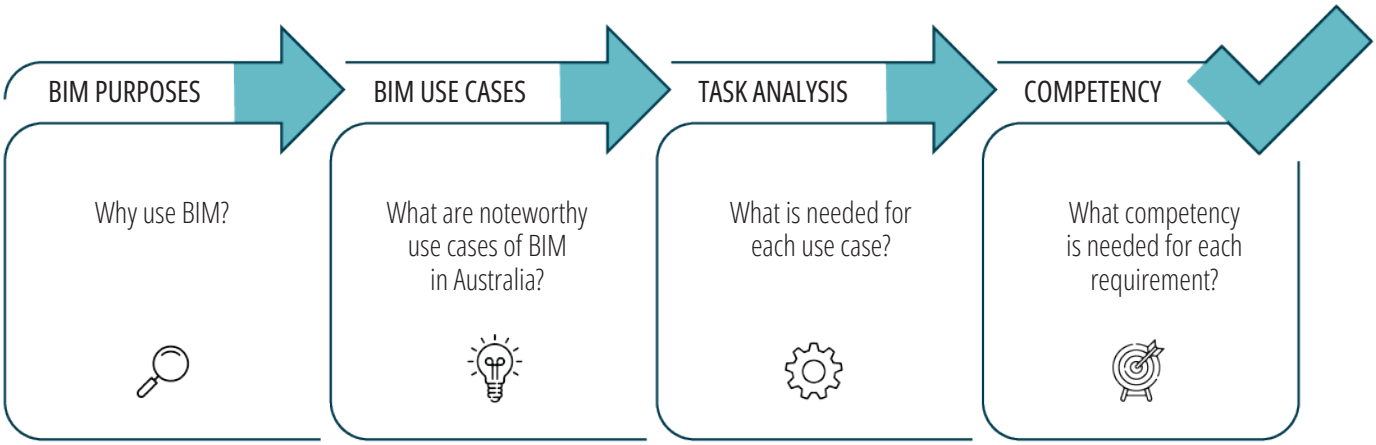

Figure 1. Job task analysis (JTA) procedure

Stage 1 (BIM purpose):
The classification framework for BIM Uses was based on replying to the question "why use BIM?" The premise was that BIM does not affect the purpose; it is solely the means by which the purpose is accomplished [11]. Defining BIM purposes or goals was the first step undertaken in identifying appropriate BIM Uses for any project, considering the project attributes, stakeholders' goals and capabilities, and agreed-upon risk allocations [8, 29].

Stage 2 (BIM Uses):
The JTA workshops started with the moderator (a member of the research team and of ABAF) posing a general question to the group and encouraging all participants to generate responses, views and opinions. The general question was: 1) What do you see as noteworthy use cases of BIM in the Australian AECO industry? As the first draft, a list of BIM Uses was collated from widely-referenced sources in the literature [cf.11, 18, 26]. This list facilitated discussions on various BIM Uses across varied organisations and project contexts within the Australian context. The list of BIM Uses was validated and finalised to achieve the expected outcome.

Stage 3 (Task analysis):
The finalised list of BIM Uses was then used to analyse the tasks associated with each BIM use. BIM Uses were broken down into duties and tasks. The outcome was a task list for each BIM use. Prioritising the tasks and identifying similarities and overlaps was the next stage. The list of tasks was then validated to produce a task inventory that accurately reflected BIM Uses, at an acceptable level of performance.

Stage 4 (Competency):
The task items in the inventory provided a source for discussion to define the required competencies (see Figure 1). Discussion and analysis focused on generating a list of competencies against each task. The outcome was several competency inventories – one for each BIM use – and hence, an inventory of competencies for BIM Uses was made available for the Australian AECO industry.

BIM Uses: Categories

The BIM Uses are categorised into two major groups:
(1) project delivery and (2) operations, in alignment with Australian Standard (AS) ISO 19650.1:2019 [30], as discussed below.

1. Project Delivery

The BIM Uses in project delivery relate to the parts of the life cycle in which an asset is designed, constructed and commissioned. They describe the fundamental processes involved in delivering the information requirements of a project through the *project delivery phase* (see Figure 2). The uses in this category are fundamental to supporting the operations and maintenance of a built asset, through creating and delivering the Project Information Model (PIM), to be incorporated into the Asset Information Model (AIM) which is used with other information sources in the *operational phase*. For the sake of brevity here, interested readers are referred to AS ISO 19650.1:2019 [30] for details.

Authoring, Communication and Coordination

Processes and tools associated with authoring, communication and coordination are involved in these BIM Uses which store and manage asset data and information as databases, enabling the exchange and management of data across the life cycle of assets [31]. These uses are characterised by the utilisation of the inherent properties of data-rich models that contain geometric and non-geometric data – dimensions, position, quantity, level of development, materials, etc.

Simulation and Analysis

Procedures and methods to improve current design practices feature in these BIM Uses which can simulate and study uncertainties about various design elements from the design's inception [32]. These uses are characterised by their utilisation of not only the model's inherent properties, but also by enabling the exchange of information associated with specific purposes and/or other data that can have an impact on the model.

2. Operations

The BIM Uses in operations relate to the processes and tools in those parts of the life cycle in which a built asset is used, operated and maintained [30]. This competency framework recognises BIM as one of the central components of the broad spectrum of other technological innovations that contribute to data and information management, for both current asset management activities and emerging practices, including predictive maintenance and digital twins [5]. In this respect, BIM Uses in this category are informed by the principles outlined in the Gemini Principles report, released by the Centre for Digital Built Britain [33].

Figure 2. BIM Uses in asset information management life cycle (adapted from Standards Australia in Standards Australia [30])

[1] The models can be made available for visual review using simple or complex visual techniques and applications (e.g., simple 3D representation through to extended realities) to enhance understanding, collaboration and issue resolution. This extends to the model's federation and either casual or automated coordination tasks (e.g., code validation and clash detection routines).

[2] Examples of additional managed information include safety checks, performance characteristics, embodied energy characteristics, etc.

The Framework: Boundaries and Scope

The framework is built upon the BIM Knowledge and Skills Hierarchy Framework developed by the Australian Construction Industry Forum (ACIF) and the Australasian Procurement and Construction Council (APCC)[34]. This describes the functions and levels across various project stakeholder groups, with the aim of identifying relevant competencies and resources to successfully meet/complete relevant BIM Uses in BIM-enabled projects (details available to interested readers from ACIF and APCC ACIF and APCC [34] and buildingSMART Australia Building SMART Australasia [35]).

In alignment with the BIM Knowledge and Skills Framework [34], the detailed ABAF BIM Competency Framework comprises the following components:

BIM Uses across the project life cycle.

Technical level: Required competencies and resources, including technologies, tools, software and databases, for BIM authors (modellers), BIM managers and BIM coordinators to meet/complete relevant BIM Uses.

Managerial level: Required competencies and resources for BIM managers, project managers and project directors to successfully handle associated BIM Uses in BIM-enabled projects.

Strategic level: Required competencies and resources for senior managers and corporate executives to successfully adopt and implement BIM in their organisations (to be developed in subsequent versions, as illustrated in Figure 3).

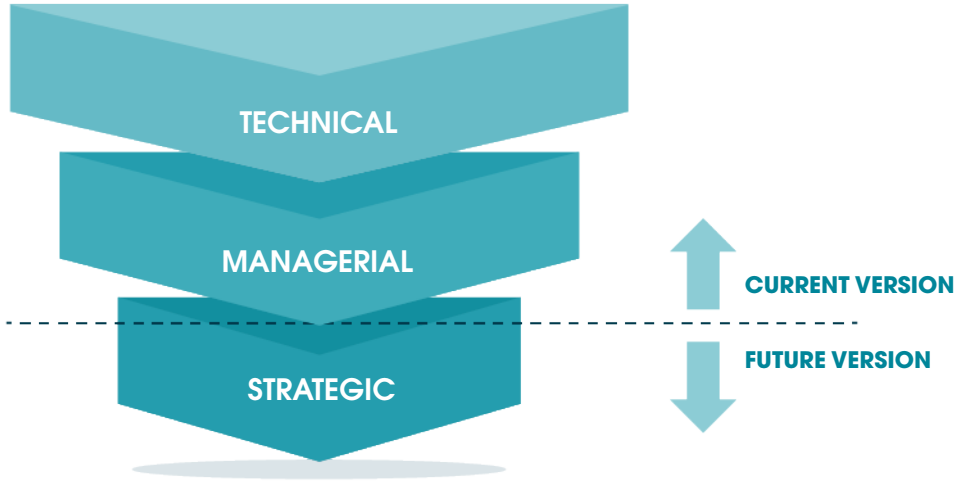

Figure 3. Coverage of ABAF BIM Competency Framework

ABAF BIM Competency Framework: BIM Uses, Required Competencies and Resources

	BIM Use (description)	**Competencies** (in the form of intended learning outcomes [ILOs])[3]	**Resources** (enablers/technologies)[4]
Project Delivery: **Authoring**	**Existing Conditions Model Authoring** Use of BIM model authoring applications to develop discipline models and associated data, according to specified standards and project requirements, representing existing conditions of a built asset or site. The definition of existing conditions can include recently altered or constructed conditions within the same project or a project site in its initial condition. Existing condition models and data can also be provided from the Asset Information Model (AIM), maintained during the operational phase.	- Apply BIM authoring tools integrated with reality capture inputs - Describe various geo-spatial measurement and reality capture tools (e.g., LIDAR [light detection and ranging] and photogrammetry) - Describe Common Data Environment (CDE) tools for all project information - dentify various roles and responsibilities of project team members - Describe data management relevant to existing condition survey and capture including classification, identification/ tagging, type and component attributes - Describe major BIM standards and guidelines applicable to modelling existing conditions - Apply relevant BIM terminologies (refer to applicable BIM terminologies) - Apply the integration of point cloud data with BIM - Describe the design and digital survey requirements and data structure to support databases	- BIM modelling applications - Geo-spatial equipment and applications - Reality capture equipment and editing applications - Surveying equipment and applications - Relevant standards and guidelines that may apply to project delivery at this stage
	Design Model Authoring Use of BIM model authoring applications to develop discipline models and associated data, according to specified standards and project requirements, to communicate design intentions.	- Characterise and apply BIM authoring tools (related to the discipline) - Describe Common Data Environment (CDE) tools for all project information - Describe BIM collaboration enablers and requirements - Describe model exchange and integration by project teams - Identify various roles and responsibilities of project team members - Describe data management relevant to design of BIM modelling including scheduling, import, export and other management tasks - Describe data schema understanding including classification, identification/tagging, type and component attributes - Identify major design and construction methods - Identify additive and subtractive printing methods including three-dimensional (3D) printing - Describe major BIM standards and guidelines applicable to design authoring of discipline models and associated data - Apply relevant BIM terminologies (refer to applicable BIM terminologies)	- BIM modelling applications - Model and data libraries and templates including manufacturers' information - 3D printing (additive and similar) equipment and supporting applications - Computer numerical control (CNC) machining (subtractive and similar) equipment and supporting applications - Relevant standards and guidelines that may apply to project delivery at this stage
	Construction Model Authoring Use of BIM model authoring applications to develop discipline models and associated data, according to specified standards and project requirements sufficient to allow for communication of construction/manufacturing intentions. Includes traditional construction processes, off-site construction and prefabrication, modular construction, design for manufacture and assembly (DfMA) and processes that print/ fabricate/assemble/construct directly from BIM models.	- Characterise and apply BIM authoring tools (related to the discipline) - Describe Common Data Environment (CDE) tools for all project information - Describe BIM collaboration enablers and requirements - Describe model exchange and integration by project teams - Identify various roles and responsibilities of project team members - Describe data management relevant to design of BIM modelling including scheduling, import, export and other management tasks - Describe data schema understanding including classification, identification/tagging, type and component attributes - Identify major design and construction methods - Identify additive and subtractive printing methods including three-dimensional (3D) printing - Describe major BIM standards and guidelines applicable to design authoring of discipline models and associated data - Apply relevant BIM terminologies (refer to applicable BIM terminologies)	- BIM modelling applications - 3D printing (additive and similar) equipment and supporting applications - CNC machining (subtractive and similar) equipment and supporting applications - Other automated set-outs, construction and fabrication tools/applications (including but not limited to robotic, augmented/mixed reality and other enabling technologies) - Fabrication parts library (as in previous point) - Common Data Environment (CDE) applications - Relevant standards and guidelines that may apply to project delivery at this stage
	As-Constructed Model Authoring Use of BIM model authoring applications to develop discipline models and associated data to specified standards and project requirements, site-verified and sufficient to represent the completed project. The deliverables will satisfy intended BIM Uses for the operational phase and can include the incorporation of deliverables from the BIM use "Existing Conditions Model Authoring".	- Characterise and apply BIM authoring tools (related to the discipline) - Describe Common Data Environment (CDE) tools and concepts for all project information - Describe model exchange and integration by project teams - Identify various roles and responsibilities of project team members - Identify non-traditional building methods including prefabrication, DfMA, modular construction and industrialised construction - Identify additive and subtractive construction methods including 3D printing - Describe data management relevant to construction BIM modelling including scheduling, import, export and other management tasks. - Describe data schema understanding including classification, identification/tagging, type and component attributes - Describe major relevant BIM standards and guidelines applicable to construction model authoring - Apply relevant BIM terminologies (refer to applicable BIM terminologies)	- BIM modelling applications - Common Data Environment (CDE) applications - Relevant standards and guidelines that may apply to project delivery at this stage
Project Delivery: **Communication**	**Visual Communication** Visual/graphic representations based on BIM models and associated data for communication and interaction with project stakeholders external to technical roles to enhance communication effectiveness, facilitate understanding and enable collaboration for various defined tasks. Visual communication BIM Uses can be separately defined as specific communication and review BIM Uses to satisfy the objectives of different project stakeholders including but not limited to safety in design, standards compliance, maintenance assessment, issue resolution, client review and approval, training and induction, etc.	- Apply BIM visualisation and review tools - Characterise various interactions and data exchange among project stakeholders - Identify various roles and responsibilities of project team members - Apply and work with rendering applications - Create design communication and review workflows	- BIM model viewing applications may include support for issue capture and management - Tools and procedures related to project team communication and information management - Data visualisation tools and applications - Extended reality tools supporting immersive, augmented, interactive and collaborative communication, and review workflows - Common Data Environment (CDE) applications - Relevant standards and guidelines that may apply to project delivery at this stage

[3] Verbs representing the intended learning outcomes (ILOs) are identify, describe, apply/characterise and create, from basic to advanced levels, accordingly, and drawing from the SOLO taxonomy.
[4] Common Data Environment (CDE) applications, AS ISO 19650 series (relevant sections) and other relevant standards and guidelines, as they apply to each specific project delivery task, are enablers for all BIM Uses in the table.

ABAF BIM Competency Framework: BIM Uses, Required Competencies and Resources Contd.

	BIM Use (description)	**Competencies** (in the form of intended learning outcomes [ILOs])[3]	**Resources** (enablers/technologies)[4]
Project Delivery: **Coordination**	**Disciplinary Models Coordination (Clash Detection)** Exchanging and federating BIM models and associated data across multiple project disciplines, increasing coordination either within model authoring applications or identifying geometry-based clash issues using automated 3D coordination applications. This can include the incorporation of deliverables from the BIM use "Existing Conditions Model Authoring".	- Apply BIM model coordination and clash detection and rule-based analysis tools - Identify various roles and responsibilities of project team members to contribute and resolve coordination issues - Apply import, export, federate, navigate and review for 3D models - Characterise interdisciplinary clashes in a 3D model - Identify simple quality issues (other than clashes) in a design - Identify standards applicable for quality checks (related to the discipline) - Describe the process of coordination	- BIM modelling applications - Geo-spatial equipment and applications - Reality capture equipment and editing applications - Surveying equipment and applications - Relevant standards and guidelines that may apply to project delivery at this stage
	Model Validation Testing single BIM models or exchanging and federating BIM models and associated data across multiple project disciplines using automated, rule-based applications. Testing issues can include validation, compliance, conflict and other use cases.	- Characterise BIM rule-based analysis tools and applications - Identify various applications of automated model checking - Identify local and national building codes, standards and regulations (related to the discipline) - Identify regulatory issues within the discipline and federated models - Identify various applications of programming and coding for compliance checks	- BIM modelling applications - Model and data libraries and templates including manufacturers' information - 3D printing (additive and similar) equipment and supporting applications - Computer numerical control (CNC) machining (subtractive and similar) equipment and supporting applications - Relevant standards and guidelines that may apply to project delivery at this stage
Project Delivery: **Simulation and Analysis**	**Site Selection Analysis** In pre-design phases, using BIM and geographic information system (GIS) tools to analyse and select the optimal location for the facility, in terms of building access, orientation, etc. Then design the building based on the selected location.	- Characterise and apply BIM authoring tools (related to the discipline) - Identify various GIS tools and applications - Identify workflows for integrating GIS data with BIM - Identify procedure to check local councils' planning regulations and conditions - Identify various surveying requirements, tools and application - Identify the workflows for integrating surveying data with BIM models - Identify various site layout design and optimisation methods	- BIM modelling applications - 3D printing (additive and similar) equipment and supporting applications - CNC machining (subtractive and similar) equipment and supporting applications - Other automated set-outs, construction and fabrication tools/applications (including but not limited to robotic, augmented/mixed reality and other enabling technologies) - Fabrication parts library (as in previous point) - Common Data Environment (CDE) applications - Relevant standards and guidelines that may apply to project delivery at this stage
	Structural Performance Analysis Using analysis applications for the study, validation and optimisation of structural design utilising BIM structural models and associated data.	- Describe or apply BIM model authoring tools for structural analysis (related to the discipline) - Identify or describe major structural analysis tools in integration with BIM authoring tools (related to the discipline) - Identify various roles and responsibilities of project team members pertinent to structural analysis - Describe the workflows for the exchange of data between structural analysis and BIM authoring tools - Describe the workflows and procedure for the use and interpretation of structural analysis results	- BIM modelling applications - Common Data Environment (CDE) applications - Relevant standards and guidelines that may apply to project delivery at this stage
	Lighting Performance Analysis Using analysis applications, including real-life simulation and compliance checking, for the study, validation and optimisation of a lighting design, utilising BIM lighting models and associated data.	- Describe or apply BIM model authoring tools, specifically related to lighting elements and practice (related to the discipline) - Identify or describe major lighting analysis tools in integration with BIM authoring tools (related to the discipline) - Identify various roles and responsibilities of project team members pertinent to lighting analysis - Describe the workflows for the exchange of data between lighting analysis and BIM authoring tools - Describe the workflows and procedure for the use and interpretation of lighting analysis results	- BIM model viewing applications may include support for issue capture and management - Tools and procedures related to project team communication and information management - Data visualisation tools and applications - Extended reality tools supporting immersive, augmented, interactive and collaborative communication, and review workflows - Common Data Environment (CDE) applications - Relevant standards and guidelines that may apply to project delivery at this stage
	Energy Performance Analysis Using analysis applications, including real-life simulation and compliance use cases, for the study, validation and optimisation of an asset's energy performance utilising BIM models and associated data.	- Describe or apply BIM model authoring tools, specifically related to energy performance elements and practice (related to the discipline) - Identify or describe major energy performance analysis tools in integration with BIM authoring tools (related to the discipline) - Identify various roles and responsibilities of project team members pertinent to energy analysis - Describe the workflows for the exchange of data between lighting analysis and BIM authoring tools - Describe the workflows and procedure for the use and interpretation of lighting analysis results	- BIM modelling applications - BIM energy performance analysis applications - Regulatory information on building/asset energy design and performance - Local weather data - National/local building energy standards - Common Data Environment (CDE) applications - Relevant standards and guidelines that may apply to energy analysis
	Sustainability Analysis Using analysis applications, including real-life simulation and compliance use cases, for the study, validation and optimisation of an asset's environmental impact (based on sustainability criteria) over its life cycle, utilising BIM models and associated data.	- Describe or apply BIM model authoring tools, specifically related to sustainability analysis (related to the discipline) - Identify or describe major sustainability analysis tools in integration with BIM authoring tools (related to the discipline) - Identify various roles and responsibilities of project team members pertinent to sustainability analysis - Describe the workflows for the exchange of data between sustainability analysis and BIM authoring tools - Describe the workflows and procedure for the use and interpretation of sustainability analysis results	- BIM modelling applications - BIM sustainability analysis applications - Local weather data - Regulatory information on sustainable design and performance - Common Data Environment (CDE) applications - Relevant standards and guidelines that may apply to sustainability analysis
	Construction Planning and Simulation (4D modelling) Utilising BIM models and associated data with other time-based information as the basis for producing and communicating construction planning and scheduling. Construction planning and simulation BIM can be separately defined as specific time-based BIM Uses to satisfy the objectives of different project stakeholders. including but not limited to construction progress monitoring and controlling, work health and safety/occupational health and safety (WHS/OH&S) analysis, status reports, location-based scheduling, delay analysis, construction simulation prior to on-site delivery for client approval, ongoing construction simulation comparison to as-built conditions, site logistics, etc.	- Describe or apply BIM model authoring tools, specifically related to four-dimensional (4D) analysis - Identify or apply planning and scheduling of design and construction methods (related to the discipline) - Characterise or describe project delivery scheduling requirements with design, construction and asset data - Describe Work Breakdown Structure (WBS) and Critical Path Method (CPM) - Identify various roles and responsibilities of project team members pertinent to 4D analysis - Describe the workflows for the exchange of data between 4D applications and BIM authoring tools - Describe the workflows and procedure for the use and interpretation of 4D analysis results	- 4D sequencing and visualisation applications - Construction management/project management applications - Common Data Environment (CDE) applications - Relevant standards and guidelines that may apply to 4D analysis

[5] For example, students in civil engineering and structural engineering disciplines are expected to have the competency of applying the tools, whereas other disciplines should be able to describe the methods and tools.

ABAF BIM Competency Framework: BIM Uses, Required Competencies and Resources Contd.

	BIM Use (description)	**Competencies** (in the form of intended learning outcomes [ILOs])[3]	**Resources** (enablers/technologies)[4]
Project Delivery: **Simulation and Analysis**	**Site Logistics Modelling (an extension to 4D modelling)** Developing a model of construction resources (labour, materials and equipment) covering temporary and permanent facilities on a site during the construction phase. The model can be linked to the Internet of Things (IoT) database for management and tracking. This can include the incorporation of deliverables from the BIM use "Existing Conditions Model Authoring".	- Describe or apply BIM model authoring tools, specifically related to site logistics analysis - Identify or apply site logistics analysis tools (related to the discipline) - Understanding of planning, design and construction methods - Identify various roles and responsibilities of project team members pertinent to site logistics analysis - Describe the workflows for the exchange of data between site logistic analysis applications and BIM authoring tools - Describe the workflows and procedure for the use and interpretation of site logistics analysis results	- 4D sequencing and visualisation applications - Construction management/project management applications - Common Data Environment (CDE) applications - Systems that capture and record information from on-site activities including radio-frequency identification (RFID) and IoT, integrated with 4D planning and visualisation applications. - Relevant standards and guidelines that may apply to site logistics analysis
	Cost Analysis (5D modelling) Utilising BIM models and associated data with other cost-based information as the basis of quantity take-offs and cost estimates. Cost analysis BIM Uses can be separately defined as specific cost-based BIM Uses to satisfy the objectives of different project stakeholders including but not limited to cash flows, progress claims, variations or change orders, depreciation, replacement cost estimates, maintenance, operational or demolition budgets, comparative cost analysis, etc.	- Describe or apply BIM model authoring tools, specifically related to five-dimensional (5D) analysis - Identify or apply measurement and estimation methods (related to the discipline) - Characterise or describe project cost and quantity surveying requirements with design, construction and asset data - Describe Cost Breakdown Structure (CBS) - Identify various roles and responsibilities of project team members pertinent to 5D analysis - Describe the workflows for the exchange of data between 5D applications and BIM authoring tools - Describe the workflows and procedure for the use and interpretation of 5D analysis results	- 5D cost estimation applications - BIM model validation applications - Cost data (Cost Breakdown Structures [CBSs]) - Common Data Environment (CDE) applications - Relevant standards and guidelines that may apply to 5D analysis
Operation	**Monitoring Maintenance** Using as-constructed model information from the project delivery phase (Project Information Model [PIM]), combined with ongoing and maintained operations information (including the Asset Information Model [AIM]) to support various asset and facilities maintenance activities.	- Describe various asset maintenance applications and information exchange procedures from project delivery to operation and maintenance - Describe BIM authoring tools applications for maintenance and operation activities - Describe Common Data Environment (CDE) tools for Project Information Model (PIM) handover - Describe applications that support BIM model integration with asset and facilities maintenance systems - Identify various roles and responsibilities of project team members pertinent to maintenance monitoring - Describe asset and facility maintenance principles and processes - Characterise data schema understanding including classification, identification/tagging, type and component attributes - Identify predictive maintenance procedures and tools - Identify relevant BIM standards and guidelines applicable to maintenance monitoring - Describe the workflows and procedures for the use and interpretation of maintenance monitoring data - Apply BIM-related terminologies (refer to applicable BIM terminologies)	- Asset monitoring and maintenance scheduling applications - Project Information Model (PIM) deliverables - BIM model visualisation applications with the capability to provide an interface to asset and facilities maintenance and operations systems - Common Data Environment (CDE) applications - Relevant standards and guidelines that may apply to project delivery - Relevant standards and guidelines that may apply to operations and asset management
	Monitoring Asset Performance Using as-constructed model information from the project delivery phase (Project Information Model [PIM]), ongoing and maintained operations information (including the Asset Information Model [AIM]) and monitoring/sensor data, to analyse the overall performance of an asset and its facility systems (e.g., structural, mechanical, security, etc.)	- Describe various asset maintenance applications and information exchange procedures from project delivery through to operation and asset performance monitoring - Describe BIM authoring tools applications for asset performance monitoring - Describe Common Data Environment (CDE) tools for Project Information Model (PIM) handover - Describe applications that support BIM model integration with asset performance monitoring systems - Identify various roles and responsibilities of project team members pertinent to asset performance monitoring - Describe asset performance monitoring principles and processes - Characterise data schema understanding including classification, identification/tagging, type and components - Identify predictive maintenance procedures and tools - Identify relevant BIM standards and guidelines applicable to asset performance monitoring - Describe the workflows and procedure for the use of IoT and sensor data for asset performance monitoring - Describe the workflows and procedure for the use and interpretation of asset performance data - Apply BIM-related terminologies (refer to applicable BIM terminologies)	- Asset and facilities monitoring/sensor integration, monitoring and recording applications and systems - Project Information Model (PIM) deliverables - BIM model visualisation applications with the capability to provide an interface to asset and facilities maintenance and operations systems, and monitoring/sensor integration systems - Common Data Environment (CDE) applications - Relevant standards and guidelines that may apply to project delivery - Relevant standards and guidelines that may apply to asset performance monitoring
	Space Utilisation Management Using as-constructed model information from the project delivery phase (Project Information Model [PIM]), combined with ongoing and maintained operations information (including the Asset Information Model [AIM]), to support the scheduling and other supporting activities of space utilisation management.	- Identify space management applications and information exchange methodologies from project delivery - Identify BIM authoring tools applications for space utilisation management activities - Identify various roles and responsibilities of project team members pertinent to space utilisation management - Identify space utilisation management principles and processes - Identify space utilisation management principles and processes - Understanding relevant BIM standards and guidelines applicable to space utilisation management - Describe the workflows and procedure for the use and interpretation of space utilisation data - Apply BIM-related terminologies (refer to applicable BIM terminologies)	- Space utilisation management and analysis applications - Project Information Model (PIM) deliverables - BIM model visualisation applications with the capability to provide an interface to space utilisation management systems - Common Data Environment (CDE) applications - Relevant standards and guidelines that may apply to project delivery - Relevant standards and guidelines that may apply to space utilisation management

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