# Building Information Modelling: Evaluating Tools for Maturity and Benefits Measurement


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## Executive summary

Building information modelling (BIM), within the context of the UK BIM Framework and this report, refers to an information management methodology that has at its core the adoption of a standards-based approach to managing information across the whole life cycle of built assets (i.e. encompassing design, build, operate and integrate). In an information-intensive industry such as construction, the adoption of such a holistic and standardised approach to information management and the innovative digital ways of working are deemed necessary to achieve a dramatic improvement in delivery and performance efficiencies.

The number of tools and methods to assess BIM maturity and evaluate BIM benefits has increased in recent years because of their promised value in guiding BIM implementation (e.g. identifying implementation challenges, informing BIM improvement strategies) and improving outcomes for organisations and projects. However, there is still limited evidence and understanding of their adoption, scope and application in the construction and asset management industries. This report evaluates the existing tools and methods for BIM maturity assessment and BIM benefits evaluation, of both organisations and projects. The distinction between tools and methods is simply that a tool has a platform such as an online survey or an Excel workbook to conduct the assessment. Methods, on the other hand, provide details of the methodology behind measuring maturity, but they do not have a platform for measurement that was made available for review.

| Tool | Owner | Type | Application |
|---|---|---|---|
| BIM Excellence Online Platform | ChangeAgents AEC | Maturity tool | Organisation; project |
| BIM Online Maturity Assessment | National Federation of Builders (NFB)/CITB | Maturity tool | Organisation |
| BIM Supporters' BIM Compass | BIM Supporters | Maturity tool | Organisation |
| CPIx BIM Assessment Form | Construction Project Information Committee | Maturity tool | Organisation |
| Maturity Matrix: Self-Assessment Questionnaire | Project 13 – Institute of Civil Engineers | Maturity tool | Organisation |
| NBIMS Capability Maturity Model | National Institute of Building Sciences | Maturity tool | Organisation |
| Organizational BIM Assessment | Pennsylvania State University | Maturity tool | Organisation |
| SFT's BIM Compass | Scottish Futures Trust | Maturity tool | Organisation |
| Supply Chain BIM Capability Assessment | Wates | Maturity tool | Organisation |
| Vico BIM Scorecard | Vico Software (now part of Trimble) | Maturity tool | Organisation |
| BIM Maturity Assessment Tool (BMAT) | University of Cambridge | Maturity tool | Project |
| BIM Maturity Measure | ARUP/Institute of Civil Engineers | Maturity tool | Project |
| BIM Working Group BMAT | Public Sector Working Group | Maturity tool | Project |
| Dstl BIM Maturity Assessment Tool | Dstl | Maturity tool | Project |
| VDC Scorecard | Centre for Integrated Facility Engineers, Stanford University | Maturity tool | Project |
| Owner's BIMCAT (Competency Assessment Tool) | Giel & Issa (2014) | Maturity method | Organisation |
| BIM Maturity Assessment Tool | Department for Transport | Maturity method | Organisation |
| Building Information Modeling Cloud Score (BIMCS) | Du et al. (2014) | Maturity method | Organisation |
| Organizational BIM Assessment Profile | Pennsylvania State University | Maturity method | Organisation |

| | | | |
|---|---|---|---|
| BIM Return on Investment Tool | Scottish Futures Trust | Benefits tool | Projects |
| BIM Value | NATSpec | Benefits tool | Organisation; projects |
| BIM Benefits | University of Cambridge | Benefits tool | Projects |
| BIM Level 2 Benefits Management Strategy | PricewaterhouseCoopers | Benefits method | Projects |
| TfL BIM Benefits Management Strategy | Transport for London | Benefits method | Projects |
| ROI Analysis | Giel & Issa (2013) | Benefits method | Organisations |

## Research methodology

The research methodology consisted of the following five work items:

- **Desktop-based evaluation of the tools and methods:** Extensive desk research was performed to first identify the available tools and methods and then to evaluate them. Unpublished tools and methodologies available within organisations, that were made available for the study, were also included in the list of tools. The tools and methods identified do not represent an exhaustive list; however, they include most of the notable tools that are available, both in the UK and internationally. An *information extraction card* was used to perform the analysis of existing BIM maturity and BIM benefits tools. It included a list of features and criteria that were used in the analysis to capture the general characteristics of the tools; detect what they measure, and how; and evaluate the quality of the measurement offered by the tools. Two information extraction cards were developed: one for the BIM maturity assessment tools; and one for the BIM benefits measurement tools. Completion of the information extraction cards entailed the analysis of available documents about a tool, its actual use to perform a simulated measurement (when access to the tool was available) and interviews with the tool's developers in some instances, such as when information was missing or required clarification. Simplified versions of the cards were used to evaluate the 'methods' for BIM maturity and BIM benefits measurements that are not operationalised into tools. The two information extraction cards are described in the tool evaluation sections: Section 6.1 for the BIM maturity assessment tools and methods; and Section 7 for the BIM benefits measurement tools and methods. The evaluation results using the information extraction cards are used for 'individual tool analysis' (Sections 6.1 and 7.1) and 'cross-tool analysis' (Section 6.2 for maturity tools, and Section 7.3 for benefits tools).

- **Analysis of 'project BIM maturity tools' against ISO 19650-2:2018:** This analysis was performed for project BIM maturity tools only, by relating the topics and items assessed in each project BIM maturity tool to the corresponding ISO 19650-2:2018 Clause(s), expressed as information management activities or tasks (e.g. at appointment, the activity 'confirm the delivery team's BIM execution plan' is a requirement upon the appointing party). The analysis of such links provides an understanding of the *relevance* of the assessment offered by a BIM maturity tool to the corresponding ISO standard and the extent of the tool's *coverage* of a standards-based approach to information management. Inferences through interpretation and coding were kept to a minimum to avoid undermining the analysis results. The analysis took into account that the issue dates of most of the analysed tools precede the publication of the ISO 19650-2:2018 and previous standards and specifications included under the UK BIM Framework; and the tool's intended audience (e.g. a tool intended for a lead appointed party usually does not assess topics and items that are related to 'Process 5.1. Assessment and need' of ISO 19650-2:2018). The results from this analysis are reported in Section D for individual tools and Section 6.2.4 for the cross-tools analysis.

- **Industry workshops:** Three industry workshops (one in Newcastle upon Tyne, and two in London) were held with experts from the UK construction sector to understand the current applications of

these tools in organisations and projects, the implications of their use, the industry requirements and the gaps in existing practice of BIM maturity assessment and BIM benefits evaluation. There were 37 participants over the 3 workshops (see Appendix A) from across different sectors and organisation types. The results from the workshops were recorded and the key themes identified that have been referred to across the different sections within this report, labelled [W].

- **Interviews**: Eight interviews were conducted with experts from the UK construction sector to address the same objectives as the workshops. The interviews targeted respondents who were not able to attend the workshops. A semi-structured approach was adopted, with questions prepared in advance to ascertain the interviewees' experiences of either using a tool or their requirements of a tool if they had not used one but were familiar with the available tools. All interviews were recorded and then transcribed. The results from the interviews were assimilated into key themes that have been referred to across the different sections within this report, labelled [I].

- **Survey:** An online survey was conducted between 30 August and 15 October 2019. Its purpose was not only to triangulate and augment the results from the desk research, industry workshops and interviews, but also to assess the level of uptake of BIM benefits and maturity assessment tools within the construction industry and to understand the business implications of their use. One hundred and eighty-four responses, obtained from across the building and infrastructure sector, were analysed. The results of the survey are mainly included in Section 8 (Industry usage and implications). However, insights derived from the survey are also reported across other sections of the report and are labelled [S].

The results from across the five work items above were analysed to identify the strengths, weaknesses and challenges of the tools (Section 6.3 for maturity tools, and Section 7.4 for benefits tool), and to perform a gap analysis between industry requirements and capabilities of the tool (Section 9).

### Key findings: BIM maturity tools

- Most of the 15 tools are free to use and publicly available (11 tools), can be used by organisations involved in both building and infrastructure (11 tools) and are discipline-agnostic (10 tools).

- Available BIM maturity tools for organisations generally assess items that belong to similar topics (e.g. strategy; mobilisation and management of human resources; mobilisation and management of technology). A full list of topics addressed by organisation BIM maturity tools is included in Table 6-3.

- Project BIM maturity tools place greater emphasis on measuring topics and items related to information management, in particular, the 'Collaborative production of Information' (ISO 19650-2 Clause 5.6), the 'Information model delivery' (ISO 19650-2 Clause 5.7) and 'Mobilisation' (ISO 19650-2 Clause 5.5). A full mapping of tools against the ISO 19650-2 is included in Table 6-8.

- Tools for assessing organisations offer varying scopes of assessment, from readiness assessment, through to capability assessment, capability maturity assessment, and fulfilling different purposes, including capability benchmarking and compliance benchmarking (including conformance[1] and compatibility assessment[2]). The majority of the tools focus on capability assessment and

[1] Assessing whether the multiple offices of a large organisation conform to their established protocols or other established targets (e.g. defined set of BIM capabilities).
[2] Assessing and comparing the BIM performance of organisations within the supply chain or project teams.

benchmarking. An explanation of these terms is included in Section 2 (BIM maturity and BIM benefits: key terminology).

- Tools for assessing projects are generally focused on compliance with standards requiring assessment to be performed at each project life-cycle phase and are used for the purpose of benchmarking against industry-wide benchmarks.

- The depth (granularity) of assessment enabled by most tools (11 out of 15) is low, offering limited understanding of the BIM maturity of organisations or projects.

- Assessments made by several BIM maturity tools suffer from some quality issues as a result of unclear formulation (issues with content and syntax) of assessment items, which compromises the accuracy and consistency of assessment. The metrics in some of the tools are unreliable because of their insufficient description and subjective nature. Other metrics are unreliable as a result of their inaccurate description, where, in some instances, individual metrics merge readiness, capability and maturity aspects.

- There is a concern among industry practitioners that the current approaches to BIM maturity assessment adopted in most of the existing tools and practices are ineffective and do not produce an accurate representation of an organisation or individual's BIM maturity. They are rigid, requiring binary (yes/no) inputs from users, largely focusing on readiness and capability for compliance purposes, and involve limited evidence or assurance of the assessment performed. There is also a need to focus more on behaviours that promote collaboration.

- There is a need to measure the maturity of the whole supply chain, rather than just focusing on Tier 1 contractors and lead designers, which appears to be current practice. Current BIM maturity tools and processes do not serve this need, as they are not sufficiently flexible to be adapted to different actors within the supply chain.

- Industry experts suggested that assessment is currently dominated by the desire to comply with clients' BIM requirements. However, requirements differ between clients and are generally very broad to measure against. Differing requirements are also attributed to the different levels of skills and awareness on the client's side, or to the uniqueness of every project. This was especially witnessed by organisations who work in different markets, for different clients, and which follow different procurement routes. As a result of the variability of BIM requirements, some participants suggested it would be difficult to produce a standardised set of BIM maturity metrics; therefore, bespoke 'maturity' metrics need to be produced. However, with bespoke metrics, benchmarking BIM performance will be difficult to achieve, and assessment will require a greater level of investment to administer.

- A total of 28% of the survey respondents (sample size 184) measure BIM maturity and use a tool to do so. A total of 18% measure BIM maturity, but not with a tool. Where respondents were measuring BIM maturity, they were more likely to agree that BIM delivers the expected benefits. The three BIM benefits, which are recognised most by those who assess maturity compared to those who do not, are: 'increase productivity for my organisation'; 'reduce professional risk for me/my organisation'; and 'increase profitability of my organisation'.

- The survey identified several benefits of measuring BIM maturity. These included: 'identifies the BIM implementation challenges faced by our organisations'; 'helps us to develop improvement strategies'; 'helps us to see the effort and investment required to develop both staff and our systems or processes'; and others that are listed in Figure 8-19. Interestingly, these are the same

benefits that are perceived more by those who measure BIM maturity compared to those who do not, which suggests there is a potential relationship between maturity assessment and benefits appreciation.

- Industry experts agreed that the tools need to reflect the transition to the ISO 19650 Series. No tool currently exists that is aligned with these standards, although many measure topics and items of relevance to the ISO 19650 Series. as demonstrated in Section 6.2.4.
- Further noteworthy findings are included across the report and the recommendations below.

### Key findings: BIM benefits tools

- All tools address benefits that are inherently associated with enablers/activities made available through BIM and the supporting ecosystem of project standards under which BIM is adopted.
- One tool (*BIM Benefits*) ties together several benefits pathways into key end-benefits; one tool (*BIM Value*) develops pathways for intermediate benefits pre-selected by users to be targeted; and one tool (*BIM Return on Investment Tool*) addresses qualitative assessment using benefits statements.
- The baseline or counterfactual situation, against which improvements are compared, refers to organisations or projects not using BIM or which have not implemented any BIM capability at the time of the evaluation. One tool (*BIM Value*) refers to benefit estimates adopted from academic literature, which in turn were derived from comparison against projects and workflows not using BIM.
- The accuracy of BIM benefits measurement enabled by the tools is questionable. This is based on factors such as the confounding nature[3] of the benefits measurement problem, the lack of benchmarking data and the reliance on estimates of the knowledge of users inputting the data and the subjectivity involved.
- Survey respondents noted that the difficulty lies not only in the measurement of BIM benefits. There are also challenges in the communication of the benefits, and those carrying out benefits measurement need to be competent to do so.
- The tools are likely to develop optimistic estimates of the benefits because of issues identified in the detailed analysis of individual tools, such as double counting of some benefits and the assumption that the evaluation is being performed within an environment (project or organisation) that has not implemented any element of BIM.
- The outputs from the benefits evaluation, including the quantitative evaluation provided by the tools, are generally not informative. Outputs produced by the tools (e.g. *BIM Return on Investment Tool*) reiterate the input of users (such as displaying amalgamated benefits with three levels of confidence) without actionable advice to users about how to achieve the benefits.
- Most organisations consulted were capturing benefits through the case studies of completed projects. Most agreed that many of the benefits explored were anecdotal rather than tangible.
- One of the most contentious points raised was whether resources should be invested to measure 'BIM benefits'. This argument was driven by the challenges facing BIM benefits evaluation and the debate around project 'outcomes' versus 'outputs'.

[3] Confounding nature refers to a situation where it is challenging to reasonably eliminate plausible alternative explanations for an observed relationship between two variables (e.g. a BIM activity/capability and an end-benefit).

- Industry experts noted that the measure of success continually changes as the industry matures and over the long lifespan of projects. The evaluation of BIM benefits should be a dynamic process, and metrics should remain able to reflect changes in requirements, technology and the project context, for the measurement to remain useful and relevant over time. There also needs to be some investigation around how to incentivise the delivery of these benefits on a project given the varying benefits standpoints of different actors.
- Industry experts perceive existing BIM benefits evaluation approaches as being focused on driving encouragement to adopt BIM instead of identifying benefits and measuring what adds the most value to the project. Some participants warned about the risk of concentrating the discussion on BIM benefits, which would become an add-on diverting attention away from enabling collaborative and information management processes.
- The survey revealed that 16% (29) evaluate BIM benefits, 77% (141) agree 'there is a need for better measurement tools' and 92% (168) strongly agree that 'measuring BIM benefits encourages an increasingly collaborative way of working'. Hence, the survey data suggests that there is important value to be derived from BIM benefits evaluation approaches and tools.
- Further noteworthy findings are included across the report and in the justification of the recommendations, presented in the subsequent section.

This gap analysis revealed several gaps between the capabilities of existing tools and the industry requirements. Based on the gap analysis, several recommendations were made for both the measurement of BIM maturity and the evaluation of BIM benefits.

### Recommendations for BIM maturity assessment

For the maturity tools, there was clear evidence from all the work items conducted for this study that there is a need for BIM maturity assessment. However, the study exposed several gaps in the existing tools against industry requirements and expectations. The recommendations and corresponding gap(s) they address are explained hereafter.

***Recommendation 1:*** *BIM maturity assessment should be encouraged to preserve and further progress the benefits experienced by those assessing BIM maturity*.

**Justification:** There was clear evidence from across all of this study's work items that there is a need for maturity assessment. Those who are assessing BIM maturity are experiencing important benefits, including: help identifying BIM implementation challenges faced by their organisations; informing improvement strategies, including the effort and investment required to develop both staff and systems or processes; and helping to appoint more qualified project teams and organisations. They also have a better appreciation of benefits compared to those who do not measure BIM maturity. BIM maturity assessment is perceived as being more important than benefits evaluation, as industry experts argue that the latter will be a by-product if the supply chain has the adequate BIM capabilities and maturity.

***Recommendation 2:*** *The gaps in BIM maturity assessment tools and practices for both organisations and projects need to be addressed in order to fulfil industry requirements and expectations.*

**Justification:** The discussion made in Section 9 exposed several gaps (e.g. rigid tools – one-size-fits-all; inaccurate and low granularity assessment; binary (yes/no) assessment focused on readiness and capabilities for compliance purposes; overlooking collaborative behaviour; inappropriate baselines

and timing used in assessment) in existing tools against industry requirements and expectations. The shortcomings of the existing tools are driving many organisations to develop their own internal BIM maturity assessment approaches. The survey showed that 45% of respondents who are assessing maturity have developed their own internal tools. This is likely to limit the widespread adoption of maturity assessment within the industry and limit its ability to develop benchmarks.

***Recommendation 3:*** *BIM competencies should play a greater role in 'invitation to tender', 'tender response', 'appointment' and 'mobilisation'. More attention should be paid to BIM competency assurance[4] during the transition across these stages. The competencies should be extended beyond readiness and capability to include maturity. This process can be assisted by adopting the ISO 19650-2:2018 approach, which has enabling requirements throughout: invitation to tender (i.e. 'Clause 5.2.3 establish tender response requirements and evaluation criteria'); tender response (i.e. 'Clause 5.3.3 assess task team capability and capacity', 'Clause 5.3.4 establish the delivery team's capability and capacity, and 'Clause 5.3.5 establish the delivery team's mobilisation plan'); appointment (i.e. 'Clause 5.4.1 confirm the delivery team's BIM execution plan'); and mobilisation (i.e. 'Clause 5.5.1 mobilise resources').*

**Justification:** There is a concern about the timing of BIM maturity assessment in projects, which, according to industry experts, is affecting the underpinning rationale behind the assessment. Project teams are often assessed late or at the handover of their deliverables. Industry requires the assessment to be more proactive and to play a role in continual improvement. There is also a trend whereby many organisations deploy their 'best-fit' individuals for the BIM assessment at tender stage, but these are not necessarily the same individuals who will be deployed on the project (Team A and Team B mentality). Solicitation of evidence when assessing BIM maturity is lacking across most existing tools. Industry experts would like to see more weight given to BIM capability and maturity at the tender stage, but this must be accompanied by competency assurance at both the appointment and mobilisation stages.

***Recommendation 4:*** *For organisation BIM maturity assessment, a multi-level framework should be developed to provide a common approach to BIM maturity assessment at industry level. The framework should identify a comprehensive range of BIM competencies required and propose metrics for their assessment. A common level of the framework should be relevant to all disciplines within the construction sector and should be adaptable to specific organisations. This should be complemented with additional levels that are specific for the different disciplines. The approach should not be focused on compliance assessment alone and should increase the focus on individuals/people and collaborative behaviour.*

**Justification:** There is a concern within the industry that current approaches to BIM maturity assessment in most of the existing tools and practices are not effective and do not produce an accurate representation of an organisation or project team's BIM maturity. They are rigid, with binary (yes/no) inputs from users largely focusing on readiness and capability. Industry experts would like to see a greater focus on people and behaviours that promotes collaboration in the assessment. A 'one-size-fits-all' for organisational assessment was conceived by industry experts to be too rigid. Such an approach would make it difficult to capture varying organisational objectives and consider wider

[4] In this context, 'assurance' refers to ensuring that the assessed BIM competencies at appointment are also available after the start of a project and that emerging competency requirements during the project are met.

digital transformation and business strategies of organisations, as these vary significantly across organisation types and sizes.

***Recommendation 5:*** *For project BIM maturity assessment, a BIM assessment method should be developed, based on the UK BIM Framework (including the ISO 19650 Series) and the additional topics and items identified during the analysis of existing tools in this report. The assessment method should ensure flexibility and adaptability to suit different actor and project types. The method and tool should remain current and relevant through periodic review and updating against the UK BIM Framework and technological advances. The tool should not be focused on compliance assessment alone but should also focus on people and collaborative behaviour. The tool needs to support proactive assessment (as opposed to reactive at the time when suppliers hand over the deliverables) and provide feedback for improvement.*

**Justification:** Industry experts argued for a consistent and unified approach to BIM maturity assessment within projects. However, industry requirements include flexibility and adaptability to different project parties and project stakeholders, and the method should be kept updated in line with advancement of industry standards and technology. The ISO 19650 Series and other related standards within the UK BIM Framework could be used as the guiding framework for the development of this assessment method. Existing tools fulfil this approach to a limited extent, but they are not without challenges, as explained in Section 9.1. The industry also seems to be unaware of such tools or unwilling to adopt them, as evidenced by the survey.

***Recommendation 6*** *Improve awareness and provide learning and professional development opportunities about the importance of BIM maturity assessment as an internal function for business and project improvement.*

***Justification:*** There is limited appreciation of the nuances around BIM maturity terminology. In many instances, several participants proposed rationales such as: 'Clients would not pay for a higher level of BIM maturity'; 'There are no incentives to reach levels of maturity that are not required within the market'; and 'There are maturity blind spots within the supply chain, which disincentivises others from reaching higher levels of maturity'. Few in the industry perceived BIM maturity to be an internal performance improvement exercise.

### Recommendations for BIM benefits evaluation

Several shortcomings affecting the evaluation approach (metrics, baselines, assumptions, type of benefits measured, granularity of evaluation) adopted in BIM benefits tools were identified. BIM benefits evaluation was a more contentious topic among industry participants than BIM maturity assessment. The need for formal evaluation of BIM benefits was questioned, and the viability of BIM benefits evaluation was subject to significant scrutiny by participants of the workshops and interviews. These contentious views are partly driven by several challenges that a BIM benefits evaluation approach needs to address in order to be meaningful and relevant. However, the survey data suggests that there is important value to be derived from BIM benefits evaluation approaches and tools.

The recommendations made for BIM benefits evaluation acknowledge these varying views and consider the findings from across all of the study's work items.

***Recommendation 1:*** *BIM benefits evaluation should be extended to address broader benefits related to embedding a digital culture and increased supply chain digital maturity.*

**Justification:** Industry practitioners argued that benefits evaluation should be assessed holistically rather than looking at BIM in isolation. In organisations and supply chains, it was suggested that benefits evaluation should be extended to evaluate broader benefits related to embedding a digital culture, and increased supply chain digital maturity. This recognises that: 1) the benefits achievable are associated with digital (not just BIM) maturity of supply chains; and 2) the benefits achievable are interlinked with the digital maturity of the whole supply chain, not just that of individual organisations.

***Recommendation 2:*** *BIM benefits evaluation should evaluate the degree of fulfilment of project requirements by corresponding deliverables across the project life cycle at set stages, from design through to construction and operation. BIM benefits evaluation for asset owners and operators should be widened beyond BIM to the benefits of broader digitalisation of asset operation, management and service delivery, and requires longitudinal measurements.*

**Justification:** Industry experts suggested that benefits should be assessed against whether the client (or other project actors) received the 'outcomes' they invested in, instead of specific digital outputs (digital outputs are generally considered an enabler of intermediate benefits). As 'outcomes' are the result of a combination of different factors that are not all attributable to BIM, this presents a challenge to measuring BIM benefits. Industry participants from asset-owning organisations noted that their main driver for efficiency gains are the savings and improvements in the operation and service-delivery phase, which are usually attributable to broader digitalisation, not just BIM (e.g. building management systems). These benefits require longitudinal measurement approaches for meaningful analysis and understanding.

***Recommendation 3:*** *BIM benefits metrics (e.g. key performance indicators) should be established at the outset of a project and then consistently and periodically measured against 'targets' to improve assurances of benefits realisation, including at handover stage and into operation and management of assets.*

**Justification:** If BIM benefits evaluation is progressive and continual, it will improve the assurance of benefits realisation and increase the likelihood of benefits occurring at the handover stage, according to industry experts. The availability of metrics, together with a clear plan determining when/how to measure, was also suggested as a way of automating benefits measurement and reducing measurement costs in future. Some of the tools reviewed, such as *BIM Benefits* by the University of Cambridge, use consistent metrics at set project stages that can be continually evaluated. However, this relies on users' subjective opinion/ratings to evaluate 'forecast benefits' linked to information management activities.

***Recommendation 4:*** *The benefits evaluation process and metrics involved should be approached as dynamic and change as projects progress. The metrics should remain 'coupled' to project requirements and context so that measurement remains useful and relevant. The benefits evaluation process and metrics need to address the challenges identified in this research, including: the convoluted and confounding nature of benefits realisation, lengthy project lifetime, time lag between performing an activity and manifestation of the corresponding benefit, frequent changes encountered in projects, evolution of success measures, evolution of benefit-enabling technology and processes, and limited availability of benchmarking data.*

**Justification:** this recommendation embeds many of the requirements and challenges captured during the workshops and interviews. Industry participants argue that, for the BIM measurements to be meaningful and noteworthy, they should address challenges such as: changing project requirements, which affect both the benefits metrics and the measured benefits; long project lifespans that increase the likelihood of changes in requirements; the development of benefits-enabling technologies and process; the time lag between implementing a BIM enabler and the manifestation of its benefits in future; the contribution of several BIM and non-BIM enablers into the same benefit; and the lack of data for benchmarking benefits. These challenges are not currently addressed by the existing tools, which mainly estimate the forecast benefits linked to BIM enablers/activities.

***Recommendation 5:*** *Introduce the 'benefit owner' concept[5] into the evaluation process and metrics to assign responsibility for benefits realisations to specific individuals and teams.*

**Justification:** As a result of the different benefit standpoints that usually exist among project participants, industry experts argued that there is a need to incentivise the delivery of certain benefits. The evaluated BIM benefit tools assume that individuals will implement the activities and BIM enablers that are necessary to realise benefits. None of the tools evaluated capture benefits from multiple actors' standpoints. This challenge is more likely to be addressed in a benefits management strategy, where there is a benefits management plan with explicitly assigned owners with responsibility for benefits realisation, rather than in a standalone BIM benefits tool.

***Recommendation 6:*** *BIM benefits evaluation methods should compare against optimal targets as baselines rather than current approaches that compare against counterfactual situations where BIM is not used.*

**Justification:** BIM benefits tools look 'downward' (e.g. compare against 'low' threshold – traditional processes not using BIM) instead of 'upward'; thus, they cannot capture the opportunity gap that may exist between an optimal state (optimised processes) and the measured state. This shortcoming is partly caused by the lack of established benchmarking data and a reliable counterfactual situation.

***Recommendation 7:*** *The BIM benefits evaluation method should be adaptable and flexible to varying levels of complexity and requirements of projects.*

**Justification:** Industry participants argued that the current tools and approaches to BIM benefits evaluation are rigid, with a pre-defined list of benefits enablers and benefits metrics, which cannot be relevant to all projects with different requirements and varying levels of complexity.

***Recommendation 8:*** *The BIM benefits evaluation approach should be infused across the project stages (from 'assessment and need', through to 'invitation to tender' … and 'project closeout'); should raise awareness of the importance of performing the activities/BIM enablers that unlock the benefits; and should provide guidance to avoid the risk that the BIM benefit evaluation is perceived as a 'bolt-on' to project processes.*

**Justification:** Industry practitioners argued that BIM benefits evaluation should be able to assess whether deliverables fulfil the requirements across the whole project life cycle. The researchers found

[5] A 'benefit owner' is an individual or a team that takes responsibility for a benefit, or set of benefits, associated with a project.

that most of the tools and methods analysed do not directly address this scope. One tool (*BIM Benefits* by the University of Cambridge) evaluates a wide range of intermediate and end-benefits whose realisation can be seen as an indication of potential alignment between specification and deliverables. Industry participants warned that focusing on BIM benefits measurement in isolation, or as a standalone process, may create the misperception that it is a 'bolt-on' to project processes, thus hindering benefits realisation instead of enabling it. This creates the need to both infuse and align the evaluation of benefits across the project stages.

***Recommendation 9:*** *Training and skills programmes should be developed to ensure that the industry has a suitably skilled workforce to engage in BIM benefits evaluation.*

**Justification:** Industry experts expressed concerns over the access to, and availability of, individuals with the skill set to manage the BIM benefits evaluation process. It is challenging for such individuals to know what 'good looks like' in the absence of reliable benchmarking data and relevant baseline/counterfactual situations.

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# 1 Introduction

The aim of HM Government's Construction Sector Deal (2018)[6] is to transform the sector's productivity through innovative processes, technologies and a more highly skilled workforce. The development and adoption of a clear methodology for information management for the delivery and operation of assets within construction and the built environment are critical to realising this transformation. In particular, the adoption of a standards-based approach to information management across the whole life cycle of built assets, from design and construction, through to operation and integration, is critical for enabling innovative ways of working across the built environment and for realising a dramatic improvement in delivery and performance efficiencies. Building information modelling (BIM) plays a critical role in the holistic information management methodology that is currently being led by the UK BIM Framework, comprising the UK BIM Alliance (UKBIMA), the British Standards Institution (BSI) and the Centre for Digital Built Britain (CDBB). The term 'BIM' in this report refers to a holistic concept and process for managing information across the delivery and operational phases of built assets, as conceived by the ISO 19650 Series.

The number of tools and methods available to assess BIM maturity and evaluate BIM benefits has increased in recent years as a result of their promised value in guiding BIM implementation (e.g. identifying implementation challenges, informing BIM improvement strategies) and improving outcomes for organisations and projects. However, there is still limited evidence and understanding of their adoption, scope and application in the construction and asset management industries.

This report evaluates the existing tools for BIM maturity assessment and the tools for BIM benefits evaluation for both projects and organisations, available in the UK and worldwide. The aim is to understand their level of adoption within the design, construction and facilities management sector; their applicability, strengths and weaknesses; and to identify gaps, challenges and areas for future improvement.

This report was commissioned by the CDBB in partnership with the UKBIMA. The CDBB is a UK government-funded body, established in partnership with the University of Cambridge in 2017, to support the transformation of the UK construction sector using digital technologies to better plan, build, maintain and use infrastructure. The UKBIMA is a construction industry alliance set up to respond to the challenges facing BIM adoption becoming commonplace. One aim of the UKBIMA is to ensure that BIM becomes business as usual, while at the same time transforming and future-proofing the way the industry works.

The full scope of the research project is as follows:

**BIM maturity tools**

- Identify BIM maturity tools.
- Evaluate the identified tools (how they are built; which aspects of BIM they measure; and their intended use, strengths and weaknesses).
- Review of the extent to which BIM maturity is being measured within the UK construction and asset management industries.
- Identify the project types to which maturity is being applied.
- Understand how organisations are applying lessons learnt from BIM maturity measurement.

[6] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/731871/construction-sector-deal-print-single.pdf

- Evaluate whether maturity tools can assist clients in appointing suitably qualified teams and/or organisations.

**BIM benefits tools**

- Identify BIM benefits tools.
- Evaluate the identified tools (how they are built; which benefits of BIM they measure; their intended use, strengths and weaknesses; and the extent to which the benefits measurement tools are useable and insightful).
- Understand the benefits of BIM adoption, which are being measured, experienced or are anticipated, and the tools used.
- Review of the extent to which organisational and project performance metrics address BIM adoption and BIM benefits.
- Review of the organisational requirements of BIM benefits measurement tools.
- Explore possible correlations/trends between maturity levels and beneficial outcomes.

The scope includes both tools that are publicly available and unpublished tools, where they are available for evaluation.

This report recognises that 'BIM Level 2' is now a superseded term that has been replaced by the UK BIM Framework, which represents the overarching approach to implementing BIM in the UK and is established through a partnership between the UKBIMA, BSI and CDBB. Most references to BIM and the UK BIM Framework refer to information management, as described in the BS EN ISO 19650[7] Series, plus:

- Collaborative production of information using COBie (BS 1192-4:2014).
- The operational phase of assets (PAS 1192-3:2014 Incorporating Corrigendum No.1).
- A security-minded approach (PAS 1192-5:2015).
- Health and safety requirements (PAS 1192-6:2018).
- Facilities and asset management (BS 8536-1:2015 and BS 8536-2:2016).

However, it is important to note that there are many instances where the notion of 'BIM' is that of the reviewed tool(s). In such instances, the authors will contextualise the meaning of the term based on a thorough review of the tools. Indeed, many of the tools evaluated in this report were developed prior to the establishment of the UK BIM Framework and the release of the ISO 19650. In such cases, this report quotes 'BIM Level 2' (to cite a term used by a tool owner/developer) when evaluating the corresponding tools, but any analysis and recommendations are made in the context of the ISO 19650.

The project's consortium included Northumbria University, Newcastle (UNN), the BIM Academy, the Royal Institute of British Architects (RIBA) and HKA. The project was led by Dr Mohamad Kassem of UNN. The work included desk research (led by Jennifer Li of UNN), eight interviews with industry experts (led by Professor Bimal Kumar of UNN), an industry survey (led by Adrian Malleson of RIBA) and three industry workshops (led by Dr Graham Kelly of BIM Academy and Dr David-John Gibbs of HKA).

This report is organised as follows. Section 1 is the introduction. Section 2 addresses the key terminology; one of the findings is that people use important terms differently, so this section aims to define some important terms from the outset, to aid consistency. Section 3 explains the research

[7] The ISO 19650 Series is an international standard of good practice. It defines information management principles and requirements within a broader context of digital transformation in the disciplines and sectors of the built environment (including construction and asset management industries). Its implementation in the UK is supported by UK National Forewords in ISO 19650 Parts 1 and 2, and a UK National Annex in ISO 19650 Part 2.

methodology. Sections 4 to 5 present the general characteristics of the BIM maturity assessment tools and methods, and BIM benefits evaluation tools and methods, respectively. Sections 6 and 7 perform an analysis of the BIM maturity assessment tools and methods, and the BIM benefits evaluation tools and methods, respectively. Section 8 considers the industry usage and implications of BIM benefits and maturity measurement tools from the survey. Section 9 investigates the extent of support of industry requirements by the existing tools. Section 10 explores the potential correlation between maturity levels and benefits realisation. Section 11 presents the recommendation, and Section 12 concludes.

## 2 BIM maturity and BIM benefits: key terminology

To perform a meaningful evaluation of the existing tools for BIM 'maturity' assessment and BIM benefits evaluation, it is important to delineate the following terms and concepts:

- **BIM compliance**: refers to the abilities of organisations and/or project teams to fulfil prescribed or mandated requirements (e.g. those of a national or international standard, a specific client, and/or industry guidelines).
- **BIM readiness**: refers to the preparatory activities that an organisation or a project team undertakes prior to the adoption of BIM.
- **BIM capability**: refers to the minimum abilities to engage with a BIM process or deliver a BIM outcome (for example, the availability of BIM tools, protocols and other artefacts within an organisation or a project).
- **BIM maturity**: refers to the extent of BIM capabilities within organisations and project teams. It is usually measured on an ordinal scale with levels such as 'ad hoc', 'defined', 'managed', 'integrated' and 'optimised'. Maturity measurement indices (or simply maturity models) usually capture gradual and continual improvement in predictability, quality and repeatability within a BIM capability. These features are necessary to enable the tool to provide *performance benchmarks* or *targets* that can be reached in a progressive manner.
- **BIM competency**: refers to any of the four items above. Usually BIM 'maturity' tools combine in their assessment 'competency' topics and items that are related to the four concepts above (compliance, readiness, capability and maturity).
- **Benchmarking:** an approach that enables the comparison of processes, activities and performance between projects, organisations or within a single organisation over time. When BIM maturity tools are used for a benchmarking purpose, they are usually concerned with BIM performance benchmarking (see next definition).
- **Performance benchmark:** a point of reference (e.g. a performance level) against which performance measurements can be conducted. BIM performance benchmarks may include the *capability* benchmark, *maturity* benchmark (adapted from BIMDictonary.com[8]) and the *compliance* benchmark, for both organisations and projects.
- **BIM benefit:** this report differentiates between intermediate benefits and end-benefits. An intermediate benefit is generally the direct consequence of an activity (e.g. an information management activity) that is enabled by BIM, and an end-benefit is the ultimate result linked to the intermediate benefit. One or more intermediate benefit(s) can lead into the same end-

[8] https://bimdictionary.com/en/performance-benchmark/1

benefit, and one intermediate benefit can contribute to more than one end-benefit. An example is the following: 'improve construction quality control' (*activity*) > 'implement mobile BIM on-site and associated information management activities for site inspection' (*BIM enabler*) > 'easier-to-spot clashes between contractors/subcontractors works' (*intermediate benefit*) > 'time savings in build and commission' (*end-benefit 1*) & 'material savings in build and commission' (e*nd-benefit 2*), and so on. Generally, an organisation or project stakeholder creates a BIM benefit by performing a BIM activity, or exercising a BIM capability, at a given maturity level. Benefits can be either quantitative or qualitative.

- **Benefits management:** a structured approach for maximising benefits for an organisation or project's stakeholders. Benefits management involves identifying, planning, measuring and tracking benefits from the start of the project until the realisation of the last projected benefit.
- **Benefits management plan:** a key document in benefits management that usually addresses these steps:
    - Identification and structuring of benefits.
    - Planning of benefits realisation.
    - Execution of benefits realisation plan.
    - Evaluation of benefits and review of results.
    - Discovery of potential for further benefits.

  Benefits measurement tools should enable most of the steps above, with a key contribution to evaluation of the benefits step.

# 3 Research methodology

To achieve an informative and reliable evaluation of the existing tools for BIM maturity and BIM benefits, a number of research methods were deployed:

- **Desk research:** Extensive desk research was performed to identify the available tools and methods. Unpublished tools and methodologies available within organisations were also included in the list of tools where the tool owner was willing to make them available for the study. Fifteen maturity tools, four maturity methods, three benefits tools and three benefits methods were identified and evaluated in this report. The distinction between tools and methods is simply that a tool has a platform such as an online survey or an Excel workbook with which to conduct the assessment. Methods provide details of the methodology behind measuring maturity, but either they do not have a platform for measurement or the platform was not available to the reviewers. The tools and methods identified do not represent an exhaustive list; however, they include most of the notable tools that are available, both in the UK and internationally. The results from the desk research identified key themes that are referred to across the different sections within this report. Findings and insights from the desk research are tagged by [DR] throughout the report.
- **Information extraction cards:** An information extraction card is an evaluation form that was used to perform the analysis of existing BIM maturity and BIM benefits tools. It included a list of features and criteria used in the evaluation to: capture the general characteristics of the tools; detect what they measure, and how; and evaluate the quality of the measurement offered by the tools. The information extraction cards structured the analysis of existing tools and subsequent cross-tool analysis. Two information extraction cards were developed: one for the BIM maturity assessment tools; and one for the BIM benefits measurement tools. Completion of the information extraction cards was an extensive exercise that entailed the analysis of available

documents about a tool, the actual use of the tool to perform a simulated measurement (when access to the tool was available) and interviews with the tool's developers in some instances, such as when information was missing or required clarification. Simplified versions of the cards were used to evaluate the 'methods' for BIM maturity and BIM benefits measurements that are not operationalised into tools. The two cards are described in the tool evaluation sections: Section 6.1 for the BIM maturity assessment tools; and Section 7 for the BIM benefits measurement tools.

- **Analysis of 'project' BIM maturity tools against the ISO 19650-2:2018:** This analysis relates the topics and items assessed in each project BIM maturity tool to the corresponding ISO 19650-2:2018 Clause(s), expressed as information management activities or tasks (e.g. at appointment, the activity of 'confirm the delivery team's BIM execution plan' is a requirement upon the appointing party). The analysis of such links or relationships provides an understanding of the *relevance* of the assessment offered by a BIM maturity tool to the corresponding ISO standard and the extent of its *coverage* of a standards-based approach to information management. This analysis was performed in a way that would not introduce inaccuracies, as inferences through interpretation and coding were kept to a minimum. The researchers were also mindful of several key factors that could affect the outcomes of the analysis: the issue date of the analysed tool relative to publication of the ISO 19650-2:2018 and preceding standards and specifications included under the UK BIM Framework; the tool's intended audience (e.g. a tool intended for a lead appointed party usually does not assess topics and items related to 'Process 5.1. Assessment and need' of ISO 19650-2:2018); and finally, avoiding the potential to favour tools focused on compliance assessment that would usually show a high degree of relevance and coverage against standards with prescriptive processes and clauses.

- **Industry workshops:** Three industry workshops (one in Newcastle upon Tyne, and two in London) were held with experts from the UK construction sector to understand the current applications of these tools in organisations and projects, the implications of their use, and the gaps in existing practice of BIM maturity and BIM benefits measurement, and the industry requirements. There were 37 participants over the 3 workshops (see Appendix A), 15 of which were focused on building projects, 14 had experience in both building and infrastructure, and 6 were focused on infrastructure. Among the 37 participants, there were 12 designers, 8 consultants, 6 contractors, 5 clients, 2 facilities managers and 2 lawyers, providing a diverse view on the subject. The workshops were split into three main activities: 1) an introduction to the findings of the desk research; 2) the participants were asked what tools or practices they use, and the strengths and challenges of the tools/practices used; and 3) participants explored the weaknesses of the existing tools and practices, potential synergies between maturity and benefits, and recommendations. All activities were split equally between evaluating maturity and benefits tools. The results from the workshops were distilled into key themes that have been referred to across the different sections within this report. Findings and insights from the workshops are labelled [W] and used throughout the report.

- **Interviews**: Eight interviews were conducted with experts from the UK construction sector to address the same objectives as the workshops. The interviews targeted respondents who were not able to attend the workshops. There were two interviewees from the contracting sector, two from the client or client-representative organisations, two from service-providers to the industry, and two from the professional services (design/architecture) sector. A semi-structured approach was adopted, with questions prepared in advance to ascertain interviewees' experiences of either using a tool or their requirements of a tool if they had not used one but were familiar with the available tools. Six interviews were held face-to-face in Newcastle upon Tyne, Edinburgh and

Glasgow, and two were held via telephone/Skype. All interviews were recorded and transcribed. Further analysis of the interviews was carried out for each recording, as well as an overarching analysis across the interviews. Findings and insights from the workshops are labelled [I] and used throughout the report.

- **Survey:** An online survey was conducted between 30 August and 15 October 2019. Its purpose was not only to triangulate and augment the results from the desk research, industry workshops and interviews, but also to assess the level of uptake of BIM benefits and maturity assessment tools within the construction industry and to understand the business implications of their use. One hundred and eighty-four responses obtained from across the building and infrastructure sector were analysed. The results of the survey are discussed in Section 8 (Industry usage and implications). However, insights derived from the survey are also used across other sections of the report and are labelled [S].

# 4 BIM maturity tools and methods: general characteristics

The general characteristics of the 15 tools for organisation BIM maturity and project BIM maturity are included in Table 4-1 and Table 4-2, respectively, where one tool (*BIM Excellence Online Platform*) can be used to assess both projects and organisations.

As can be seen from Tables 4-1 and 4-2, the owners (or developers) of the tools range in organisation type from consultants and universities to public-sector bodies and industry associations. Only two of the tools originate from outside the United Kingdom or the United States. Most tools are free to use and are publicly available. *BIM Excellence Online Platform (BIMe OP)* consists of a consultation to provide an adaptable tool to an organisation's needs with regards to maturity assessment. *BIM Supporters' BIM Compass* is a free online assessment designed to encourage users to opt for follow-on assessment by a certified consultant. The *BIM Working Group BMAT* is for use by public-sector organisations only, and the *Dstl BIM Maturity Assessment Tool* is for use by Dstl only; both were made available for this review by the CDBB.

The format of the tools varies between online survey-type assessments to extensive MS Excel workbooks and interview-based questionnaires. Depending on the objectives of the tool and depth of assessment, the time required for completion ranges from around 15 minutes for the *Maturity Matrix: Self-Assessment Questionnaire* through to three months or more for the *BIMe OP,* where the online assessment is bespoke for clients employing the services of the tool and then followed up with workshops and interviews on-site.

Ten of the fifteen tools can be used to assess organisations in the building *and* infrastructure sectors, while the remaining five tools assess either buildings *or* infrastructure sectors. The granularity of assessment, indicating the depth of the assessment, is low or moderate for most tools. Those with high granularity − *BIMe OP* and *VDC Scorecard* − take significantly longer to conduct than the other tools. With regards to applicability, 12 of the 15 tools are discipline-agnostic, while 5 are market-specific to the UK.

Table 4-3 provides the general characteristics of the BIM maturity methods reviewed. Three of the four methods were developed in the United States, with two of those evaluated being in the form of academic papers. All four methods are developed for assessing the BIM maturity of organisations and three are applicable at a generic level.

An overview of the tools and methods is provided in Section 6.1, followed by a detailed evaluation in Sections 6.2 and 6.3.

*Table 4-1: Evaluation of BIM maturity tools for organisations: general characteristics*

| Tool | BIM Excellence Online Platform (BIMe OP) | BIM Online Maturity Assessment | BIM Supporters' BIM Compass | CPIx BIM Assessment Form | Maturity Matrix: Self-Assessment Questionnaire | NBIMS Capability Maturity Model | Organizational BIM Assessment | SFT's BIM Compass | Supply Chain BIM Capability Assessment | Vico BIM Scorecard |
|---|---|---|---|---|---|---|---|---|---|---|
| **Owner** | ChangeAgents AEC | National Federation of Builders (NFB)/ CITB | BIM Supporters | Construction Project Information Committee | Project 13 – Institute of Civil Engineers | National Institute of Building Sciences | Pennsylvania State University | Scottish Futures Trust | Wates | Vico Software (now part of Trimble) |
| **Version/ year** | Customised to user requirements | No date. Online version assessed 31/07/2019 | 2019 | 2011 | 2018 | Version 3, 2015 | 2013 | No date. Online version assessed 19/08/19 | No date. Online version assessed 04/08/2019 | 2011 |
| **Country** | Australia | United Kingdom | The Netherlands | United Kingdom | United Kingdom | United States | United States | United Kingdom | United Kingdom | United States |
| **Access** | Paid consultation | Free | Free for the online self-assessment; fee for consultation | Free | Free | Free | Free | Free | Free | Free |
| **Format** | Online assessment followed by consultation | Online survey | Online survey; paid consultation | PDF questionnaire | Online survey | Excel workbook | Excel workbook | Online Survey | Online survey | Online survey |
| **Completion time** | Up to 3 months (longer for large organisations) | <30 minutes | <1 hour for online self-assessment; one day for consultation | ~0.5 day (longer if depth and evidence required) | 10–15 minutes | ~1 hour | 30–60 minutes | ~15 minutes | <30 minutes | <30 minutes |
| **Sector** | Building; infrastructure | Building; infrastructure | Building; infrastructure | Building; infrastructure | Infrastructure | Building | Building; infrastructure | Building; infrastructure | Building | Building |
| **Granularity** | High | Low | Moderate | Low | Low | Low | Moderate | Low | Low | Low |
| **Applicability: discipline** | Discipline-agnostic | Discipline-agnostic | Discipline-agnostic | Discipline-agnostic | Discipline-agnostic | Discipline-agnostic | Discipline-specific (owners) | Discipline-specific (procurers) | Discipline-agnostic | Discipline-specific (contractors) |
| **Applicability: market** | Market-agnostic | Market-agnostic | Market-agnostic | Market-specific (UK) | Market-agnostic | Market-agnostic | Market-agnostic | Market-specific (UK) | Market-agnostic | Market-agnostic |

*Table 4-2: Evaluation of BIM maturity tools for projects: general characteristics*

| Tool | BIM Excellence Online Platform (BIMe OP) | BIM Maturity Assessment Tool (BMAT) | BIM Maturity Measure | BIM Working Group BMAT | Dstl BIM Maturity Assessment Tool | VDC Scorecard |
|---|---|---|---|---|---|---|
| **Owner** | ChangeAgents AEC | University of Cambridge | ARUP/ Institute of Civil Engineers[9] | Public Sector Working Group | Dstl | Centre for Integrated Facility Engineers (CIFE), Stanford University |
| **Country** | Australia | United Kingdom | United Kingdom | United Kingdom | United Kingdom | United States |
| **Version/year** | Customised to user requirements | 2018 | Version 2, 2015 | 2018 | 2016 | 2012 |
| **Access** | Paid consultation | Free | Free | Not publicly available | Not publicly available | Free PDF available online |
| **Format** | Online assessment followed by consultation | Online survey | Excel workbook | Excel workbook | Excel workbook | Interview with CIFE team (a PDF of tool available online) |
| **Completion time** | Up to 3 months (longer for large organisations) | ~30 to 60 min per discipline completing the assessment | ~30 minutes per discipline completing the assessment | >1 hour (dependent on project stage and no. of disputes raised in team) | >1 hour (dependent on project stage and no. of disputes raised in team) | ~4 hours |
| **Sector** | Building; infrastructure | Building; infrastructure | Building; infrastructure | Building; infrastructure | Building; infrastructure | Building; infrastructure |
| **Granularity** | High | Moderate | Low | Low | Low | High |
| **Applicability: discipline** | Discipline-agnostic | Discipline-agnostic | Discipline-agnostic | Discipline-agnostic | Discipline-agnostic | Discipline-agnostic |
| **Applicability: market** | Market-agnostic | Market-specific (UK) | Market-agnostic | Market-specific (UK) | Market-specific (UK) | Market-agnostic |

*Table 4-3: Evaluation of BIM maturity methods: general characteristics*

| Tool | Owner's BIMCAT | BIM Maturity Assessment Tool | BIM Cloudscore | Organizational BIM Assessment Profile |
|---|---|---|---|---|
| **Owner** | Giel & Issa (2014)[10] | Department for Transport | Du et al. (2014)[11] | Pennsylvania State University |
| **Country** | United States | United Kingdom | United States | United States |
| **Version/year** | 2013 | 2016 | 2014 | 2013 |
| **Scale** | Organisation | Organisation | Organisation | Organisation |
| **Sector** | Building | Infrastructure and transport | Building; infrastructure | Building |
| **Applicability: discipline** | Discipline-specific (building owners) | Discipline-agnostic | Discipline-agnostic | Discipline-agnostic |

[9] ARUP and the Institute of Civil Engineers offer similar versions of this tool. Their works are a derivative of the BIM Project Execution Planning Guide by the CIC Research Group, Department of Architectural Engineering, Pennsylvania State University, which is licensed under a Creative Commons Attribution-Share-Alike 3.0 United States License: http://creativecommons.org/licenses/by-sa/3.0/us/ .

[10] Giel, B. and Issa, R. (2014) 'Framework for Evaluating the BIM Competencies of Building Owners', *2014 International Conference on Computing in Civil and Building Engineering,* June 23–25, Orlando, Florida, United States, pp. 552–559. DOI: https://doi.org/10.1061/9780784413616.069.

[11] Du, J., Liu, R. and Issa, R.R. (2014) 'BIM cloud score: benchmarking BIM performance', *Journal of Construction Engineering and Management, 140*(11), p.04014054.

| | | | | |
|---|---|---|---|---|
| **Applicability: market** | Market-agnostic | Market-agnostic | Market-agnostic | Market-agnostic |

## 5 BIM benefits tools and methods: general characteristics

Three BIM benefits measurement tools and three BIM benefits methods were identified. Table 5-1 and Table 5-2 present the general characteristics of the tools and methods, respectively. Four of the tools and methods were developed in the UK, with the remaining two developed in Australia and the United States. All of the tools are free to use and publicly available, taking the form of online questionnaires. Completion times range from less than 30 minutes to around 2+ hours. All three tools can be used to measure project benefits from adopting BIM, with the *BIM Value* tool also measuring the benefits to organisations. All tools are applicable to both the building and infrastructure sectors, however two methods are specific to buildings, and one to infrastructure. All tools and methods are discipline-agnostic, with only one tool (*BIM Return on Investment Tool*) applicable at market level.

*Table 5-1: BIM benefits tools: general characteristics*

| Tool | BIM Return on Investment Tool | BIM Value | BIM Benefits |
|---|---|---|---|
| **Owner** | Scottish Futures Trust | NATSPEC and SBEnrc | University of Cambridge |
| **Country** | United Kingdom | Australia | United Kingdom |
| **Version** | No date. Online version assessed 1/08/19 | 2015 | 2018 |
| **Format** | Online questionnaire | Online questionnaire | Online questionnaire |
| **Access** | Free | Free | Free |
| **Completion time** | <1 hour | <30 minutes | 1-2+ hours |
| **Scale** | Projects | Projects; organisations | Projects |
| **Sector** | Building; infrastructure | Building; infrastructure | Building; infrastructure |
| **Applicability: discipline** | Discipline-agnostic | Discipline-agnostic | Discipline-agnostic |
| **Applicability: market** | Market-specific (UK) | Market-agnostic | Market-agnostic |

*Table 5-2: BIM benefits methods: general characteristics*

| Tool | TfL BIM Benefits Management Strategy | BIM Level 2 Benefits Measurement Methodology (BMM) | ROI Analysis |
|---|---|---|---|
| **Owner** | Transport for London | PricewaterhouseCoopers | Giel and Issa (2013) |
| **Country** | United Kingdom | United Kingdom | United States |
| **Version** | 2017 | 2018 | 2013 |
| **Scale** | Projects | Projects | Organisations |
| **Sector** | Infrastructure | Building | Building |
| **Applicability: discipline** | Discipline-agnostic | Discipline-agnostic | Discipline-agnostic |
| **Applicability: market** | Market-agnostic | Market-agnostic | Market-agnostic |

## 6 Analysis of BIM maturity tools and methods

To ensure consistency of data collection, and to support in-depth analysis of each tool, an information extraction card was used to perform the evaluation of tools. Details of the information extraction card are shown in Table 6-1.

A simplified version of the full card (for example, by removing fields such as quality of measurement, and usability of the tool) was used to evaluate the maturity methods.

The information extraction cards were used to analyse each tool individually (Section 6.1) and then to perform cross-tool analysis (Section 6.2) in order to identify commonalities and differences across the tools.

## 6.1 Individual tool and method analyses

The next three sub-sections, respectively, evaluate the organisation BIM maturity tools, the project BIM maturity tools and the BIM maturity methods. A more detailed evaluation of tools and methods is included in the full information extraction cards in Appendix C (organisation BIM maturity tools), Appendix D (project BIM maturity tools) and Appendix E (BIM maturity methods).

*Table 6-1: Information extraction card used to analyse BIM maturity tools and methods*

| Field | Purpose |
|---|---|
| Name of tool/method | Formal name of tool/method. |
| Link to tool | Publicly available link to tool/method, where available. |
| Supporting document(s) | Any available guidelines, instructions or supporting documents to support evaluation of the tool. |
| Author/owner | Developer and owner (if different) of the tool. |
| Date of release, and version assessed | For veracity of evaluations with regards to the available version. The latest versions were assessed where more than one was available. |
| Tool used to assess | Does the tool assess organisations, projects, other? |
| Sector | Does the tool assess building, infrastructure, other? |
| Applicability | Is the tool market-specific, generic or discipline-specific? |
| Definition of BIM | To help in understanding the purpose of the tool, particularly where there is still confusion about the definition of BIM globally. |
| Definition of maturity adopted | To clarify what the purpose of the tool is, given the different categories of maturity identified for this research. |
| Implicit assumptions | Inherent assumptions that the tool makes when performing the measurement to better understand the results. |
| Intended use | Purpose of the tool. |
| Intended users | Who the intended users of the tool are. |
| Use setting | How it is intended to conduct the assessment. |
| What maturity level/index is used? Number of levels? | Which maturity level or index, if any, is used to take the measurement. |
| Topics and items assessed, and number of measures? | Lists the topics and items assessed by the tool. |
| Scoring model | How the assessment is made, and how the score is calculated. |
| Level of evidence [required/requested?] | What evidence is required to demonstrate the maturity level or response given? |
| Assessor requirements | Whether there are any requirements for conducting the assessment or whether the tool can be used by anyone. |
| Quality of assessment offered by the tool in terms of good practice of performance management | Evaluation of the tool against the following criteria:<br>- Accuracy and applicability of metrics.<br>- Attainability of benchmarks and logical progression towards benchmark targets.<br>- Flexibility and consistency of assessment.<br>- Neutrality of metrics.<br>- Use of assessment outcomes to provide informative feedback for improvement. |
| Granularity of assessment | The level of detail that the assessment uses. |
| Usability of tool/model | Evaluation of ease of use; quality/aesthetics of the user interface; help, dictionary, support documentations; completion effort/time. |
| Case studies/research demonstrating application of the tool/model | Any published demonstration(s) of the tool. |
| License to use | Accessibility of the tool. |
| Additional information | Any relevant information not covered by the above fields. |

### 6.1.1 Organisation BIM maturity tools: analysis of individual tools

The following 10 organisation BIM maturity tools were evaluated for this research:

- BIM Excellence Online Platform (BIMe OP) *by ChangeAgents AEC*
- BIM Compass *by BIM Supporters*
- BIM Compass *developed by Constructing Excellence, hosted by the Scottish Futures Trust*
- BIM Online Maturity Assessment *by the National Federation of Builders (NFB) and CITB*
- CPIx BIM Assessment Form *by the Construction Project Information Committee*
- Maturity Matrix: Self-Assessment Questionnaire *by Project 13 – Institute of Civil Engineers*
- NBIMS Capability Maturity Model *by the National Institute of Building Sciences*
- Organizational BIM Assessment *by Pennsylvania State University*
- Supply Chain BIM Capability Assessment *by Wates*
- Vico BIM Scorecard *by Vico Software (now part of Trimble)*

For full individual project tool evaluations, refer to Appendix C. A short summary of each is provided below.

***BIM Excellence Online Platform (BIMe OP)*** was developed by ChangeAgents AEC in Australia and is used to assess the BIM maturity of organisations. The tool can also be used to assess the BIM maturity of individuals and project teams; hence, it is also evaluated in Section 6.1.2 alongside other project BIM maturity tools. The tool is designed to be implemented as a consultation service and is generally bespoke to each customer. The customer works with ChangeAgents AEC to devise the areas of assessment from 8 topics (managerial; administration; functional; operation; technical; implementation; supportive; research and development), with 57 competency items across the 8 topics. The tool can combine assessment of BIM compliance, readiness, capability and maturity. This tool was developed prior to the release of the ISO 19650 Series. However, because of its bespoke nature, amending the assessment to account for the new international standard is feasible. A full analysis of the tool is included in Appendix C.1.

***BIM Compass,*** developed by BIM Supporters, was built based on an earlier tool, *BIM Quickscore*. Four topics are assessed, each containing six key performance indicators (Chapter 1: organisation and management; Chapter 2: mentality and culture; Chapter 3: information structure and information flow; and Chapter 4: tools and applications), plus an additional 10 'aspects' (company culture, employee education, employee mentality, internal information flow, organisation, partners, resources, strategy, use and application of open standards, and use of tools). Most of the assessment topics and items focus on measuring organisation capability. The assessment is made up of 45 multiple-choice questions across the 4 topics and 10 aspects, with an algorithm sitting behind the assessment calculating a maturity score based on non-disclosed weightings. The results are plotted against the Bew-Richards BIM Maturity Model (Level 0, Level 1, Level 2, etc.). The *BIM Compass* is intended for use alongside the *BIM Execution Plan Generator*, a tool that assists with the creation of a 'BIM execution plan'. A full analysis of the tool is included in Appendix C.2.

***BIM Compass***, developed by Constructing Excellence and hosted by the Scottish Futures Trust (SFT), is a compliance measurement tool assessing compliance and adoption against eight 'core competencies', as defined by the BIM Task Group – Collaborative Management: BS1192:2007; Design Management: BS7000-4:2013; Library Objects: BS8541; Information Management (CAPEX): PAS1192-2:2014; Information Management (OPEX): PAS1192-3:2014; Information Exchange: BS1192-4; Soft Landings: BS8536; and Security: PAS1192-5. The tool is set against UK Level 1 and Level 2 BIM standards, two of which (BS1192:2007 and PAS1192-2:2014) have now been superseded by the ISO

19650 Series. The tool follows three steps: *the capability assessment* – a series of evidence-based questions concerning the level of experience of an organisation, aligned to the eight core BIM competencies; *the results* – the answers given generate capability charts to allow users to compare themselves against the industry average of BIM Levels 1 and 2 and provide average scores for all answers given for each core competency; and *the upskilling action plan* – an action plan is populated from the results, showing which areas require improvement using red, amber and green coding. A full analysis of the tool is included in Appendix C.3.

***BIM Online Maturity Assessment*** was developed by the National Federation of Builders (NFB) and CITB, and it measures: principles (the building blocks in place to support BIM and collaborative working); people's competence, knowledge and skills; existing processes; project experience; and key principles. Twenty-one multiple-choice questions provide a score out of fifty to determine both the 'BIM maturity and collaborative working maturity' of an organisation. Both BIM and collaborative maturity are expressed by a single score for the whole organisation. The overall score falls within one of the four wide-scoring categories (denoting four intervals of performance), each with a short narrative summarising the BIM and collaborative performance maturity of the assessed organisation. The multiple options (four in most cases) provided for each question do not 'explicitly' or 'implicitly' embed levels of maturity. The options often merge awareness/readiness (e.g. Are you aware of ...?), capability (e.g. Do you have formal processes for information management?) and compliance and maturity (e.g. having processes complying with BIM Level 2 and applying them consistently in projects), which impairs the accuracy and usefulness of the measurement. A full analysis of the tool is included in Appendix C.4.

***CPIx BIM Assessment Form,*** by Construction Project Information Committee, is a qualitative assessment tool that uses open-ended questions designed to be performed in what appears to be an interview setting. The tool measures: design/construction intelligent 3D modelling; life-cycle cost (LCC) and life-cycle assessment (LCA) analysis; facilities management; quantity take-off, costing; sales/visualisations; safety planning; clash detection; 4D scheduling; production BIM; procurement; supply chain management; and simulations for energy, fire, and so on. Its intended use is to understand the general readiness and capability of a supplier by the appointing party. The form is structured to first ask 'BIM gateway questions' focused on what the company does with regards to BIM training, qualifications, compliance with BS 1192, and so on. The second stage considers '12 areas of BIM' (see topics assessed in Appendix C.5), where respondents have to articulate their understanding of these model uses and provide evidence, where appropriate. The third stage asks questions about BIM project experience, requiring a minimum of three projects. The final section asks 29 questions in what is called the 'BIM capability questionnaire', which contains a range of questions covering aspects of knowledge/competency and readiness/capability. A full analysis of the tool is included in Appendix C.5.

***Maturity Matrix: Self-Assessment Questionnaire,*** by Project 13 – Institution of Civil Engineers, assesses: governance; organisation; integration; digital transformation; and capable owner. There are 16 questions, for which users can select 1 option. At the end of each assessed topic, a total score is calculated that determines the collaborative and digital construction 'maturity' of the organisation/enterprise for each topic on a three-level index: simple collaboration; integrated functions and relationships; and high-performing enterprise. The feedback is directly related to the questions asked for each and provides a narrative of the level that the organisation is currently at. The tool does not provide improvement plans, but it does provide a narrative about the position of an organisation's collaborative and digital transformation 'maturity' within a matrix. Sometimes dissimilar elements are combined in a single option. For example, Option 1. A maturity measure at a

certain level (e.g. 'data provides some insight on value for the customers and other stakeholders'); Option 2. An awareness/readiness measure (e.g. 'customer-led culture developing to understand customer need'); and Option 3. Another maturity measure at a more advanced level than the first one (e.g. 'deep understanding of customer and other stakeholder needs and wants at the centre of all investment decisions'). Given the aforementioned scoring model, organisations with Option 2 (awareness only) may score higher than organisations with Option 1 (capability). This inconsistency may simply have been caused by a syntax issue, but it is present in several questions, not only across the digital transformation topic but also in the other topics. This affects the accuracy of assessment and means the benchmarks are not achievable in a logical progression. A full analysis of the tool is included in Appendix C.6.

***NBIMS Capability Maturity Model*** is a National Institute of Building Sciences tool, measuring 11 areas of interest that are weighted based on importance, as shown in brackets: data richness (84%); life-cycle views (84%); change management (90%); roles or disciplines (90%); business process (91%); timeliness/response (91%); delivery method (92%); graphical information (93%); spatial capability (94%); information accuracy (95%); and interoperability/IFC support (96%). For each of the 11 areas of interest the achieved 'maturity level' (called credit) is calculated by multiplying the perceived maturity level (on a scale of 1 to 10) by the area's corresponding weight. This result is compared against the required 'minimum BIM' score. The maturity levels range from 1 to 10, with 1 being the least 'mature' and 10 being the most 'mature'. The definitions of the maturity indices provided within the tool have 10 levels, whose differences are not easily detectable/distinguishable. These characteristics limit the accuracy and consistency of assessment and the attainability of benchmarking through progressive accumulation of defined actions. An accuracy evaluation test reported in NBIMS-US_V3[12] found that it yielded no more than a 5% difference in the various scores of the evaluators. The metrics apply to all project stakeholders who are involved in model and data production, management and delivery. A full analysis of the tool is included in Appendix C.7.

***Organizational BIM Assessment,*** by Pennsylvania State University, measures: strategy, BIM uses, process, information, infrastructure and personnel. Users score each item on a 0–5 scale (0 – non-existent, 1 – initial, 2 – managed, 3 – defined, 4 – quantitatively managed, and 5 – optimising). Then, the sum of the scores of all topics represents the total maturity score for the organisation. The same is done for the 'target maturity' level, which can be established by the organisation undertaking the assessment. No weighting is assigned to any element. For most items, the description of the levels aims to establish the maturity of the items gradually. The amount of detail adopted to describe the levels is generally fair and sufficient for an organisation to be able to select a correct score for its level; hence, the tool offers consistency when it is used by different assessors. Organisations can reach the optimising (Level 5) maturity level across all items. However, for two items (model element breakdown and level of development), Level 5 can be reached only by organisations whose practices are balloted for inclusion in industry standards. The scores of all topics are aggregated into an overall score for both achieved maturity and target maturity. However, the tool developers note that, 'while the organization could score high, there could be some key areas not implemented that could hinder the organization's BIM Implementation'. Organisations can use the tool to benchmark their performance against themselves at different points in time. Metrics are neutral and can be used by all owners and facility management organisations and do not prejudice proprietary, non-proprietary, free, open or commercial solutions. A full analysis of the tool is included in Appendix C.8.

[12] Available at: https://www.nationalbimstandard.org/.

***Supply Chain BIM Capability Assessment*** was developed by Wates to gather general information about the organisations taking the assessment regarding: general organisation information, standards, costs, software, model use and references (e.g. two previous projects). Most questions assess capability and require yes/no answers. No score is provided after submission. This is mainly a questionnaire used by a lead appointed party (e.g. contractor) to assess the capabilities of their supply chain. A few questions assess the preparedness/readiness of suppliers to engage in certain processes (e.g. engaging in a CDE) or produce certain deliverables (e.g. sharing of native models). A full analysis of the tool is included in Appendix C.9.

***Vico BIM Scorecard,*** by Vico Software (now part of Trimble), is a multiple-choice questionnaire designed to assess capabilities across: portfolio and project management; cost planning; cost control; schedule planning; production control; coordination; and design team engagement. A list of BIM capabilities is given for each of the seven topics. For each of the topics, there are several questions related to 'product', 'process' and 'integration' aspects, which results in an overall BIM score that is sent on completion of the survey by email. No details are available regarding the score calculation method. Some questions about the seven topics combine capabilities and maturity measurements in their assessment. For example, in response to the question 'Do you have formatted data that people access and modify for each project?', which assesses a capability item, the option follows this syntax 'Yes, our company uses a central database with resource and material price information that is updated regularly', which usually indicates a maturity level of 'defined' or 'higher'. While this arrangement of questions and response options is not uncommon, the ordering of options becomes important, as it determines the score. In this tool some questions list options from A to D, in ascending order of maturity level, while other questions list them in descending order. The tool captures organisational priorities across the capability topics at the beginning of the survey. The feedback is expected to relate the score/outcomes back to these priorities when the results are received – this feature could not be verified during the simulated assessment. The tool's metrics are not all neutral, as several proprietary applications are mentioned (as examples) in some of the options given. This tool is more suitable to assessing compatibility between different units/offices of an organisation, in this case a general contractor. A full analysis of the tool is included in Appendix C.10.

### 6.1.2 Project BIM maturity tools: analysis of individual tool

The following six project BIM maturity tools were evaluated:

- BIM Excellence Online Platform (BIMe OP) *by ChangeAgents AEC*
- BIM Maturity Assessment Tool (BMAT) *by the University of Cambridge*
- BIM Maturity Measure *by Arup/Institute of Civil Engineers*
- BIM Working Group BMAT *by the Public Sector Working Group*
- Dstl BIM Maturity Measurement Tool *by Dstl*
- VDC Scorecard *by the Centre for Integrated Facility Engineers (CIFE), Stanford University*

***BIM Excellence Online Platform (BIMe OP)*** is summarised in Section 6.1.1 (above). Its evaluation against the ISO 19650-2:2018 can be seen in Appendix D.1.

***BIM Maturity Assessment Tool (BMAT),*** by the University of Cambridge, consists of two parts. *Part I – Information Delivery Stages* covers: assessment and need; post-contract award; mobilisation; production; and AIM maintenance. *Part II – Supporting Processes* covers: performance management; information security; information quality; and collaborative working. There is a combination of questions with responses on a four-, five- or six-level scale; most items are measured using four levels. These levels are not labelled using a formal maturity scale. Part I of the tool measures the BIM

development maturity of a project regarding the compliance of employer, contractor, designer and the project (joint venture) against key concepts/requirements of 'BIM Level 2'. Part II assesses the project and disciplines involved across four topic items assessed on either four, five or six levels. These follow a similar pattern to Part I, although in Part II not all items measured are compliance items/requirements. A full analysis of the tool is included in Appendix D.2, with an evaluation of the tool against the ISO 19650-2:2018.

***BIM Maturity Measure*****,** by Arup/Institution of Civil Engineers, assesses across projects and disciplines. *Project assessment*: employer's information requirements (EIR);[13] BIM design data review; BIM execution plan (BEP); project procurement route; common data environment (CDE); document/model referencing, version control and status; marketing strategy; virtual design reviews (VDR); open standard deliverables; BIM contractual obligations; and BIM champion. *Discipline assessment*: 3D coordination; drawings; level of information/detail; discipline model reviews; embedded data, schedules and specifications; visualisation; 4D (construction sequencing); 5D (quality and cost); links to design analysis tools; handover to contractor; and use in operations and facilities management. The tool uses a six-level scale to measure maturity. Descriptions are generally high-level and several items lack a description for some 'maturity' levels. The description of levels for most topics/items is aimed at measuring not maturity but the availability of certain capabilities on a project. The description of levels confuses the concept of maturity ('extent of a capability') with the evidence required. For example, for the 'open standard deliverables' Level 5 (optimising) is attained with 'successful client handover of IFC/COBie as deliverables', which is usually evidence-based instead of a maturity level or target. Most of the other topics are assessed in terms of the availability of a certain requirement/activity/practice and its diffusion ('the extent of …') across the project team or within the discipline/organisation involved. Measuring the extent of practising certain abilities/activities is a partial interpretation of maturity assessment that still precludes the assessment of the quality, repeatability and degree of excellence across the topics assessed. The tool can be used to measure the diffusion/extent of certain capabilities across a project and the disciplines involved. Consistency of assessment is challenged by the short/broad descriptions provided for the six levels. The metrics used for the assessment are neutral and do not prejudice proprietary, non-proprietary, free, open or commercial solutions. A full analysis of the tool is included in Appendix D.3, with an evaluation of the tool against the ISO 19650-2:2018.

***BIM Maturity Measurement Tool,*** by Dstl, uses a questionnaire to measure: BIM procurement/employer engagement; BIM delivery; data, verification and validation; collaborative working; visualisation/stakeholder engagement; discipline-based model authoring; construction; model-based estimating and change management. The tool is intended for use in a meeting between project parties. 'Maturity' is expressed as a percentage score for each area of measurement; however, there is no description of ranges across percentages. The score for each topic is calculated as the percentage of questions answered with 'yes'. The average of all topics gives the project a 'maturity' score. Separate scores are also calculated for 'client BIM delivery' and 'supplier BIM delivery' using weighted calculations with a 60/40 client/supplier ratio (see Appendix D.5 for details of weighting). The tool mainly assesses the compliance of the project's activities/deliverables against BIM Level 2 standards and guidelines. There are no maturity levels to measure the extent of abilities and quality of deliverables. Maturity is measured throughout the project stages with changes from 'no' to 'yes' (from non-compliant position to a compliant position) as the same assessment is repeated at the end of each stage. Full compliance (100%) can only be achieved at the end of the final stage. The user feedback for improvement is limited, as the options given to assess each topic are in the form of

[13] As reflected in ISO 19650, EIR now refers to *exchange* information requirements.

checklists. A full analysis of the tool is included in Appendix D.4, with an evaluation of the tool against the ISO 19650-2:2018.

***BIM Working Group BMAT,*** by the Public Sector Working Group, assesses: BIM procurement/employer engagement; BIM delivery; data, verification and validation; collaborative working; visualisation/stakeholder engagement; discipline-based model authoring; construction; model-based estimating and change management. The questions should be answered in full at the end of each project stage, looking back over that stage. The questions should be answered collectively by the project team, with the employer's project manager having the final say if there is disagreement. The questions are the same for each project stage, and therefore at the early stages of a project, many of the answers will be 'no' – the intention is to show 'maturity' growing throughout the project stages. If at a given project stage a question is 'not applicable' then the answer given should be 'no'. It would only be possible to score 100% at the end of Stage Six. The tool assesses the compliance of the project's activities/deliverables with BIM Level 2 standards and guidelines and provides overall scores for: 'BIM maturity project', 'client BIM delivery and 'supplier BIM delivery'. The items, assessed under each topic with yes/no, are in the form of checklists. There are no maturity levels to measure the extent of abilities and quality of deliverables. The checklists remain fixed for all stages, while not all options are relevant to all stages. A full analysis of the tool is included in Appendix D.5, with an evaluation of the tool against the ISO 19650-2:2018.

***VDC Scorecard,*** by the Centre for Integrated Facility Engineers (CIFE), Stanford University, has four areas, each with their own divisions (10 in total): planning (objective, standard, preparation); adoption (organisation, process); technology (maturity, coverage, integration); and performance (quantity, quality). Each division has its own measures, of which there are 56 in total across all divisions. In a recent update, the 'maturity' division (currently under technology) has been changed to 'application' to measure VDC applications, model uses, hardware, software, and so on. A publicly available document provides a list of the topics assessed and some of the metrics used. Interview-based questions assess a combination of readiness, capability and maturity aspects. The 10 scorecard division scores are created using the 56 scorecard measures. In turn, the four scorecard area scores are created using the 10 scorecard division scores; and, finally, the total VDC score is calculated using a weighted sum of the four scorecard area scores. The division scores are 10 measures, each created using a weighted average of division-related measurements. The tool is conceived as a benchmarking tool against industry-wide benchmarks that are movable targets over time. It is difficult to ascertain whether performance targets can be reached in a progressive manner, given the large number of both quantitative and qualitative measures involved and the concealed indices/measures. The topics and items assessed are neutral and can be used in any project. A full analysis of the tool is included in Appendix D.6, with an evaluation of the tool against the ISO 19650-2:2018.

### 6.1.3 Analysis of BIM maturity methods

The following four BIM maturity methods were evaluated:

- Owner's BIMCAT (competency assessment tool) *by Giel & Issa (2014)*
- BIM Maturity Assessment Tool *by the UK Department for Transport*
- Building Information Modeling Cloud Score (BIMCS) *by Du et al. (2014)*
- Organizational BIM Assessment Profile *by Pennsylvania State University*

***Owner's BIMCAT (competency assessment tool),*** by Giel & Issa (2014), considers three competency areas, each with sub-topics. *Operational competencies:* BIM deliverable evaluation (data richness, geometry), project BIM use requirements, technology, and staff aptitude and organisational BIM use.

*Strategic competencies:* documentation, project standards, and preparation and goals/objectives. *Administrative competencies:* project procedures (personnel, culture), and practices and policies. The method consists of 124 questions in total, for a maximum total score of 1,200 points across 6 levels. No information is available about the questions asked at item level and their corresponding scores. The initial list of 66 factors was derived from the literature (other models in existence at the time – *NBIMS CMM*, *BIM Maturity Matrix*, *BIM Quickscan* (now *BIM Compass* by BIM Supporters), *BIM Proficiency Matrix*, *VDC Scorecard* and *Owners' Maturity Matrix*), leading to the assumption that they provided suitable representation. The method assumes that there is a need to provide different weightings for the different competency areas and their factors. The final weighting for the three competency areas is calculated following the application of weightings to each of the individual BIM competency factors, received from the final Delphi with 21 prequalified BIM experts. The weightings are as follows: operational competencies 49%; strategic competencies 29%; and administrative competencies 24%. A full analysis of the method is included in Appendix E.1.

***BIM Maturity Assessment Tool,*** by the UK Department for Transport, offers two types of assessment: a *simplified maturity assessment* tool, and an *extensive maturity assessment* tool. The simplified maturity assessment tool contains a series of items that are ordered across BIM Level 0, Level 1 and Level 2. The items are generally capability and compliance items. The extensive maturity assessment tool is offered to assess the 'maturity' of the organisation against the BIM Standards (BS 1192:2007; BS 7000-4:2013; PAS 1192-2; PAS 1192-3; BS 1192-4; PAS 1192-5). Its categories are: organisational information requirements; asset information requirements; built asset security information requirements; and employer's information requirements. A full analysis of the method is included in Appendix E.2.

***Building Information Modeling Cloud Score (BIMCS),*** by Du et al. (2014), proposes metrics that aim to capture the technical aspects of the development process and final products of BIM. There are 20 metrics across 6 aspects: productivity; effectiveness; quality; accuracy; usefulness; and economy. Productivity and effectiveness quantify production (BIM modelling); and the remaining aspects quantify product (BIM model). *BIMCS* is mainly intended for benchmarking purposes. Scores are given as a percentage for each category and then collated to provide an overall BIM cloud score (BIMCS). The benchmarking aspect provides a percentile score against other organisations. The initial *BIMCS* was developed based on perceptions of the domain experts, but once sufficient data is obtained, data mining will be conducted to generate a weighting system for the metrics. Factor analysis is also planned for use to devise a new list of metrics, which are linear combinations of the original list. The tool can be used as an add-in to Autodesk Revit®, which integrates with the information model. It has three functions: to monitor, upload information and view benchmarking results. The information model is not affected by the add-in. Users can redistribute the weighting, which is then sent to the add-in for other users in other organisations to offer the option of accepting the new weighting. The purpose of this is to reflect the latest trends in BIM performance. Validation of new metrics is done with the users via the add-in. A full analysis of the method is included in Appendix E.3.

***Organizational BIM Assessment Profile,*** by Pennsylvania State University, assesses across four planning elements: BIM project execution planning experience; collaboration experience; BIM tools; and BIM champion. Owners can solicit evidence to accompany the assessment through additional questions. The method uses a six-level scale. For the four planning elements above, users plot their current 'stage' on a BIM maturity matrix. This matrix is used in the first step of a three-step approach

– assessment, alignment, and advancement – in the BIM Planning Guide for Facility Owners.[14] A full analysis of the method is included in Appendix E.4.

## 6.2 Cross-tool analysis: BIM maturity tools

This section presents a cross-analysis of BIM maturity tools for organisations and projects. This analysis assimilated information from all work items, including the desk research, the workshops, the interviews and the survey. This analysis excludes the methods and focuses solely on the tools.

### 6.2.1 Organisation BIM maturity tools: a cross-tool analysis

To understand which aspects are measured by BIM maturity tools for organisations, a full analysis of their content was performed. This analysis provides a side-by-side comparison of what this report terms *topics* and *items* covered across the tools identified. Table 6-2 shows the differences in the use of this terminology from one tool to the next.

*Table 6-2: Terminology used by tool owners to describe* 'topics' *and* 'items' *of organisation BIM maturity tools*

| Tool | Terminology to describe *topics* | Terminology to describe *items* |
|---|---|---|
| BIM Excellence Online Platform | Competency sets [8] | Competency topics [57] |
| BIM Online Maturity Assessment | (Topics) [5] | (Items) [14] |
| BIM Supporters' BIM Compass | Chapters [4] | Key performance indicators [24]; aspects [10] |
| CPIx BIM Assessment Form | - - - | Areas of BIM [12] |
| Maturity Matrix: Self-Assessment Questionnaire | Core areas [5] | (Items) [13] |
| NBIMS Capability Maturity Model | - - - | Areas of interest [11] |
| Organizational BIM Assessment | Planning elements [6] | Sub-elements [20] |
| SFT's BIM Compass | - - - | Capability areas [8] |
| Supply Chain BIM Capability Assessment | (Topics) [6] | (Items) [17] |
| Vico BIM Scorecard | - - - | BIM capabilities [7] |

(…) terminology in round brackets indicates that a tool does not provide labels for its topics and items.
[#] the number shown in square brackets indicates the number of topics or items a tool has.

*Items* of assessment used in the BIM maturity tools were analysed to develop a representative categorisation (i.e. taxonomy) (Table 6-3). This categorisation involved the clustering of 207 items from across the 10 tools into categories and is shown in Appendix D for each tool.

This categorisation of items enables a like-for-like comparison of what is assessed by the organisation tools. The distribution of items across the categories for all tools are displayed in Table 6-4. The result clearly shows that the highest concentration of items assessed by existing organisation maturity tools is within 'generation and delivery of information'. This is followed by 'mobilisation and management of human resources', 'organisational processes and management' and 'BIM processes', respectively. It is important to highlight that, although it was possible to classify the items from across the different tools using the same categories, such items are assessed differently among the selected tools (e.g. in terms of their focus on readiness, compliance, capability and maturity). This analysis is included in the next section.

[14] Available at: https://www.bim.psu.edu/owners_guide/.

*Table 6-3: Categorisation of topics assessed by BIM maturity tools for organisations*

| Category | Description | Examples |
|---|---|---|
| **Strategy** | Activities related to establishing organisational vision, long-term objectives, and approach to knowledge management and business development. These can be BIM-related and non-BIM related. | – Vision and strategy [Org&Mgmt] (BIM Supporters' BIM Compass)<br>– Commercial Approach [Org] (Maturity Matrix: Self-Assessment Questionnaire) |
| **Mobilisation and management of human resources** | Preparing and maintaining a desired competency level within organisations through training, education and mentoring. Assignment of individuals and teams within organisations for a specific purpose. | – Technical training [Implementation] (BIM Excellence Online Platform)<br>– Capability and Skills [CapOwner] (Maturity Matrix: Self-Assessment Questionnaire) |
| **Mobilisation and management of technology** | Preparing, developing, installing and maintaining information and communication technology systems to support the delivery of organisation objectives. | – General IT support: troubleshooting software issues and supporting staff in resolving technical problems [Supportive] (BIM Excellence Online Platform)<br>– Software: the programs and other operating information used by a computer to implement BIM [Infrastructure] (Organizational BIM Assessment) |
| **Procurement** | Procurement and tender activities of projects and resources within organisations. | – Tendering and procurement [Administration] (BIM Excellence Online Platform)<br>– Procurement for BIM and collaborative working [ProjExp] (BIM Online Maturity Assessment) |
| **Handover** | Handover of information about built assets, including Government Soft Landings. | – Government Soft Landings [ProjExp] (BIM Online Maturity Assessment) |
| **Generation and delivery of information** | Generation of information and data throughout a project, and delivery of that information to other actors within a project at an organisation level. | – Performing 3D modelling, model coordination, adding data to model, final 'Construction Information Model' at handover [Costs] (Supply Chain BIM Capability Assessment)<br>– Use of scheduling software to track schedule progress [ProdControl] (Vico BIM scorecard) |
| **Assurance** | Processes for checks and reviews of project data and information and security of data and information within organisations. | – System and process testing [Implementation] (BIM Excellence Online Platform)<br>– Quality assurance [Org&Mgmt] (BIM Supporters' BIM Compass) |
| **Organisational processes and management** | Processes at an organisational level for managing projects and individuals, not specific to BIM. | – How monthly/weekly information reports are provided [PPM] (Vico BIM scorecard)<br>– General management [Managerial] (BIM Excellence Online Platform) |
| **BIM processes** | Processes at an organisational level for managing project processes and individuals involved, specific to BIM. | – Project uses: the specific methods of implementing BIM on projects [BIM Uses] (Organizational BIM Assessment)<br>– Working experience with UK BIM Standards and Uniclass [Standards] (Supply Chain BIM Capability Assessment) |

[…] details shown in square brackets in the Examples column indicate the parent topic of an item.
(…) details shown in round brackets from the Examples column indicate the tool from which the examples originate.

*Table 6-4: Summary of metrics measured: organisation tools. Figures indicate the number of items assessed by each tool for each category*

| Tool | BIM Excellence Online Platform | BIM Supporters' BIM Compass | SFT's BIM Compass | BIM Online Maturity Assessment | CPIx BIM Assessment Form | Maturity Matrix: Self-Assessment Questionnaire | NBIMS Capability Maturity Model | Organizational BIM Assessment | Supply Chain BIM Capability Assessment | Vico BIM Scorecard | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Strategy** | 5 | 5 | - | 2 | - | 2 | - | 3 | - | - | **17** |
| **Mobilisation and management of human resources** | 5 | 10 | - | 3 | - | 3 | 1 | 4 | 3 | 1 | **30** |
| **Mobilisation and management of technology** | 7 | 5 | - | 2 | - | - | - | 2 | 3 | 2 | **21** |
| **Procurement** | 1 | - | - | 1 | 1 | - | - | - | - | - | **3** |
| **Handover** | - | - | 1 | 1 | - | - | - | - | - | - | **2** |
| **Generation and delivery of information** | 14 | 5 | 2 | 4 | 10 | 3 | 6 | 5 | 9 | 11 | **69** |
| **Assurance** | 5 | 1 | 1 | - | - | - | 2 | - | - | - | **9** |
| **Organisational processes and management** | 10 | 4 | - | - | 1 | 5 | 2 | 4 | 1 | 1 | **28** |
| **BIM processes** | 10 | 4 | 4 | 1 | - | - | - | 2 | 1 | 6 | **28** |
| **Total** | **57** | **34** | **8** | **14** | **12** | **13** | **11** | **20** | **17** | **21** | **207** |

### 6.2.2 BIM maturity tools for organisations: scope and purpose of assessment

A detailed analysis at item level was performed for the 10 organisation tools. This involved an analysis of both the content and the syntax of questions and response options used in the tool's assessment and helped to determine the actual scope and purpose of the assessment offered by each tool.

The results from this analysis for organisation BIM maturity tools are presented in Table 6-5. Tools with items focused on pre-implementation or adoption of BIM are tools that mainly assess readiness. Tools with items that investigate the availability of certain BIM abilities or capabilities (e.g. usually with yes/no propositions) within organisations are tools that assess capability (which is defined as a minimum ability); and tools with items attempting to detect the extent and degree of excellence within the available BIM abilities/capabilities are tools that assess maturity. Tools can use the performed measurement for compliance purposes and/or benchmarking purposes.

Tools usually combine in their evaluation the measurement of readiness, capability and maturity, as shown in Table 6-5. However, the relative focus on readiness, capability and maturity varies between tools. Table 6-5 shows the relative distribution of the assessment scope for each tool. These results are to be interpreted horizontally for individual tools only; in other words, two circles of the same size in two different lines are not the same as the absolute number of items within tools, as shown in the previous section.

The results (Table 6-5) clearly show that most of the organisation tools are mainly focused on assessing the capability of organisations and are intended for capability benchmarking purposes, using either external or internal benchmarks. Two tools (*BIMe OP* and *Organizational BIM Assessment)* also measure maturity. However, these two tools perform the assessment using two different approaches. *BIMe OP* involves an extensive consultation service to implement a customisable assessment that is tailored to the user-specific requirements; hence, the scope is adaptable and can measure BIM readiness, capability and maturity, and/or a combination of the three. *Organizational BIM Assessment* instead offers a fixed measurement using a static matrix for maturity assessment.

The tools that have an 'unclassified' scope are tools where the assessed items are not clear because they merge together within the same metric aspects of readiness, capability and/or maturity, making it difficult to classify the scope and perform an accurate and clear measurement.

*Table 6-5: Relative level of assessment focus of BIM maturity tools for organisations*

| | Extent of readiness assessment | Extent of capability assessment | Extent of maturity assessment | Purpose (benchmark, compliance) |
|---|---|---|---|---|
| **BIM Excellence Online Platform (BIM Ex OP)** |  |  |  | An online platform with items used for assessment and scope of assessment customisable to meet individual organisations' requirements (a consultation service). The tool can perform assessment for different purposes (internal benchmark, compliance assessment, compatibility assessment, etc.), as required by the organisation. |
| **BIM Online Maturity Assessment** |  | | Not targeted | Survey tool with items assessed using multiple-choice questions, most of which have four options. Assessment of individual items merges readiness, capability and capability maturity, making it difficult to determine what is being assessed. The intended application stated is 'to measure an organisation's maturity around collaborative working and BIM'. |
| **BIM Supporters' BIM Compass** |  |  |  | The tool operates like a questionnaire/survey. Most items assess capability and readiness of organisations. The tool is intended for readiness/capability benchmarking against industry averages that can be a moving target. |
| **CPIx BIM Assessment Form** |  |  | Not targeted | Most items assess the capabilities available within organisations and some assess readiness. This is an open-ended questionnaire, designed to understand the general readiness and capability of a supplier by the lead appointed party (e.g. a general contractor). |
| **Maturity Matrix: Self-Assessment Questionnaire** |  |  |  | The tool is intended to assess the capabilities across five topics, one of which is digital transformation/BIM. Several of the individual items related to BIM combine in their assessment aspects of readiness, capabilities and capability maturity, making it difficult to perform an accurate and clear measurement. |
| **NBIMS Capability Maturity Model** |  |  | Not targeted | Items assessed are mainly capability items and their corresponding readiness. The tool is intended for readiness/capability benchmarking against industry averages that could be a moving target. |
| **Organizational BIM Assessment** | Not targeted | Not targeted |  | Most items assess the maturity of organisations across several topics. The tool is intended to benchmark organisational BIM capability maturity at different points in time. |
| **SFT's BIM Compass** |  |  | Not targeted | Items assess the readiness of implementing the standards required to comply with BIM Level 2 and the extent of use of such standards on projects. The intended application is to assess the readiness to comply and the diffusion/spread (in terms of number of projects) of compliance. The compliance assessment offered is elementary. |
| **Supply Chain BIM Capability Assessment** |  |  | Not targeted | Most items assess the capabilities of organisations with yes/no propositions using an online questionnaire. The tool is intended to assist a general contractor to understand the readiness and capabilities of their supply chain. |
| **Vico BIM Scorecard** | Not targeted |  | Not targeted | Most items assess the capabilities of organisations across a few technical BIM topics. Although not explicitly mentioned, the tool may be used to assess compatibility between the capabilities of different units/offices of an organisation, in this case a general contractor. |

**Legend**

 **Adaptable**  **High**  **Medium**  **Low**  **Unclear** (items merge readiness, capability and capability maturity, making it difficult to determine the scope of assessment offered)

### 6.2.3 BIM maturity tools for projects: scope and purpose of assessment

The same analysis performed in the previous sub-section for organisation tools was also performed for project tools. The results are presented in Table 6-6.

Tools for projects (Table 6-6) assess either the capability or maturity of projects, with the exception of the *VDC Scorecard,* which includes some measures of readiness. Three of the tools (*BIM Maturity Assessment Tool*, *BIM Working Group BMAT* and *Dstl BIM Maturity Assessment Tool*) have a significant focus on compliance, while the other two (*BIM Maturity Measure* and *VDC Scorecard*) are intended for external benchmarking. In the case of the *VDC Scorecard*, the benchmarking is performed against industry-wide benchmarks that are movable targets over time.

*Table 6-6: Relative level of assessment focus of BIM maturity tools for projects*

| | Extent of readiness assessment | Extent of capability assessment | Extent of maturity assessment | Purpose (benchmark, compliance) |
|---|---|---|---|---|
| **BIM Excellence Online Platform** |  |  |  | An online platform with items used for assessment and scope of assessment customisable to meeting an individual project's requirements (a consultation service). The tool can perform assessments for different purposes (benchmarking of project teams, compliance assessment, etc.). |
| **BIM Maturity Assessment Tool (BMAT)** | Not targeted | Not targeted |  | Assesses the maturity of projects at each stage of the project life cycle. Assessment entails both compliance topics/items (PQQ, EIR, BEP, etc.) and non-compliance topics/items (joint communication strategy, collaboration). It is intended to track the evolution of BIM compliance/capability maturity throughout the project life cycle. |
| **BIM Maturity Measure** | Not targeted | Not targeted |  | Assesses the BIM maturity of the project and disciplines involved across a number of topics/items related to collaboration and delivery, CDE, interoperability and model uses, among others. |
| **BIM Working Group BMAT** | Not targeted |  | n/a | Assesses the compliance (using checklists and yes/no questions) of the project's activities/deliverables with BIM Level 2 standards and guidelines and provides scores for 'BIM maturity project', 'client BIM delivery' and 'supplier BIM delivery'. |
| **Dstl BIM Maturity Assessment Tool** | Not targeted |  | Not targeted | Assesses the compliance of the project's activities/deliverables with BIM Level 2 standards and guidelines and provides scores for 'BIM maturity project', 'client BIM delivery' and 'supplier BIM delivery'. Most items are assessed using yes/no against different elements organised in checklists throughout the project phases. It enables users to track the evolution of the compliance position of a project across its delivery phases. |
| **VDC Scorecard** |  |  |  | Evaluates the 'maturity' of 'virtual design and construction' (VDC) based on an industry performance rating framework, and 'measures the degree of VDC innovation in planning, adoption, technology and performance'. |

**Legend**

 **Adaptable**  **High**  **Medium**  **Low**

### 6.2.4 Relevance of project BIM maturity tools to ISO 19650-2:2018

This analysis investigated the relevance of the assessment offered by project BIM maturity tools to the ISO 19650 Series of standards. This analysis provides gap analysis that supports tool owners in updating existing tools and could be used to support the development of new tools to measure the BIM maturity of projects in relation to the ISO standard.

This analysis recognises that all project BIM maturity tools evaluated were developed prior to the release of the ISO 19650 series (

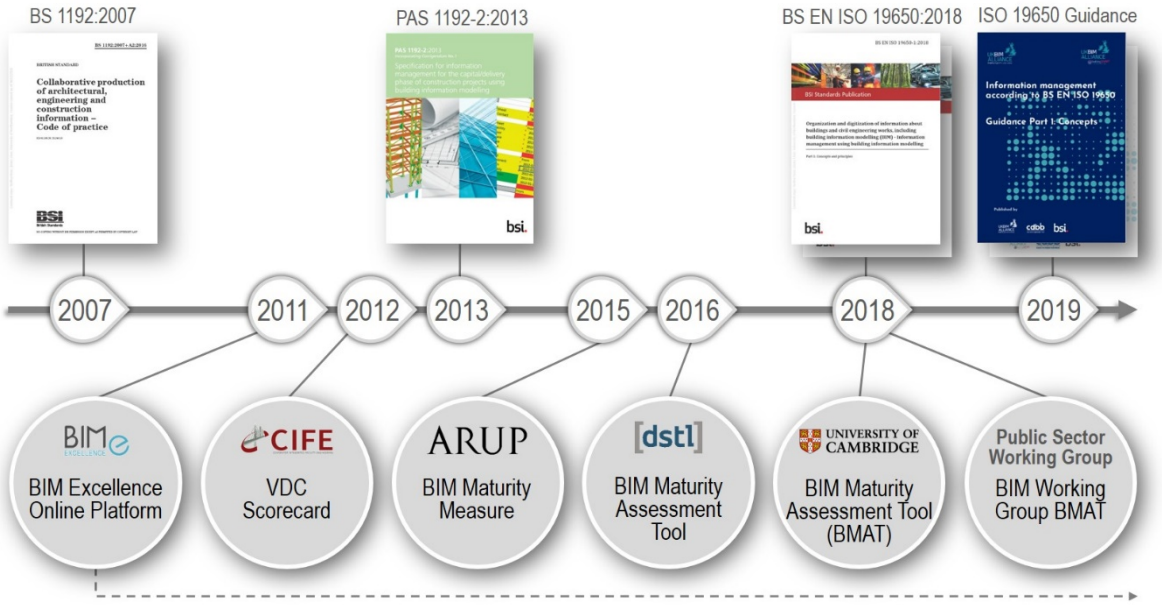



Figure 6-1); hence, it implements an analysis approach that does not penalise the evaluated tools in this regard. The approach consisted of relating the topics and items assessed in each project BIM maturity tool to the corresponding ISO 19650-2:2018 Clause(s), expressed as information management activities or tasks (e.g. at appointment, the activity of 'confirm the delivery team's BIM execution plan' is a requirement upon the appointing party).

The analysis of such links or relationships provides an understanding of the relevance of the assessment offered by a BIM maturity tool to the corresponding ISO standard and the extent of the tool's coverage of a standards-based approach to information management. This analysis was performed in a way that would not introduce inaccuracies, as inferences through interpretation and coding were kept to a minimum level. The method of analysis also prevented favouring tools focused on compliance assessment that would usually show a high degree of relevance and coverage against standards with prescriptive processes and clauses. Finally, the analysis also considers the tool's intended user when performing the analysis in order to avoid the identification of irrelevant gaps (e.g. a tool intended for a lead appointed party does not usually assess topics and items that are related to 'Process 5.1. Assessment and need' of ISO 19650-2:2018). The dotted arrow from the *BIM Excellence Online Platform* indicates that the tool is adaptable to changes in standards through time, given its bespoke and adaptable nature.

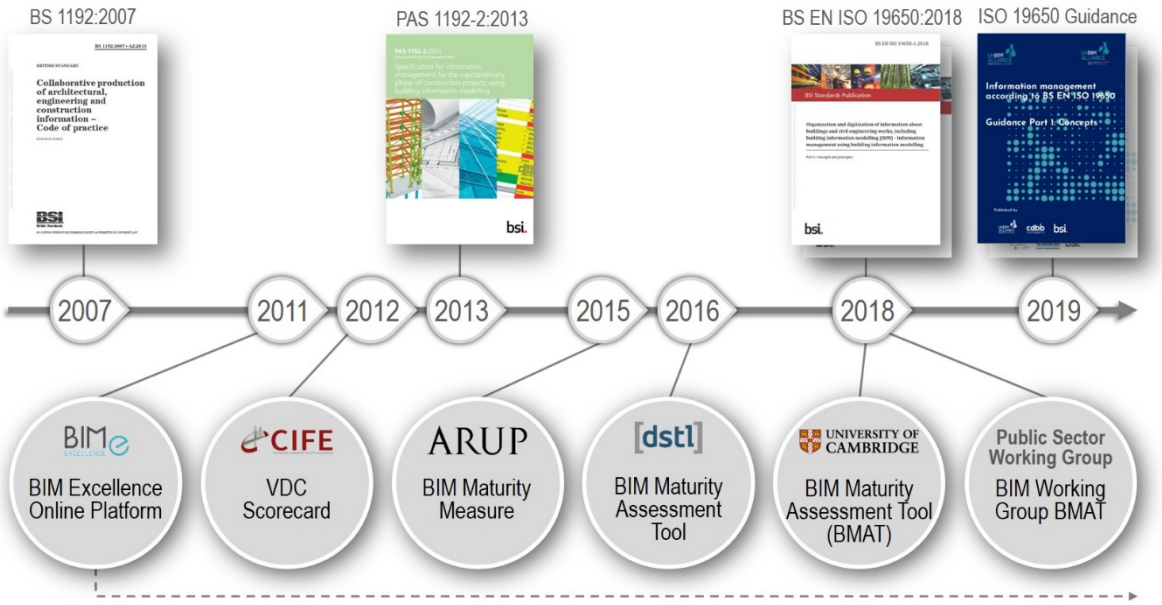



*Figure 6-1: Project tools: year of issue (launch or version evaluated) relative to UK BIM Framework standards*

Table 6-7 shows the differences in terminology used to organise the assessment between the six project BIM tools. The numbers in square brackets within the table indicate the total number of topics or items at each level. The terminology in round brackets indicates the lack of a label. This analysis was performed at *item*-level. A total of 297 *items* were analysed and related to the relevant clauses of the ISO 19650-2:2018 – *information management process during the delivery phase of assets*.

*Table 6-7: Terminology used by tool owners to describe* topics *and* items *in project BIM maturity tools*

| Tool | Terminology to describe *topics* | Terminology to describe *items* |
|---|---|---|
| BIM Excellence Online Platform | Competency sets [8] | Competency topics [57] |
| BIM Maturity Assessment Tool (BMAT) | Stages [4]; processes [6] | (Items) [49] |
| BIM Maturity Measure | - - - | Questions [22] |
| BIM Working Group BMAT | (Topics) [8] | Questions [47] |
| Dstl BIM Maturity Assessment Tool | (Topics) [8] | Primary questions [47] |
| VDC Scorecard | Areas [4]; divisions [10] | Measures [56] |

The detailed results from the analysis of each individual tool against the ISO 19650-2:2018 are included in each tool's corresponding table in Appendix D. Items were categorised against the clauses on a best-fit basis; however, it is acknowledged that some items may also be related to other/further clauses than those identified in the presented analysis.

Table 6-8 shows the cross-analysis of all tools against the ISO standard.

Some key findings from this analysis include the following:

- The focus of assessment across all project BIM tools is concentrated on the information management activities of 'collaborative production of Information' [ISO 19650-2 Clause 5.6], followed by 'information model delivery' [ISO 19650-2 Clause 5.7] and 'mobilisation' [ISO 19650-2 Clause 5.5], respectively.
- The top four information management activities that are addressed by assessment items within the project BIM tools are, respectively: 'generate information' [ISO 19650-2 Clause 5.6.2]; 'review and accept the information model' [ISO 19650-2 Clause 5.7.4]; 'mobilise resources' [ISO 19650-2 Clause 5.5.1]; and 'review information and approve for sharing' [ISO 19650-2 Clause 5.6.4].
- There are gaps in the existing tools where several information management activities (clauses) are either addressed by a few tools or not addressed at all. The clauses that are not addressed are indicated with amber cells in Table 6-8.
- The tool that has the highest number of items relating to the ISO 19650-2 Clauses is the *BIM Maturity Assessment Tool (BMAT)* by the University of Cambridge.
- The *Dstl BIM Maturity Measurement Tool* and the *BIM Working Group BMAT* include assessment that is required to be performed at the end of each stage, where many of the assessment questions will not receive a 'yes' (compliance achieved) until certain project stages have been reached. The way they are written is based on what happens during a project and assumes that many of the information requirements are already established and focus on assessing the **compliance** with such requirements. Hence, these tools include few questions about **establishing** the requirements.
- Arup's *BIM Maturity Measure* appears to be focused on BIM as a geometric model rather than BIM as a method for managing information throughout a construction project. Items have been categorised accordingly. With some rewording of the items, it could easily be more closely aligned with the ISO 19650 definition of BIM.
- The terminology used in the tools is often in line with BIM Level 2 (e.g. employer's information requirements, BIM champion) rather than the terminology used in the ISO. These items have been categorised in line with ISO terminology, recognising that they would need to be updated by the tool owners to align with the ISO 19650 terminology.
- There are many items across the tools that do not relate to ISO clauses. The description of these items is included in the analysis tables of each tool in Appendix D. This is not to be seen as a shortcoming, as these items measure relevant competence. The tools with the highest number of items that do not relate to the ISO clauses are the two tools developed outside the UK (*BIM Excellence Online Platform* and *VDC Scorecard*). However, in the case of the *BIM Excellence Online Platform,* there is good coverage of the key ISO clauses identified earlier, and the tool is a customisable service that can be adapted to measure against topics and items of relevance to any ISO clause.

The following aspects should be noted when considering the results of this analysis:

- The mapped relationships between items assessed by a tool and the corresponding ISO clauses are not an indicator of the quality of assessment offered by the tool. They do not indicate that the referenced clause/activity is adequately assessed (whether this is a readiness, capability or maturity assessment) by the tool. The quality of assessment offered by each tool is assessed in the individual tool analysis outlined in Section 6.1 and detailed in the information extraction cards included in Appendix C.

- The ISO clauses generally differentiate between information management activities (clauses) according to the three roles: appointing party, lead appointed party and appointed party. Whenever the concerned role with a tool's *item* was not clear or explicit, a judgement was made to support the analysis. For example, the *BIM Maturity Measure* tool developed by Arup is generally intended for use by a lead appointed party, with few items relating to 'assessment and need' [ISO 19650-2 Clause 5.1].

- The descriptions of some items are not sufficiently specific to establish clear links with the ISO clauses. For example, links to the 'exchange information requirements' (referred to as 'employers information requirements' by the tools, as they pre-date the ISO) are difficult to establish, as it is not clear whether the tools refer to the appointing party's EIR or the lead appointed party's EIR. Where items correlate to more than one clause they have been categorised against all relevant clauses. Therefore, the total number of items mapped for each tool may be more than the total number of items included in the tool.

*Table 6-8: Cross-analysis of all project tools against the ISO 19650-2:2018*

| ISO 19650-2:2018 Clauses | | BIM Excellence Online Platform | BIM Maturity Assessment Tool (BMAT) | Dstl BIM Maturity Assessment Tool | BIM Maturity Measure | BIM Working Group BMAT | VDC Scorecard | Total |
|---|---|---|---|---|---|---|---|---|
| Assessment and need [ISO 19650-2 Clause 5.1] | 5.1 | 2 | - | - | - | - | - | 2 |
| | 5.1.1 | - | 1 | 1 | - | 1 | - | 3 |
| | 5.1.2 | - | 2 | - | - | - | - | 2 |
| | 5.1.3 | - | - | - | - | - | - | - |
| | 5.1.4 | - | 1 | - | - | - | - | 1 |
| | 5.1.5 | - | 1 | - | - | - | - | 1 |
| | 5.1.6 | - | - | - | - | - | - | - |
| | 5.1.7 | - | - | 1 | 1 | 1 | - | 3 |
| | 5.1.8 | - | 3 | - | - | - | - | 3 |
| Invitation to tender [ISO 19650-2 Clause 5.2] | 5.2.1 | - | 2 | 5 | 1 | 2 | - | 10 |
| | 5.2.2 | - | 1 | - | - | - | - | 1 |
| | 5.2.3 | 1 | 1 | - | - | - | - | 2 |
| | 5.2.4 | - | 1 | - | - | - | - | 1 |
| Tender response [ISO 19650-2 Clause 5.3] | 5.3.1 | - | - | - | - | - | - | - |
| | 5.3.2 | - | 1 | - | 1 | - | 2 | 4 |
| | 5.3.3 | - | - | - | 1 | - | - | 1 |
| | 5.3.4 | - | - | - | - | - | - | - |
| | 5.3.5 | 3 | 2 | - | 1 | - | - | 6 |
| | 5.3.6 | - | - | - | - | - | - | - |
| | 5.3.7 | - | - | - | - | - | - | - |
| Appointment [ISO 19650-2 Clause 5.4] | 5.4 | - | - | - | - | 3 | - | 3 |
| | 5.4.1 | 1 | 1 | 1 | 1 | 1 | - | 5 |
| | 5.4.2 | - | 1 | - | 1 | - | - | 2 |
| | 5.4.3 | - | - | - | - | - | - | - |
| | 5.4.4 | - | - | - | - | - | - | - |
| | 5.4.5 | - | - | 1 | - | 1 | - | 2 |
| | 5.4.6 | 1 | - | - | 1 | - | - | 2 |
| | 5.4.7 | 1 | - | - | - | - | - | 1 |
| Mobilisation [ISO 19650-2 Clause 5.5] | 5.5 | - | - | - | 1 | - | - | 1 |
| | 5.5.1 | 2 | 12 | 2 | - | 2 | 1 | 19 |
| | 5.5.2 | 4 | 1 | - | - | - | 3 | 8 |
| | 5.5.3 | 1 | 3 | - | - | - | 1 | 5 |
| Collaborative production of information [ISO 19650-2 Clause 5.6] | 5.6.1 | - | 1 | 2 | 1 | 2 | - | 6 |
| | 5.6.2 | 17 | 7 | 14 | - | 14 | 4 | 56 |
| | 5.6.3 | 4 | - | 2 | - | 4 | - | 10 |
| | 5.6.4 | - | 1 | 4 | 12 | 1 | - | 18 |
| | 5.6.5 | - | - | - | 13 | - | - | 13 |
| Information model delivery [ISO 19650-2 Clause 5.7] | 5.7.1 | - | 1 | 1 | 1 | - | - | 3 |
| | 5.7.2 | - | 2 | 5 | - | 5 | 1 | 13 |
| | 5.7.3 | - | - | - | - | - | - | - |
| | 5.7.4 | - | 1 | 9 | - | 10 | - | 20 |
| Project close-out [ISO 19650-2 Clause 5.8] | 5.8.1 | - | - | - | - | - | - | - |
| | 5.8.2 | 1 | - | - | - | - | - | 1 |
| No. of items that do not correlate to ISO 19650 | | 21 | 3 | - | 2 | - | 43 | 69 |
| Totals | | 59 | 50 | 48 | 38 | 47 | 55 | 297 |

## 6.3 Maturity tools and methods: strengths, weaknesses and challenges

The strengths, weaknesses and challenges of the BIM maturity tools and methods were identified from different work items: the evaluation of individual tools and the cross-analysis of tools made during the desktop research [DR], the three workshops [W], the survey [S] and the eight interviews [I]. This section describes the findings relating to the strengths, weaknesses and challenges of the BIM

maturity tools and methods, and links each finding to the corresponding source. It is important to highlight that the adoption of BIM maturity tools among participants in the workshops and interviews was low (6 out of 37 workshop participants were performing BIM maturity assessment, 4 were using internal tools and 2 were using off-the-shelf tools; and 1 in 8 interviewees were using an internal tool). However, all participants were either aware of the existing tools, were in the process of developing their own internal tools/processes, or were knowledgeable about industry practices and developments in BIM maturity assessment. Hence, some of the strengths, weaknesses and challenges refer to BIM maturity assessment in general. Only when the term 'tool' appears in the descriptions below is a reference made to existing off-the-shelf tools. Otherwise, the descriptions refer to existing BIM maturity assessment practices experienced by industry experts.

**Strengths of BIM maturity assessment tools**

- The available BIM maturity tools for both organisations and projects generally assess items that belong to the same topics (refer to Table 6-3 and Table 6-4). However, these topics are assessed differently, as the tools have different scopes and purposes (refer to Table 6-5 and Table 6-6), ranging from readiness assessment, through to capability assessment and maturity assessment, or a combination of the three. [DR]

- A particular strength of the BIM maturity tools and practices highlighted by the interviewees was the breadth of overarching topics and methods addressed by the tools. These included: a set of organisation-wide themes assessed and compared against target scores; culture and behaviour topics; technology usage capabilities; case-study-based assessment; and benefits-driven maturity assessment where target benefits drive maturity measurement. Some interviewees suggested that a hybrid BIM maturity assessment approach utilising these multiple methods in a synergistic way is required, as none of the existing approaches and tools was deemed to be encompassing all aspects of maturity measurement. [I]

- The tools offer varying scopes of assessment, from readiness assessment, through to capability assessment, capability maturity assessment and fulfilling different purposes, including capability benchmarking and compliance benchmarking (including conformance[15] and compatibility assessment[16]). The majority of the tools focus on capability assessment and benchmarking. [DR]

- Most of the 15 tools are free to use and publicly available (11 tools), can be used by organisations involved in both building and infrastructure (11 tools) and are discipline-agnostic (10 tools). [DR]

- Project BIM tools place greater emphasis on measuring topics and items related to information management, in particular, the 'collaborative production of Information' [ISO 19650-2 Clause 5.6], the 'information model delivery' [ISO 19650-2 Clause 5.7] and 'mobilisation' [ISO 19650-2 Clause 5.5].

- Workshop participants who had assessed BIM maturity using internal methods and tools (4 out of 37) were using the measurement to focus and drive continual improvement. Some organisations and projects were required to report these maturity scores to senior

[15] Assessing whether the multiple offices of a large organisation conform to their established protocols or other established targets (e.g. defined set of BIM capabilities).
[16] Assessing and comparing the BIM performance of organisations within the supply chain or project teams.

management, alongside other key performance indicators (KPIs), such as health and safety. [W]

- Maturity scores were being used to help projects and organisations target where investment was required, in particular, the development of required competencies. The methods used to assess BIM maturity provided a framework to pragmatically map organisational and personal development. Depending on the metrics used, some participants suggested that measurement of BIM maturity encourages innovation and quality improvements at both project and organisational levels. Scores were being used as a useful mechanism to identify areas for improvement, especially where aspirational or peer benchmarking scores were available. [W]

- Measuring BIM maturity is informing the development of organisational strategies and policies, according to one interviewee. However, according to the interviewee, current assessments are generally focused on readiness, capability and compliance in most cases rather than maturity. [I]

- BIM maturity assessment methods were thought to help drive alignment between external project team members, as well as internal digital initiatives. By committing to measuring BIM maturity, workshop participants recognised that the process helped with improving the uptake and delivery of BIM on projects and it was found to help give clients 'what they want'. To achieve this, it was suggested that project actors, their actions and behaviours need to be clearly defined. This led one participant to suggest the inclusion of collaborative behaviours as a key topic when assessing BIM maturity. [W]

- The survey (see Section 8) shows that 46% of respondents measure BIM maturity, and 28% do so using a tool. Comments suggested that, when undertaken, evaluating BIM maturity helped to: improve collaboration across the organisation; track client demand; improve internal communication concerning new ways of working; increase staff job satisfaction; improve budget control; and enable learning pathways. [S]

**Weaknesses of BIM maturity assessment tools**

- The depth (granularity) of assessment enabled by most tools (11 out of 15) is low, offering limited understanding of the BIM performance of organisations or projects. [DR]

- Most tools (14 out of 15) offer a fixed assessment using either a static maturity matrix or a fixed list of questions/answers, which makes the assessment inflexible to organisations and projects. *BIM Excellence Online Platform* is the only tool that offers a continuous, flexible assessment [DR]. This finding was echoed by the interviewees, who frequently raised concerns about the lack of flexibility to accommodate a particular organisation's objective(s) and tailor the maturity assessment accordingly. [I]

- Many publicly available tools are rigid, with binary (yes/no) inputs from users, largely focusing on compliance and readiness issues in a very objective sense. This was seen to be a major weakness of the existing tools. However, such a simple and rigid assessment approach was deemed to be suitable for small organisations, as it helps them to start their BIM maturity assessment journey before adopting more sophisticated assessments [I]. Two interviewees, one from a large asset-owning client organisation and one from a large professional services organisation, considered existing BIM maturity assessment tools to be inadequate for their

requirements and business models. They require internal BIM maturity assessment tools and methods that are not isolated from their organisation's overall digital strategy. [I]

- All workshop participants agreed on the need to measure the whole supply chain, rather than focusing on Tier 1 contractors and lead designers only, which appears to be current practice. BIM maturity tools and processes do not serve this need, as they are not sufficiently flexible to be adapted to different actors within the supply chain. The competencies required by a client are very different to those of a steel manufacturer, for example. A client predominantly needs to assess the maturity of the delivery team on a project, whereas contractors need to measure their own maturity, as well as within their supply chain. It is important to define which competencies need to be assessed for each party. It is therefore difficult to have a one-size-fits-all system/tool to measure all of this. [W]

- The key motivation for measuring the BIM maturity of the whole supply chain is that some participants see BIM as an enterprise-wide process where weak links in the supply chain will compromise the performance of the whole enterprise. [W]

- There is currently no standardised method of maturity assessment across projects, which affects the ability to report performance consistently across programmes and portfolios. A standardised method would reduce the costs associated with performing BIM maturity assessment. [W]

- Several tools give weight to different assessment topics and items, and some tools do not give users the opportunity to change such weightings. This is often done to serve the benchmarking purpose of the tools. [DR]

- Assessments made by several tools suffer some quality issues as a result of unclear formulation (issues with content and syntax) of assessment items, which compromises the accuracy and consistency of assessment. The metrics in some of the tools are unreliable because of their insufficient description and subjective nature, and their poor definition, where in some instances individual metrics merge readiness, capability and capability maturity aspects. [DR]

- Most tools do not have follow-up questions to assess items in more detail or to provide organisations with the opportunity to supply additional evidence. Some tools do not offer a skip logic to enable the assessment to exclude items that may not be relevant to the actor being assessed. [DR]

- Most tools do not provide actionable advice to organisations and projects regarding how their BIM maturity can be improved. [DR]

- Tools for assessing projects are either focused on assessing compliance with standards, requiring the assessment to be performed at each project life-cycle phase, or are used for the purpose of benchmarking against industry-wide benchmarks [DR]. Workshop participants agreed that compliance does not necessarily reflect levels of performance. [W]

- Some of the client organisations admitted that the BIM 'maturity' assessment used within tenders (invitation to tender, and tender response) was rudimentary and had very little, if any, bearing on the project team that was chosen, as there were many other factors in play. However, there was agreement that this should be given more weighting than currently, but they acknowledged difficulties, as tenders are often cost-driven. [W]

- Many supplier organisations evidence their BIM 'maturity' with case studies of projects that they have worked on. However, this approach was considered by workshop participants to provide only anecdotal evidence. [W]

- A major discussion point during the workshops was that many suppliers have BIM specialists who are included in tenders in order to pass maturity assessments set for projects. This assessment does not therefore reflect the actual team that will be working on the project. One of the recommendations to resolve this was to ensure that there was continual measurement throughout projects. This would also allow for previous projects to be considered when assessing and appointing potential parties. [W]

- One of the key motivations given for undertaking BIM maturity assessment by different teams and aiming to score high is that there is currently no way of exhibiting low 'maturity' levels without being penalised. The industry needs to ensure that suitable guidance and training are available to the supply chain to improve BIM maturity. [W]

- Of the survey respondents measuring BIM maturity, not all saw it as useful, with some describing it as a 'waste of time' or a 'box-ticking' exercise. Measuring maturity and performance was said to be complex and costly. Some commented on a lack of clarity in the terms being used. [S]

- There was agreement among workshop participants that current BIM maturity assessment tools and processes, whether off-the-shelf or bespoke, do not produce an accurate representation of an organisation or individual's BIM maturity [W]. Interviewees agreed that off-the-shelf tools perform a relatively simplistic, capability-based assessment, which is generally focused on assessing the availability of technologies, skills and other artefacts within an organisation. This does not sufficiently capture the key information management competencies that are required to produce the right information, for the right people, at the right levels of role and responsibility in an organisation. Interviewees also expressed concerns over the outputs/feedback produced by such tools, which is fundamental to their need for more profound feedback to support activities such as strategic transformation of their organisation through BIM and upskilling. [I]

- Participants in workshops and interviews generally agreed that the tools need to reflect the transition to the ISO 19650 Series [W][I]. No tool currently exists that is aligned with these standards, although many measure topics and items of relevance to ISO 19650 Series, as demonstrated in Section 6.2.4 [DR].

**Challenges facing BIM maturity assessment tools**

- Most of the workshop participants considered the difficulty of determining what to measure for every organisation within the construction supply chain (clients, contractors, consultants, suppliers and operators/FM), and for the project's enterprise, to be the biggest challenge. It was also suggested that there is a need to agree on such competencies and their assessment approach in order to use the assessment for internal and external benchmarking purposes. [W]

- Some workshop participants highlighted that the challenge above was exacerbated by the absence of a clear definition for 'Level 2 BIM'' (now superseded by the UK BIM Framework approach and the ISO 19650 Series). Some participants also argued that if BIM maturity assessment is dominated by 'Level 2 BIM', this could be a misdirected strategy, as BIM

performance development should be encouraged beyond this level. The focus of existing tools on this level was justified by the fact that the industry is lagging behind in terms of 'information management capabilities and maturity'. However, further topics outside the 'Level 2 BIM' (such as collaborative behaviour) need to be considered, as these affect the attainment of both these baseline capabilities and maturity levels and their future advancement. [W]

- Some workshop participants suggested that assessment is currently dominated by the desire to comply with clients' BIM requirements. However, different clients have different requirements, and these are generally very broad to measure against. Differing requirements are also attributed to the different levels of skills and awareness on the client's side, or to the uniqueness of every project. This was especially witnessed by organisations who work in different markets, for different clients, and who follow different procurement routes. Because of the variability of BIM requirements, some participants suggested that it would be difficult to produce a standardised set of BIM maturity metrics; hence, bespoke maturity metrics need to be produced. However, with bespoke metrics, benchmarking BIM performance will be difficult to achieve, and assessment will require a greater level of investment to administer. [W]

- Workshop participants expressed concerns over the limited or missing obligations for information managers in the operational phase of built assets and the limited focus of BIM maturity assessment tools and practices on this aspect. Including related competencies in BIM performance assessment approaches may help to address this issue and ensure that BIM maturity assessment extends throughout an asset's life cycle. [W]

- A one-size-fits-all assessment approach adopted by existing tools was considered not to be effective across all organisations and projects by workshop participants and interviewees. They suggested this to be the driver that had led organisations to develop their own internal BIM maturity assessment approaches, which are often focused on ensuring that organisations can fulfil the requirements of their appointing party. [W], [I]

- Workshop participants argued that most organisations have scattered pockets of BIM expertise, and there is often disparity between regional offices. Individuals and teams with the most developed BIM performance are usually the ones that are exposed to external assessments by the appointing party and lead appointed party. They expressed concerns regarding the individual who is in charge of performing the assessment on behalf of the lead appointing party or lead appointed party, the individual who is assessed within the appointed party, and whether the assessed individuals will actually be employed on the job, which raises the challenge of competency assurance. If this practice is widespread, participants argued that it would disguise the extent of BIM capabilities and maturity that are actually available within the industry as a whole. [W]

- Workshop participants perceived many of the BIM maturity tools to be aimed at suppliers, with few addressing clients. Participants stated that most of the existing BIM maturity tools are inward-looking, do not drive performance improvement and do not encourage innovation. They agreed that the tools were assessing against a low threshold or old, sometimes out-of-date, requirements. This emphasised the challenge of keeping BIM assessment tools relevant in light of the pace of industry developments. [W]

- Referring to project assessment, workshop participants expressed concerns over the process and timing of the assessment. Many participants expressed that they had been measured at

the handover of their deliverables. They pointed out that this may undermine the purpose of the assessment, which they felt should be about continually driving improvement. Nevertheless, the workshop participants recognised the challenge of continually measuring maturity, such as limited incentives and the cost of performing the assessment. [W]

- Workshop participants extensively discussed the use of KPIs that are set out in contracts at the start of a project, or project audits for compliance within the EIR or BEP, to hold suppliers accountable for specific deliverables. The general feeling across the workshops was that these drive compliance and are performed too late in the project. Participants argued that this approach would only be beneficial if these KPIs and project audits were recorded for use in future projects. [W]

- Maturity assessment in projects is challenged by the limited awareness and clarity of contractual requirements in relation to BIM, from both the client and supplier side. [W]

- One of the biggest challenges perceived by many of the participants (in both interviews and workshops) was the lack of common understanding of 'maturity'. Many participants did not fully appreciate the concepts of readiness, capability and maturity, as distinct from one another, perhaps reflecting the wider understanding (or lack thereof) within the industry. [I], [W]

- Some interviewees argued that BIM maturity assessment should always provide a *relative* measurement (i.e. to be compared against a desirable target) to enable performance improvement. However, most tools address it as an *absolute* measurement, and wherever tools benchmark the measurement against a target, they lack the capabilities to provide insights for moving towards the target. [I]

- Some interviewees contemplated that if an industry-wide tool is to be developed, it should be adaptable in a way that can address industry-wide processes and cultural values, but at the same time it should be customisable to the specific nuances of an organisation/project. This approach was perceived to be highly challenging to capture and implement in a single tool. [I]

- An assertion made in relation to asset-owning client organisations was the need to justify BIM based on long-term value proposition rather than short-term benefits, and on an asset portfolio level instead of individual assets. Hence, maturity assessment for these organisations should consider these aspects. This is in contrast with contracting organisations where project-based outputs can shape maturity topics. [I]

# 7 Analysis of BIM benefits tools and methods

The BIM benefits evaluation tools were assessed using an information extraction card (Table 7-1). The completed cards for all benefits tools are included in Appendix F. The results of the application of the information extraction card to evaluate the three tools are included in Section 7.1. A simplified version of the full card was used to analyse the benefits methods by removing unnecessary fields, such as quality of measurement and usability of the tool. The analysis of the three methods, based on information extraction cards, is summarised in Section 7.2.

*Table 7-1: The information extraction card used to analyse BIM benefits tools and methods*

| Field | Purpose |
|---|---|
| Name of tool/method | Formal name of tool/method. |
| Link to tool | Publicly available link to tool/method, where available. |
| Supporting document(s) | Any available guidelines, instructions or supporting documents to support evaluation of the tool. |
| Author/owner | Developer and owner (if different) of the tool. |
| Country/origin | Geographic location of where the tool was developed. |
| Date of release, and version assessed | For veracity of evaluations with regards to the available version. The latest versions were assessed where more than one was available. |
| Benefits measured in | Does the tool measure BIM benefits for organisations or projects? |
| Benefits are measured for | Does the tool measure benefits for planning, design, construction or operation? |
| Applicability | Is the tool generic, market-specific or discipline-specific? |
| Intended use | Purpose of the tool – to assess general BIM benefits to the adopting organisation and/or project or specialised BIM benefits from specific technologies (e.g. mobile/site BIM technologies) for a specific purpose (e.g. snagging). |
| Intended users | Who the intended users of the tool are. |
| Benefits management approach | Details of the approach taken by the organisation or project to manage BIM benefits, where benefits management is 'the identification and structuring/definition of benefits, the planning of benefits realisation, the realisation and tracking of benefits, and the evaluation (review and optimisation) of benefits'. |
| Assumptions made | Inherent assumptions that the tool makes when performing the measurement to better understand the results. |
| Baseline used | Details of which baseline is used to compare the benefits of using BIM. |
| Definition of benefit | How the term benefit in the context of BIM is defined. |
| Benefits/key performance indicators measured by the tool/model, and how each is used | Lists the benefits/KPIs assessed by the tool and provides details of how the assessment is conducted. |
| Quality of assessment offered by the tool/model | Narrative on how well the tool conducts the following aspects: accuracy; informative; neutral; effort involved; monetisation of benefit measured/KPI. |
| Means of assessment/data collection | How the assessment is made of how the data is collected, with the following options: offline questionnaire; online questionnaire; on-site; automated collection; other. |
| Usability of tool/model | Ease of use; quality/aesthetics of user interface; help, dictionary, support documentations. |
| Details of any case studies demonstrating application of the tool/model | Any published demonstration(s) of the tool. |
| Additional information | Any relevant information not covered by the above fields. |

The following two sections provide summaries of the BIM benefits evaluation tools and methods and examine the quality of their BIM benefits measurement.

## 7.1 BIM benefits tools: analysis of individual tools

The following thee BIM benefits tools were analysed:

- BIM Return on Investment Tool *by the Scottish Futures Trust*
- BIM Value *by NATSPEC and SBEnrc*
- BIM Benefits *by the University of Cambridge*

***BIM Return on Investment Tool,*** by the Scottish Futures Trust, implements the following four steps and evaluations: Step 1 – project details data input; Step 2 – qualitative assessment across the seven life-cycle stages; Step 3 – quantitative assessment of benefits across brief and design, procure and construct, and operation; and Step 4 – investment details for the CDE investment, information manager role, BIM training, EIR development, OIR and AIR development, investment in facilities

management system, maintenance of AIM during operations, and additional investment costs. Users rate the benefits across project stages, either qualitatively or quantitatively. Users also estimate the investment/cost of implementing BIM (e.g. for CDE, OIR, BIM training, maintenance of AIM, facilities management systems). Then, the costs are deducted from the benefits and the return on investment (ROI) is calculated. The qualitative assessment uses the seven-stage project model. The quantitative assessment uses a three-stage project model: brief and design, procure and construct, and operation. Following completion of the assessment, a project dashboard shows both the qualitative and quantitative benefits of the projects. The full analysis of this tool is included in Appendix F.1.

***BIM Value,*** by NATSPEC and SBEnrc, does not measure BIM benefits but provides guidance about the type of benefits and metrics that are relevant to different stakeholders. It is a decision-support tool designed to help users develop a value realisation strategy. The tool enables users to link together a specific benefit (for example, improved coordination) at a specific asset life-cycle stage (for example, construction and operations) with an enabler (for example, design reviews) and the corresponding metrics (for example, variations and change orders). Measures proposed for the metrics are based on peer-reviewed literature and some industry guidelines (for example, for the 'variation and change order', the tool suggests the 'number of changes or variation/change orders as a percentage of number of changes in similar non-BIM projects' as a measure). The summary provided at the end of the questions offers a description of each metric, a supporting example and a reference. See Appendix F.2 for a list of the 30 metrics covered by this tool and its full analysis.

***BIM Benefits,*** by the University of Cambridge, measures benefits across seven categories: time savings; cost savings; materials savings; improved health and safety; reduced risk; improved asset utilisation; and improved asset quality. For each benefit KPI above, an 'activity' is designated, a corresponding 'enabler' is described (how 'BIM Level 2' is an enabler for the benefit) and a brief description of the 'benefit' is given. Then, users estimate the impact of performing a certain activity on a Likert scale (none, low, medium, high) and add a forecast of the expected savings in terms of number of days. While rating, users have a description of the activity (e.g. develop information requirements), the enabler ('BIM Level 2 compliance enables [them] to develop detailed EIR, AIR, OIR') and the benefit (information received at the right time, in the right format, without delays). The KPI used for most benefits is time (saved days), which is then converted into monetary values based on daily wages/rates. Days saved are the result of performing some of the proposed activities at certain project stages (e.g. 'develop detailed information requirements (EIR, AIR, OIR) at early project stages' at 'Stage 0 – Strategy'), but it is not clear when, or at what stage, the benefit being estimated (days saved) is occurring. The same benefit (days saved) is also calculated for the whole schedule/duration of the project, which may indicate an overlap or double counting in the estimation of the benefits. The tool resembles a questionnaire designed to understand the implications of 'BIM Level 2' for construction projects in general, instead of a benefit tool for estimating BIM benefits in specific projects. The full analysis of this tool is included in Appendix F.3.

## 7.2 Analysis of BIM benefits methods

The following three BIM benefits tools were evaluated:

- BIM Level 2 Benefits Measurement Methodology (BMM) *by PricewaterhouseCoopers*
- BIM Benefits Management Strategy *by Transport for London (TfL)*
- ROI Analysis *by Giel and Issa (2013)*

***BIM Level 2 Benefits Measurement Methodology (BMM),*** by PricewaterhouseCoopers, organises BIM benefits into eight categories of metrics/indicators. Each contains several metrics (see summary of the eight categories and metrics in Appendix E). The methodology also identifies 117 impact pathways

describing the different routes to unlocking the benefits. The categories are defined based on similarities in the measurement process, and they are independent of the stage of the asset life cycle at which the benefits are realised. The 117 benefit pathways were consolidated into 22 high-level benefit areas, which were further grouped into eight measurement categories: time savings; materials savings; cost savings; H&S improvement; risk reduction; improved asset utilisation; improved asset quality; and improved reputation. A range of quantification and monetisation techniques were used for the different types of benefit. 'Quantification of the benefits involves identifying the form and scale of the actual or expected benefit. Monetising each benefit involves placing an economic value on each.'[17] The methodology acknowledges that the costs of implementing BIM can be easily quantified, while the less tangible and more complex benefits of BIM are more difficult to quantify. The methodology uses a counterfactual situation. 'This involves comparing the outcomes achieved with the application of BIM Level 2 and those that would have been achieved if BIM Level 2 had not been used or available.'[18] It involves isolating changes in an outcome (e.g. risk, time, cost, quality) and attributes the change to the use of BIM Level 2. The methodology acknowledges the challenges of measuring the net benefits against an appropriate counterfactual, which cannot be directly observed, and so the impact must be determined in some other way. The methodology uses empirical observation (compare the outcomes between two otherwise similar projects where one uses BIM Level 2 and one does not); expert judgement (compare elements of a project or asset with-BIM Level 2 to one without-BIM Level 2 by drawing on expert opinion/experience to assess the scale of the impact on the key benefit metrics); and a combination of empirical observation and expert judgement. The full analysis of this method is included in Appendix G.1.

***BIM Benefits Management Strategy,*** by Transport for London (TfL), includes a benefits statement setting out the expected benefits and dis-benefits of adopting BIM in TfL projects. They are separated into two categories – intermediate benefits and end- or wider benefits – and identified by one of four benefit types: direct monetary benefits (tangible); direct non-monetary benefits (tangible); indirect benefits (intangible); and dis-benefits. The tool utilises a benefits profile table that provides details for each benefit such as: ID; benefit description; change logic; target; potential measure(s); measurement methodology; responsible for delivery; and trajectory. BIM is aligned with the organisation's strategic objectives. BIM benefits evaluation is part of an iterative improvement process, which refers to early adopters to improve the BIM processes while tracking performance and enabling refinement before BIM becomes business-as-usual (BAU). The TfL BIM team creates a benefits map to capture and illustrate the following: relationships between the outputs produced; the business changes needed to take on new capability; the outcomes expected from the successful conduct of business change activity; the benefits (intermediate and wider benefits) that are anticipated to be realised because of those outcomes; and the TfL strategic objectives that will be achieved as a result. The process is iterative, with each step learning from experience and making improvements that will be fed into BAU: planning the benefits; identifying and mapping the benefits; setting benefit priorities; benefit profiles; benefits realisation plan; executing the benefits realisation plan; and reviewing and evaluation benefits realisation. The full analysis of this method is included in Appendix G.2.

***ROI Analysis,*** by Giel and Issa (2013), measures cost savings and man hours saved on: original contract value; total cost of change orders; original schedule duration; duration of schedule delay that was, or was not, experienced; building size; type of construction; and use. The method applied a model for estimating BIM ROI that reviewed requests for information (RFI) logs, change order logs and delay

[17] PricewaterhouseCoopers (2018) *BIM Level 2 Benefits Measurement Introductory note: Approach and benefits framework.* Available at: https://www.cdbb.cam.ac.uk/files/2._pwc_introductory_note_to_bmm.pdf, p. 7.
[18] ibid, p. 24.

claims. Interviews were held with people who worked on the project to collect additional data. Direct savings (e.g. cost) and indirect savings (e.g. time) were assessed after the direct cost of BIM implementation (e.g. hardware and software) had been subtracted. The cost of BIM was represented as 0.5% of the initial contract value. The full analysis of this method is included in Appendix G.3.

## 7.3 BIM benefits tools: a cross-tool analysis

This aim of the cross-analysis was to understand: the stages addressed by the tools as the stages where benefits accrue (Table 7-2); the benefit metrics evaluated by each tool (Table7-3); and the approaches to benefits evaluation in terms of their coverage of a benefits management strategy, types of benefit evaluated, and their use of concepts such as pathways to benefits, setting baselines and monetisation (Table 7-4).

Table 7-4

Two of the tools (*BIM Benefits* and *BIM Value*) address benefits across all asset life-cycle stages, including asset delivery, asset operation and service delivery. One tool, *BIM Return on Investment Tool*, does not explicitly address benefits at the service delivery stage and considers the organisation's investment to implement BIM on projects (see items within the dotted rectangle in Table 7-3). The benefit metrics addressed within each tool are listed in Table 7-3.

The *BIM Return on Investment Tool* adopts benefit measures that can be evaluated qualitatively by asking users to rate them on a Likert scale; or quantitatively by asking users to provide estimates of the benefits (e.g. assumed efficiency saving per annum at operation stage) and the likelihood of the benefit realisation (e.g. low, medium, high). The investment/cost of implementing BIM (e.g. for CDE, OIR, BIM training, maintenance of AIM, and facilities management systems) is estimated and deducted from the benefits.

*Table 7-2: Stages addressed by BIM benefits evaluation tools*

| | Asset delivery | | | Asset operation | | Service delivery | Organisation investments |
|---|---|---|---|---|---|---|---|
| | Brief to strategy | Design | Construction | Maintenance | Management | | |
| **BIM ROI Calculator** | • | • | • | • | • | | • |
| **BIM Value**[19] | • | • | • | • | | • | |
| **BIM Benefits** | • | • | • | • | • | • | |

The *BIM Value* tool does not evaluate the benefits but provides guidance to different stakeholders in a project on how to realise their pre-selected end-benefits. It is a decision-support tool designed to help users develop a value realisation strategy. The tool allows the user to link together a specific benefit (e.g. improved coordination) at a specific asset life-cycle stage (e.g. construction and operations) with an enabler (e.g. design reviews) and the corresponding metrics (e.g. variations and change orders). The measures are based on peer-reviewed literature and some industry guidelines (e.g. for the 'variation and change order', the tool suggests the 'number of changes or variation/change orders as a percentage of number of changes in similar non-BIM projects' as a measure).

The aim of the *BIM Benefits* tool is to quantify the benefits obtainable from information management practices associated with the adoption of 'BIM Level 2'. Most benefits are expressed as cost savings or time savings, which are subsequently monetised. The tool adopts the concept of 'pathways', where benefits are achieved following the execution of certain project information management activities (e.g. develop project business case and information requirements) according to an enabler, which is a specific information management practice of 'BIM Level 2' (e.g. 'develop detailed information requirements: EIR, AIR, OlR').

Finally, the analysis of the tools in terms of their coverage of a benefits management strategy, types of benefits evaluated, and their use of concepts such as pathways to benefits, setting baselines and monetisation, are described in Table 7-4. It is important to highlight that, although these tools are not expected or conceived to address all the stages of a benefits management strategy, it is useful to identify the stages to which current tools can contribute.

[19] The *BIM Value* tool does not measure benefits but provides guidance about their realisation.

Table 7-3: Benefits measured[20] by BIM benefits evaluation tools

| BIM ROI Calculator | BIM Value | BIM Benefits |
|---|---|---|
| - 50 qualitative statements[21]<br>- Reduce internal management costs<br>- Reduce preliminary costs on-site<br>- Improved tender prices<br>- Reduce construction risk<br>- Reduce client-held risk<br>- Reduce costs for CBWIC<br>- Reduce cost to manage change<br>- Robust data transfer at completion<br>- Efficient data management<br>- Improved energy performance<br>- Efficient maintenance events<br>- Bundling of maintenance events<br>- Additional quantitative events | - Cost of change<br>- Variations and change orders<br>- Time for change<br>- Request for information<br>- Conflict<br>- Latency<br>- Labour intensity<br>- Cost predictability<br>- Sustainability and environmental performance scores<br>- Resource use and management<br>- Carbon footprint<br>- Quality<br>- Knowledge management metrics<br>- Stakeholder involvement<br>- Accuracy and number of errors/omissions<br>- Cost of change<br>- Variations and change orders<br>- Time for change<br>- Request for information | - Time savings in strategy: from improved definition of the information required by the client, received at the right times in the right format; stage gate reviews passed without delay<br>- Time savings in brief from faster, more streamlined procurement process for client and suppliers; and 3D modelling and automated rule-checking reduce design time<br>- Time savings in design (15 benefit pathways)<br>- Time savings in build and commission (12 benefit pathways)<br>- Time savings in answering RFIs during build and commission from: fewer requests for additional information during construction; and faster information exchange and access between the construction<br>- Time savings in handover (4 benefit pathways)<br>- Time savings in incident response from more/better information about the asset in support of recovery/rebuild<br>- Material savings in 'build and commission' (10 benefits pathways)<br>- Environmental benefit from fewer materials used (20 benefits pathways)<br>- Cost savings from better clash detection (6 benefit pathways)<br>- Cost savings from fewer changes (5 benefit pathways)<br>- Cost savings in operations – facilities management (4 benefit pathways)<br>- Cost savings in asset maintenance (4 benefits pathways)<br>- Cost savings in asset disposal (3 benefit pathways)<br>- Cost savings in litigation (3 benefit pathways)<br>- Improved health and safety in construction (3 benefit pathways)<br>- Improved health and safety in maintenance/demolition (3 benefit pathways)<br>- Reduced project risk contingency in capital delivery phase (5 benefit pathways)<br>- Increased certainty in operating expenditure estimates (5 benefit pathways)<br>- Improved asset utilisation (5 benefit pathways)<br>- Improved asset quality (5 benefit pathways) |
| **Investments/costs:**<br>- CDE investment<br>- Information manage role<br>- BIM training<br>- EIR development<br>- OIR & AIR development<br>- Investment in facilities Management system<br>- Maintenance of AIM during operations<br>- Additional investment costs | - Conflict<br>- Latency<br>- Cost savings/avoidance<br>- Speed of production<br>- Volume of rework<br>- Clashes<br>- Off-site manufacturing<br>- Model (or drawing) coordination consistency<br>- Time per unit<br>- Meeting effectiveness<br>- Meeting efficiency<br>- Satisfaction<br>- Cost per defects-warranty<br>- Fire safety<br>- Overall time<br>- Overall cost<br>- Profit<br>- Asset/equipment useful life | |

[20] Ibid.

[21] Statements are rated on a Likert scale, all following this format: 'BIM Level 2 will offer and support [benefit description]. As an example [Improved security in the management of an assets digital data].'

*Table 7-4: Approach to benefits evaluation adopted in BIM benefits evaluation tools*

| | Benefit management strategy | | | Type of benefits | | Pathways to benefits | Baseline/ counterfactual situation | Monetisation |
|---|---|---|---|---|---|---|---|---|
| | Plan benefits realisation | Execute/ realise benefits | Review benefits | Forecast | Actual | | | |
| BIM Return on Investment Tool | ✓ | ✓ | ✗ | ✓ | ✗ | ✗ | Projects and organisations not using BIM | ✓ |
| BIM Value | ✓ | ✗ | ✗ | ✓ | ✗ | ✓ | Estimates from academic literature | ✗ |
| BIM Benefits | ✓ | ✓ | ✗ | ✓ | ✗ | ✓ | Projects and organisations not using BIM | ✓ |

## 7.4 BIM benefits tools: strengths, weaknesses and challenges

The strengths, weaknesses and challenges of the BIM benefits tools were identified from different sources: the evaluation techniques (information extraction card, actual use of tools, individual and cross-tool analyses) used during the desktop research [DR], the three workshops [W], the survey [S] and the eight interviews [I]. This section describes the findings in terms of the strengths, weaknesses and challenges of the BIM benefits tools and links each of the findings to the corresponding source.

Most of the participants in the workshops and interviews had either an awareness of the existing tools or an interest in exploring the use of such tools, but few had experience of using a tool. Of the survey respondents, 51% were measuring the benefits of BIM but only 16% did so using a tool. As a result, some of the strengths, weaknesses and challenges were referring to BIM benefits evaluation approaches instead of specific tools. Only when the term 'tool' appears in the description of the strengths, weaknesses and challenges is the reference to specific tools.

**Strengths of BIM benefits evaluation tools and approaches:**

- All tools address benefits that are inherently associated with enablers/activities made available through BIM and the supporting project/standards ecosystem under which BIM is adopted. [DR]
- The tools address benefits across the whole asset life cycle, from early strategy, through to design and construction, and operation and service delivery. [DR]
- One tool (*BIM Benefits*) ties together several benefits pathways into key end-benefits; one tool (*BIM Value*) develops pathways for intermediate benefits pre-selected by users to be targeted; and one tool (*BIM Return on Investment Tool*) addresses qualitative assessment using benefits statements. [DR]
- All of the tools provide useful information on the general benefits of adopting BIM. [DR]
- Workshop participants stressed the importance of a consistent and stable evaluation approach for some benefits (time, cost and quality) that can generate benchmarking data against which the performance of other BIM projects can be compared. Until then, situations where BIM is not adopted (e.g. traditional 2D ways of working) could be used as a baseline. Participants proposed that benefits may also be measured using existing KPIs, such as those that exist on a framework contract or those developed by Constructing Excellence. [W].

- Demonstrating benefits against benchmarks (targets) enables teams to gain recognition when they exceed targets. Benchmarking could also be used to unlock investment, as it would provide evidence to justify where improvements can be made, especially in skills and training. A benefits evaluation approach could also assist with sharing knowledge between team members and communicating the value of BIM and digital ways of working to sceptics. [W]

- Beyond project level, workshop participants thought there was an opportunity to link BIM benefits evaluation to business outcomes. This could even be extended to evaluating the benefits against government targets, such as those presented in the Government Construction Strategy 2016–2020. [W]

- Large, multinational organisations were seen to have a considerable advantage in relation to building a baseline from across domestic and international projects. Their proprietary tools also have the opportunity to evaluate and compare benefits across various functions, different geographies, cultures and work practices. [I]

- One approach adopted in the organisation of one of the interviewees does not refer to or require industry-wide benchmarks. Instead, it uses target benefits (not just BIM but also for planning, commercial, etc.) that are established from the outset for each project and reported on a monthly basis to senior management. Benefits against these targets are accumulated as the project progresses. [I]

**Weaknesses of BIM benefits evaluation tools and approaches:**

- The baseline or counterfactual situation, against which improvements are compared, refers to organisations or projects not using BIM or which have not implemented any BIM capability at the time of the evaluation. One tool (*BIM Value*) refers to benefits estimates adopted from the academic literature, which in turn were derived from comparison with projects and workflows not using BIM. [DR]

- The accuracy of BIM benefits evaluation enabled by the tools is questionable. This is challenged by factors such as the confounding nature[22] of the benefits measurement problem, the lack of benchmarking data, and the reliance of estimates on the knowledge of users inputting the data and the subjectivity involved. [DR]

- Survey respondents noted that the difficulty is not only in the measurement of BIM benefits. There are also challenges in the communication of the benefits, and those carrying out benefits measurement need to be competent to do so. [S]

- The tools are likely to develop optimistic estimates of the benefits because of issues, identified in the detailed analysis of individual tools, such as double counting of some benefits and the assumption that the evaluation is being performed within an environment (project or organisation) that has not implemented any element of BIM. [DR]

- The outputs from the benefits evaluation, including the quantitative evaluation provided by the tools, are generally not informative. The outputs produced by the tools (e.g. *BIM Return on Investment Tool*) reiterate the input of users (such as displaying amalgamated benefits with

[22] Confounding nature refers to a situation where it is challenging to reasonably eliminate plausible alternative explanations for an observed relationship between two variables (e.g. a BIM activity/capability, and an end-benefit).

three levels of confidence) without actionable advice to users about how to achieve the benefits. [DR]

- Most of the organisations consulted were capturing benefits through the case studies of completed projects. Most agreed that many of the benefits explored were anecdotal rather than tangible. [W]

- Some organisations have launched attempts to establish the financial value of benefits arising from BIM on projects. However, these are still at a very high level, with no granularity to the results. This workshop discussion highlighted how little is currently measured. At present, the measures rarely go beyond time, budget and quality metrics. [W]

- One of the most contentious points raised was whether resources should be invested in measuring 'BIM benefits'. This argument was driven by the challenges facing BIM benefits evaluation and the debate around project 'outcomes' versus 'outputs'. There was an agreement that, whatever is measured, the measurement must add value to the project, without adding unnecessary complexity. [W]

- Some workshop participants argued that the available BIM benefits evaluation tools tend to be focused on the client, are too rigid, do not address all stages of an asset's life cycle, and capture benefits at set project stages [W]. This is contrary to a desk research finding that all tools address benefits across the whole asset life cycle, from early strategy, through to design and construction, and operation and service delivery. [DR]

- All interviewees were unanimous in their view that the BIM benefits evaluation tools do not enable linking with organisations' business models and key outcomes. They suggested that BIM benefits evaluation requires a more holistic approach; for example, some organisations may only be interested in the return on capital investments (CAPEX), as their business model has no involvement in operational-phase-related (OPEX) activities, while, for others, OPEX-related benefits may be far more critical [I]. Survey respondents agreed that the evaluation of BIM benefits needs to be ongoing within the wider organisational system, network or portfolio. [S]

- It was suggested by a workshop participant that benefits evaluation should have clarity regarding what and when to measure in order to understand the true benefits of the BIM process on a project. Benefits evaluation is a complex problem where the benefits associated with a certain project's activity or process may appear a long time (years in some cases) after that activity has been performed. Workshop participants suggested that the current measures do not go beyond time, cost and quality. [W]

- A major weakness in the current benefits evaluation tools and approaches is in their use of traditional situations/workflows where BIM is not used as a baseline. It was suggested that even if the same building on the same site was delivered with or without implementing BIM, it would still be difficult to evaluate how many of the differences are attributable to BIM. [W]

- Workshop participants noted that the measures of success continually change as the industry matures. The current BIM benefits evaluation tools do not take this into account. The evaluation of BIM benefits is a dynamic process, and metrics should remain 'coupled' to reflect changes in requirements, technology and project context in order for measurements to remain useful and relevant. There also needs to be some investigation around how to incentivise the delivery of these benefits on a project. [W]

- Two interviewees argued that all benefits tools evaluate improvements against low baselines (for example, traditional process not using BIM) and cannot estimate the benefits opportunity gap that may exist between an optimal state (optimised processes) and the measured situation. If the evaluation has an adequate granularity level, this gap analysis should inform improvement strategies in the short, medium and long term. [I]

- The current BIM benefits evaluation tools are rigid and cannot capture and isolate the effect of factors that influence benefits realisation, which, according to industry participants, should also include the digital maturity of organisations involved in the supply chain working on the project being evaluated. [I]

- Workshop participants argued that assessing BIM in isolation creates the misperception that BIM is a 'bolt-on' to project delivery. Some participants advised against making the 'BIM benefits evaluation' too formal and warned that this might discourage benefits realisation rather than enabling it. It was suggested that benefits evaluation be extended to evaluate benefits related to embedding a digital culture, increased digital supply chain and project maturity. [W]

**Challenges of BIM benefits evaluation tools and approaches**

- The counterfactual situation is generally not available/observable when performing benefits evaluation, and several confounding factors will determine the same end-benefits. Moreover, even if the counterfactual situation were available, it would not represent an adequate baseline given the lack of extensive benchmarking data across the industry to guide BIM benefits evaluation [DR]. That said, interviewees argued that a tool/approach that can credibly compare a BIM-based solution with a non-BIM-based solution for the same or similar problem(s) would provide an effective message to early adopters and sceptics about the value of BIM and encourage adoption. [I]

- The complex nature of projects means that several factors influence outcomes at different stages of the life cycle. [DR]

- Existing BIM benefits evaluation approaches appear to be focused on driving encouragement to adopt BIM instead of identifying benefits and measuring what adds the most value to the project. Some participants warned about the risk of concentrating the discussion on BIM benefits, which would become an add-on diverting attention away from enabling collaborative and information management processes. [W]

- Workshop discussions frequently pointed to the subjective and general nature of many BIM requirements as a challenge for BIM benefits evaluation. Some of the workshop participants attributed this in part to the vague definition of 'BIM', as well as the challenge of defining a 'benefit', especially as the perspective of a benefit varies between different project stakeholders. [W]

- From the client's point of view, workshop participants highlighted the importance of understanding the benefits associated with BIM by the client before BIM is adopted on a project. Clients reported this as a challenge, especially as there are so many unknowns at the start of a project and there is often a significant time lag between the implementation of BIM and the realisation of benefits. This lag in the realisation of benefits resonated as a challenge to benefits evaluation with other actor types, not just clients. [W]

- Workshop participants suggested that benefits be assessed against whether the client received the outcomes they invested in, instead of specific digital outputs. Positive outcomes result from a combination of different factors and may not be attributed to BIM alone. This presents a difficulty when measuring benefits as 'outcomes'. For example, if risk levels on a project are reduced, it is difficult to link this outcome to a specific enabler such as a BIM activity or a BIM digital output. [W]

- Some participants argued that the measure of BIM benefits is only as good as the data available and the metrics used. These individuals felt that, currently, the data required to measure benefits is not always available and the data that does exist cannot always be relied upon. This limits the opportunity for automating benefits evaluation and the use of artificial intelligence, making the task of benefits evaluation resource-intensive. [W]

- Access to, and availability of, individuals with the skill set to manage the BIM benefits evaluation process was also raised as a challenge. Workshop participants noted that this requires the assessor to know what 'good looks like'. Many argued that it is difficult to find individuals with the skills to deliver the benefits associated with BIM, let alone finding out whether others have delivered benefits. [W]

- Workshop participants suggested that the continual development of projects and the evolving digital ways of working are a challenge to BIM benefits evaluation. Frequent changes encountered in most projects add complexity to the process of BIM benefits evaluation. Furthermore, as digital technologies and processes evolve, especially over the very long lifespan of certain project, it is important to understand what the benefits are being measured against and how the metrics and baselines are updated. One participant commented: 'Are we going to measure the benefits realised using processes and technologies that are 8 years old?' [W]

- Longitudinal measurements were identified as a key challenge for certain types of organisation. Some interviewees expressed that for client organisations the main driver for efficiency gains are the savings in the operational phase, and therefore a tool/approach encompassing operation and maintenance, and service-delivery-related benefits over a prolonged period, would represent an effective and relevant evaluation approach. [I]

- Flexibility/adaptability of tools was frequently mentioned during the interviews. Benefits evaluation tools should be adaptable to varying levels of complexity present across different projects and scenarios. Two interviewees considered this feature to be a key determinant of their decision regarding which tool to adopt. They envisage a tool where they can 'switch on and off' some functionality/layers depending on the situation being evaluated. [I]

- Two interviewees highlighted the challenge of creating a BIM benefits evaluation tool that captures and processes tangible and intangible benefits in an integrated way. They also warned against the risk of broadening the scope of assessment (according to the interviewees, some tools try to cover 'too much' in their scope, such as assessing commercial, sustainability performance, effectiveness of information flows, etc.). This tends to make the tools overly complex and diminishes their usefulness, as it was felt unlikely that tools could provide meaningful/reliable evaluation of such a broad range of benefit types. [I]

# 8 Industry usage and implications

A survey was carried out to assess industry usage of BIM maturity assessment and BIM benefits evaluations and their implications. The survey involved a wide range of construction professionals and its aim was to analyse their current attitudes towards the perceived benefits of BIM, the assessment of BIM maturity and the evaluation of BIM benefits.

The online survey opened on 30 August 2019 and closed on 15 October 2019. It was promoted through professional bodies and social media and by direct invitation of the CDBB and the UKBIMA. In total, 184 people gave their views through the survey.

## 8.1 Survey methodology and sample

An assessment of the comments given by the respondents suggests that those who chose to respond tended to have detailed knowledge of BIM. This may not fully represent the whole construction and built environment sector. Furthermore, the sample size was relatively small. Therefore, this survey should be taken as giving *indicative* results among those who are already engaged in BIM rather than a robust overview of the entire construction industry and related professions.

In terms of the make-up of the respondents, views were gathered from a range of company sizes, geographical locations and organisation activities. Figure 8-1 to Figure 8-3 (below) show the distribution of each of these categories.

While a significant number of respondents have a workplace overseas, these respondents were not excluded from the analysis. UK companies carry out significant design, contracting and professional services work overseas, and they are based overseas. The UK approach to BIM is of international interest.


*Figure 8-1: Demographics of survey participants*

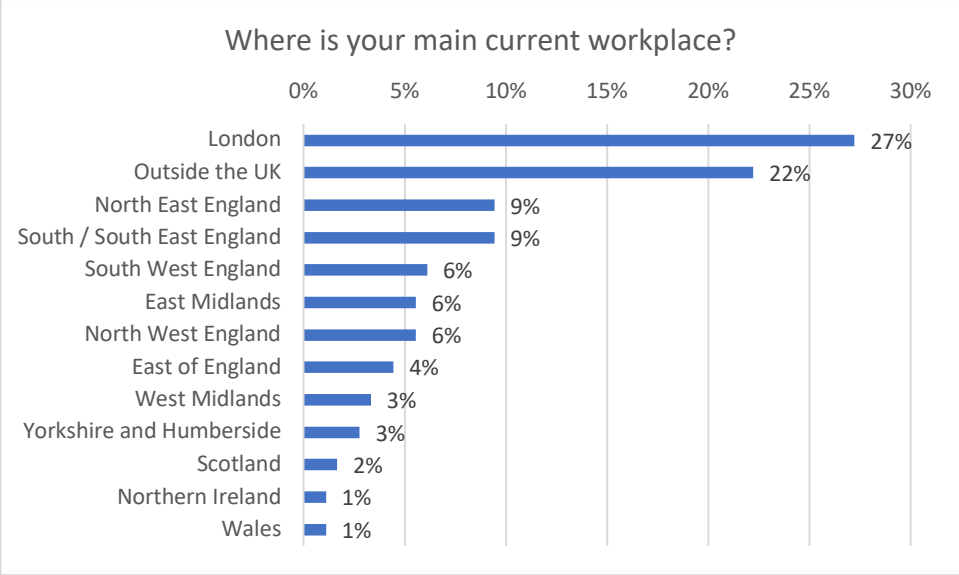



*Figure 8-2: Location of survey participants*

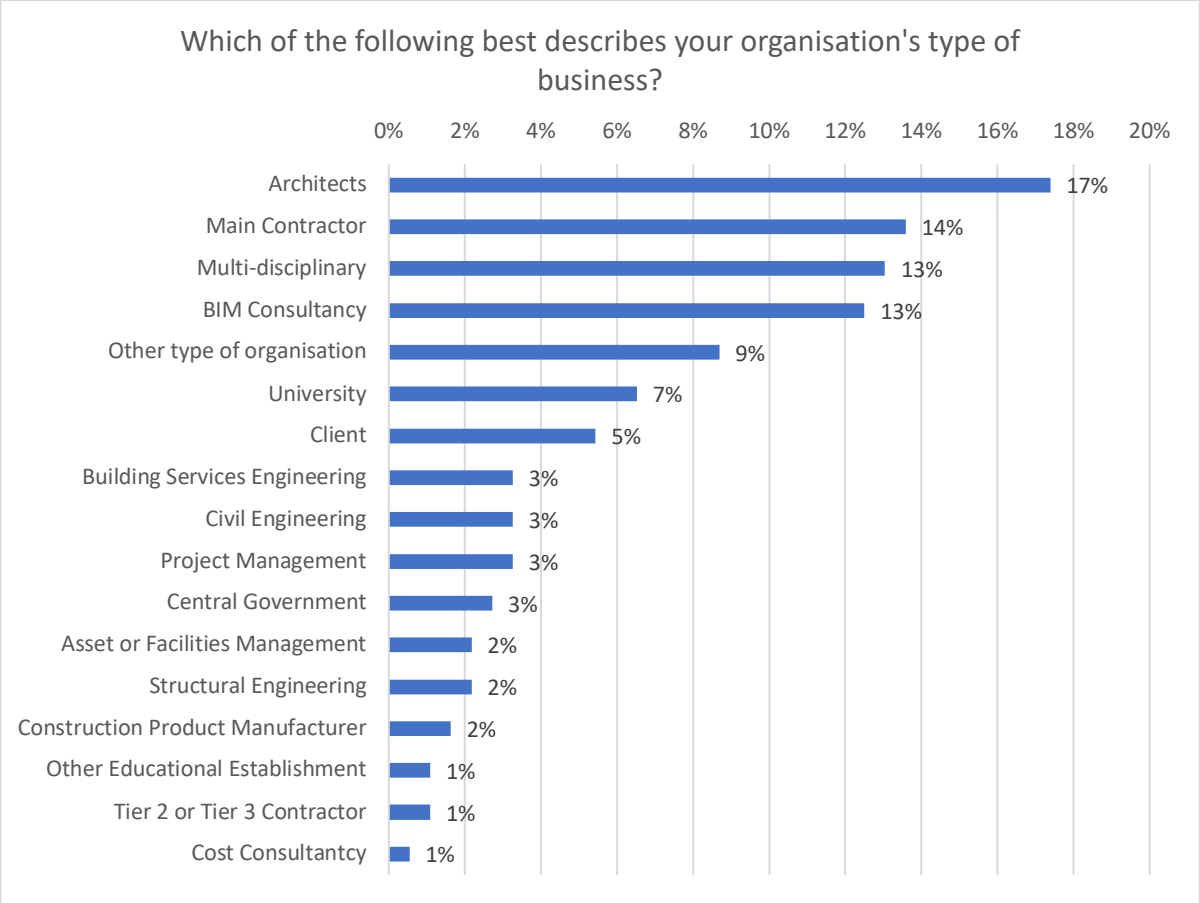



*Figure 8-3: Business types of survey participants*

## 8.2 Use of BIM and perceptions of BIM benefits

Given that everyday use of the term 'BIM' may not conform to a current standard definition, the survey was prefaced with an agreed definition of BIM as follows:

***'BIM** in this survey refers to "getting benefit through better specification and delivery of just the right amount of information concerning the design, construction, operation and maintenance of buildings and infrastructure, using appropriate technologies", as defined by the ISO 19650 Series.'*

This definition means that, to complete the survey, respondents were invited to think of BIM as more than just geometrical modelling and visualisation, and to include information management and other BIM applications.

This was tested later in the survey through a dedicated question:

*'Do you use BIM for purposes other than geometrical modelling and visualisation on your projects?'*

The responses to the survey suggest that few use BIM as a 3D visualisation tool *only*. The majority (82%) of respondents use BIM for purposes other than geometrical modelling. The results for this question are shown in Figure 8-4. Designers[23] were more likely than others to implement BIM for purposes other than geometrical modelling.

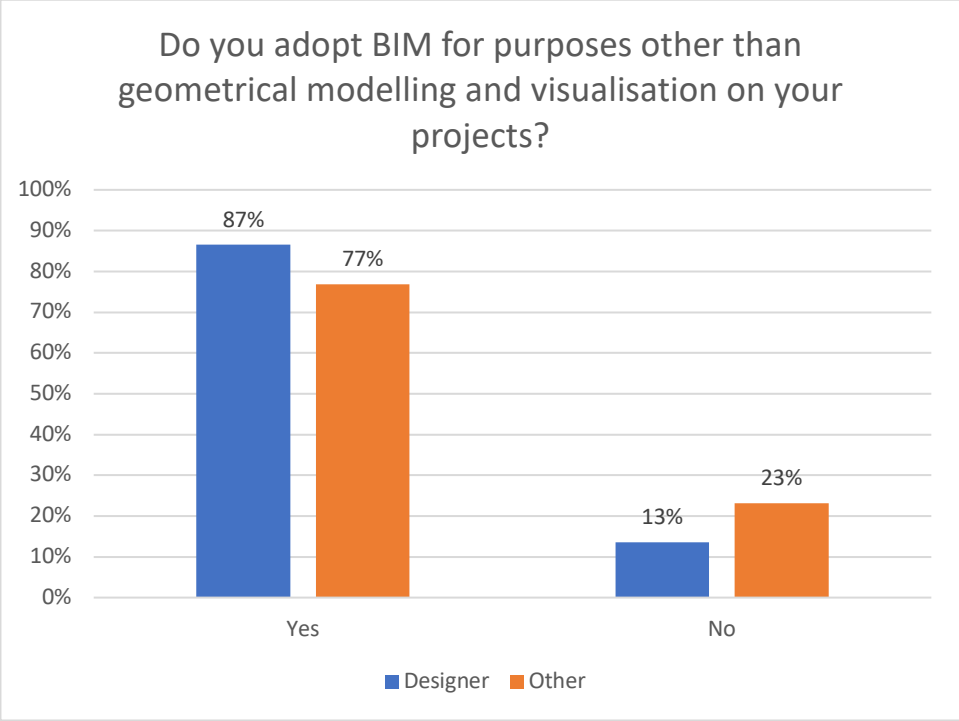



*Figure 8-4: Adoption of BIM by respondent type*

The responses to this question can be further broken down for groups of 20 or more respondents (see Figure 8-5). The percentages, among those groups, for whom BIM is adopted for 'purposes other than geometrical modelling', is:

- Main contractor (92%)
- Multi-disciplinary (92%)

[23] Those working within organisations whose type of business is: architects, BIM consultants, building services engineering, landscape architects, multi-disciplinary or structural engineering.

- Architects (78%)
- BIM consultancy (87%)

There was little difference in the adoption of BIM ('for purposes other than geometrical modelling') between infrastructure projects and projects for buildings other than infrastructure. A total of 82% of those carrying out infrastructure projects adopt BIM for purposes other than geometrical modelling, compared to 83% of those working on buildings other than infrastructure.

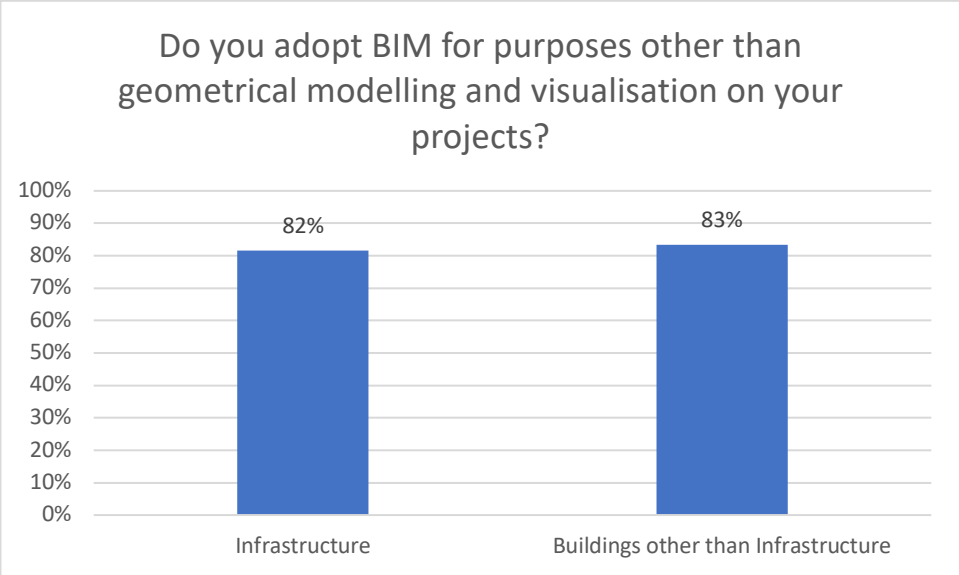



*Figure 8-5: Adoption of BIM by project type*

The survey also asked about the regularity with which BIM is adopted for purposes other than geometrical modelling. Figure 8-6 shows that 29% *always* implement BIM for purposes other than geometrical modelling on their projects, and 26% *usually* do. A total of 19% *never* use BIM for purposes other than geometrical modelling.

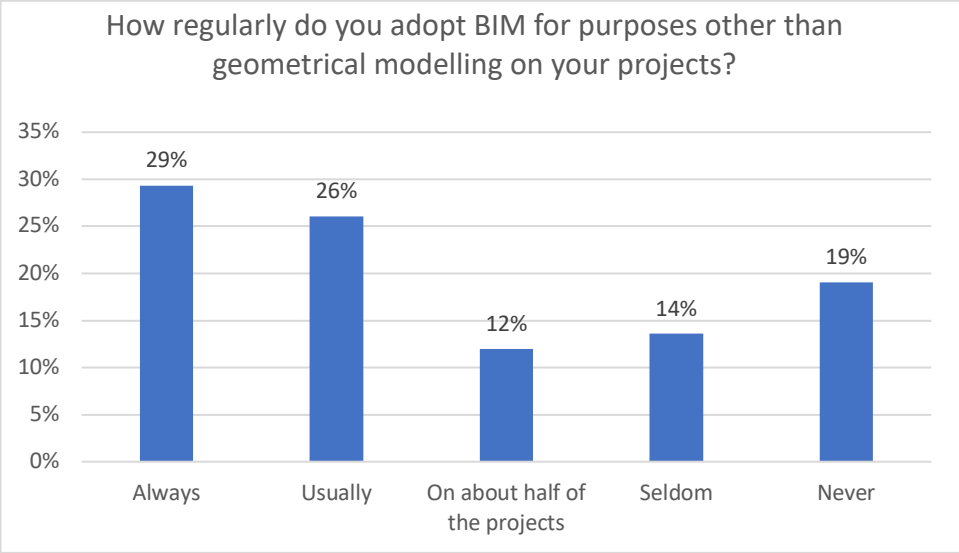



*Figure 8-6: Participants' purposes for adopting BIM*

Breaking the data down by the categories of 'designer' and 'other', designers are more likely to adopt BIM for purposes other than geometrical modelling 'always' or 'usually': 65% compared with 46% for others (Figure 8-7).

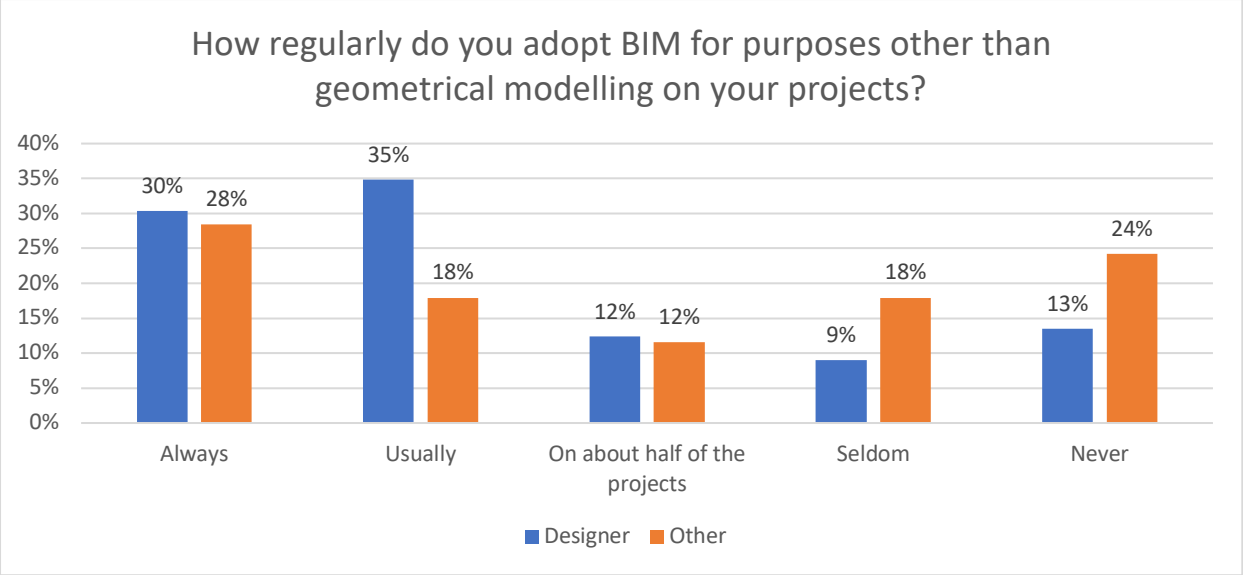



*Figure 8-7: Regularity of adopting BIM for purposes other than geometrical modelling by respondent type*

Looking at specific organisation type (where there were 20 or more respondents), the regularity of adopting BIM for purposes other than geometrical modelling is shown in Table 8-1.

*Table 8-1: Regularity of adopting BIM for purposes other than geometrical modelling by group type with 20 or more respondents*

| Organisation type | Always | Usually |
|---|---|---|
| Architects | 22% | 31% |
| BIM consultancy | 52% | 26% |
| Main contractor | 40% | 16% |
| Multi-disciplinary | 17% | 54% |

Respondents were asked what benefits they think BIM *currently* brings to their projects (Figure 8-8). For all the potential benefits proposed, a majority agreed that BIM:

- Improves design quality (89%)
- Promotes a culture of collaboration (85%)
- Improves client outcomes (81%)
- Increases the productivity of the design-build process (80%), and
- 'Increases the productivity for my organisation' (72%)

The lowest-ranked benefit was the ability of BIM to help meet agreed sustainability targets.

These findings may help when thinking about which benefits may best be measured by any given benefits measurement tool.

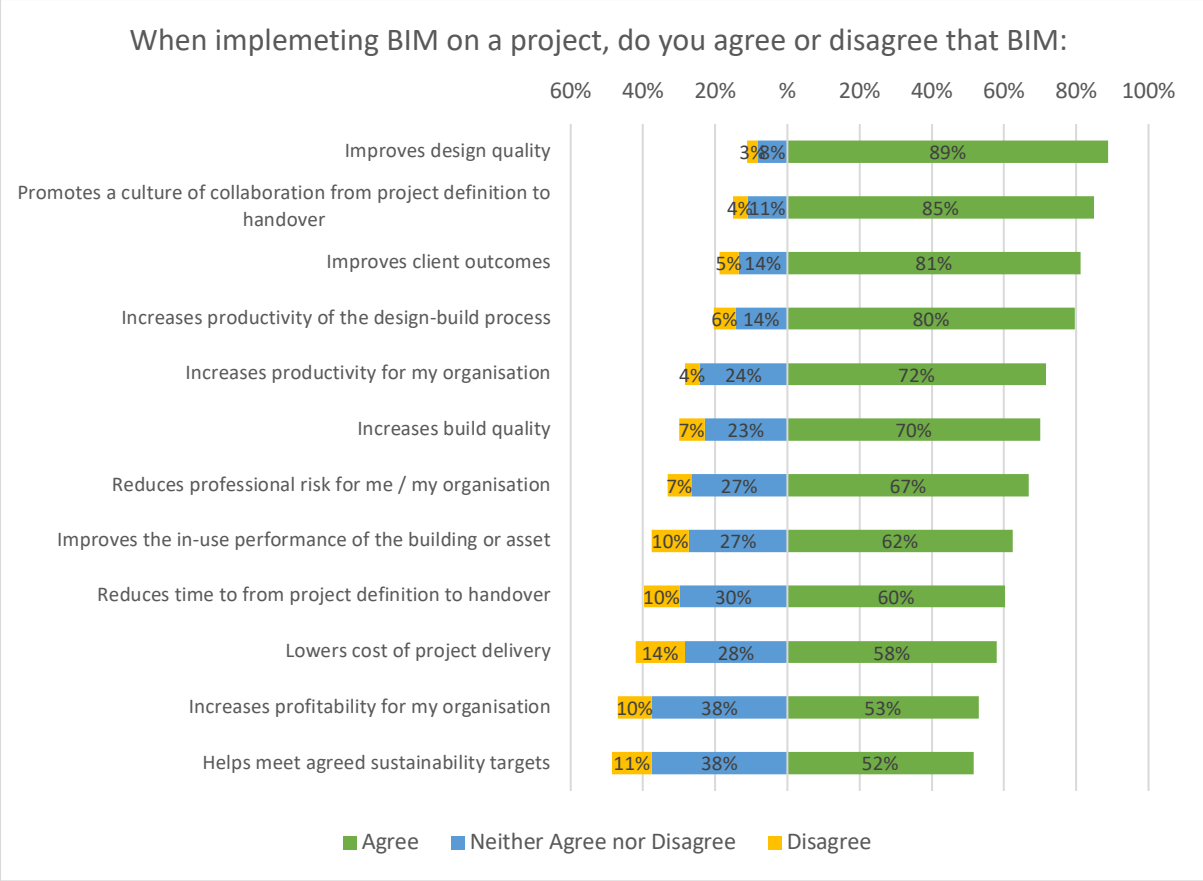



*Figure 8-8: The benefits that participants think BIM currently brings to projects*

## 8.3 Measurement of the benefits of BIM and BIM maturity

*'Does your organisation measure the benefits of BIM (whether formally or informally)?'*

The survey asked whether respondents measure the benefits of BIM (Figure 8-9). A total of 49% of respondents do not measure the benefits of BIM.

Those who measure the benefits of BIM were then asked if they use a tool to do so.

*'Do you use a tool to measure the benefits of BIM?'*

Only 16% both measure the benefits of BIM and use a tool to do so. A total of 35% measure the benefits of BIM, but not with a tool.

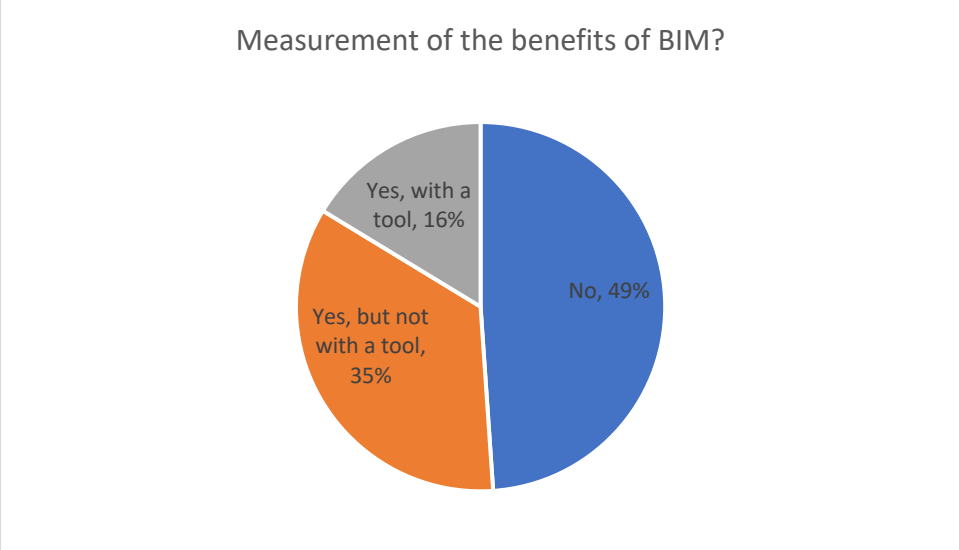



*Figure 8-9: How participants measure the benefits of using BIM*

No relationship between the size of an organisation and the likelihood of measuring the benefits of BIM was detected. For example, 53% of companies with more than 5,000 employees measure the benefits of BIM, but so do 86% of organisations with 51 to 100 employees, and 41% of organisations with 1 to 2 employees.

Similarly, there was no significant difference between the percentage of design organisations and other organisations in measuring the benefits of BIM, as shown in Figure 8-10.

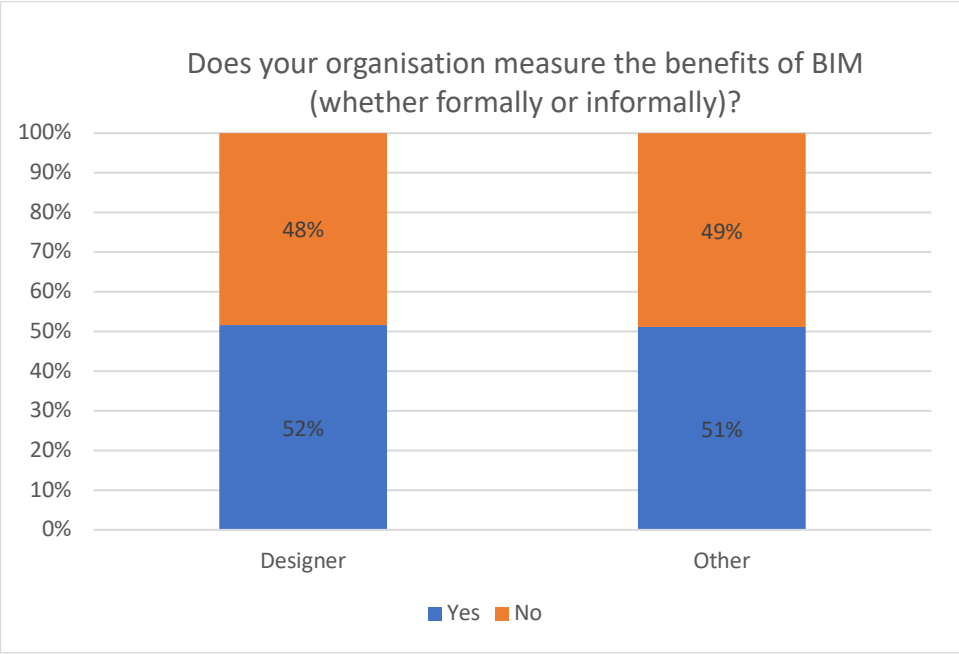



*Figure 8-10: Benefit measurement and organisation type*

> *'Does your organisation measure the BIM maturity of either your organisation or the projects your organisation works on?'*

Respondents were also asked about measuring BIM maturity. They are less likely to measure BIM maturity than the benefits of BIM. However, they are more likely to use a tool to measure BIM maturity (Figure 8-11).

Overall, 54% of respondents do not measure BIM maturity, either in their organisation or on the projects their organisation works on.

> *'Do you use a tool to measure the BIM maturity of either your organisation or the projects your organisation works on?'*

A total of 28% both measure BIM maturity and use a tool to do so. In total, 18% measure maturity, but not with a tool.

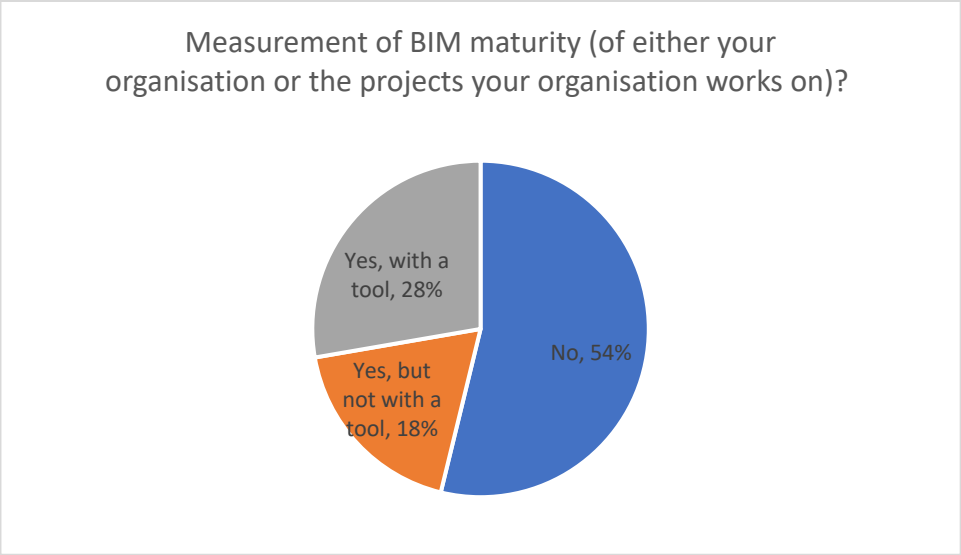



*Figure 8-11: How participants measure BIM maturity within their organisations*

As with the measurement of the benefits of BIM, no relationship between the size of an organisation and the likelihood of measuring BIM maturity was detected. For example, 51% of companies with more than 5,000 employees measure the benefits of BIM, but so do 67% of organisations with 26 to 50 employees, and 50% of organisations with 3 to 5 employees.

There was no significant difference between the percentage of design organisations and other organisations in measuring BIM maturity, as shown in Figure 8-12.

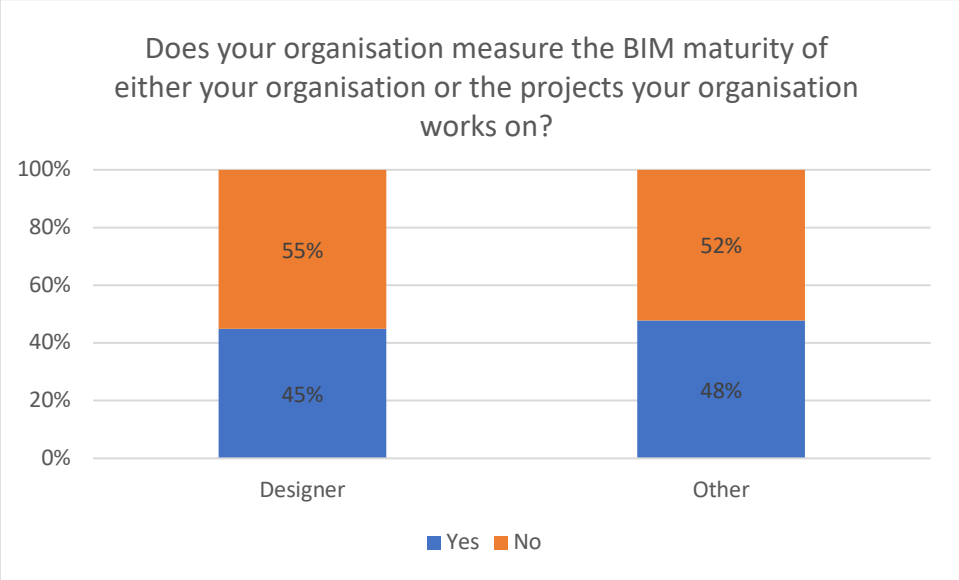



*Figure 8-12: Maturity measurement and organisation type*

By putting this data on the measurement of both BIM maturity and BIM benefits together, the percentage of those evaluating both BIM maturity and the benefits of BIM can be calculated. The chart below (Figure 8-13) shows that 35% of respondents measure both BIM maturity and the benefits of BIM. A total of 11% measure BIM maturity but not the benefits of BIM. In total, 16% assess the benefits of BIM, but not BIM maturity. Overall, 38% evaluate neither BIM maturity nor the benefits of BIM.

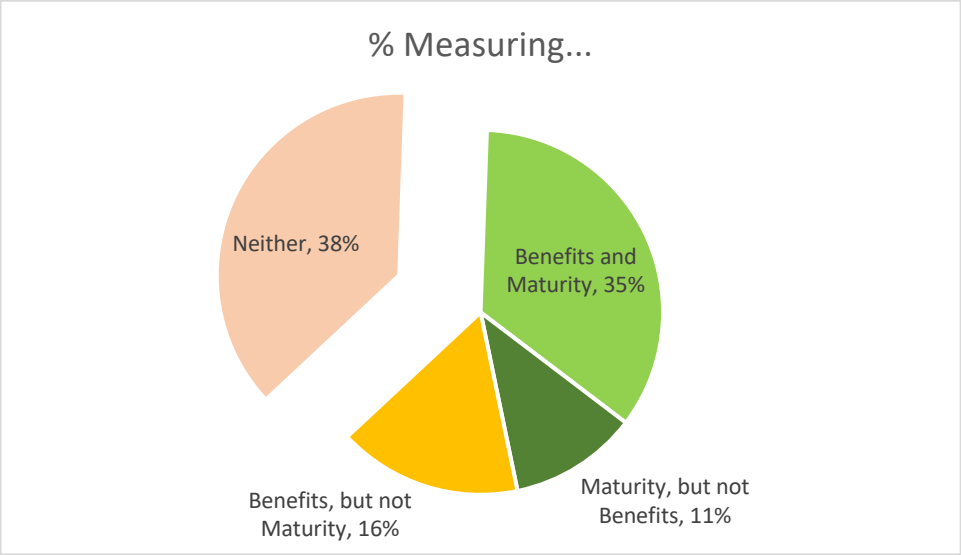



*Figure 8-13: Participants measuring both BIM benefits and BIM maturity within their organisations*

Figure 8-14 provides a further level of detail. It shows the use of tools, and whether or not a tool-based measurement is being carried out for both BIM maturity and BIM benefits. Only 12% measure both BIM benefits and BIM maturity, by using a tool for each. A total of 10% measure BIM benefits and BIM maturity, but they do not use a tool to measure either.

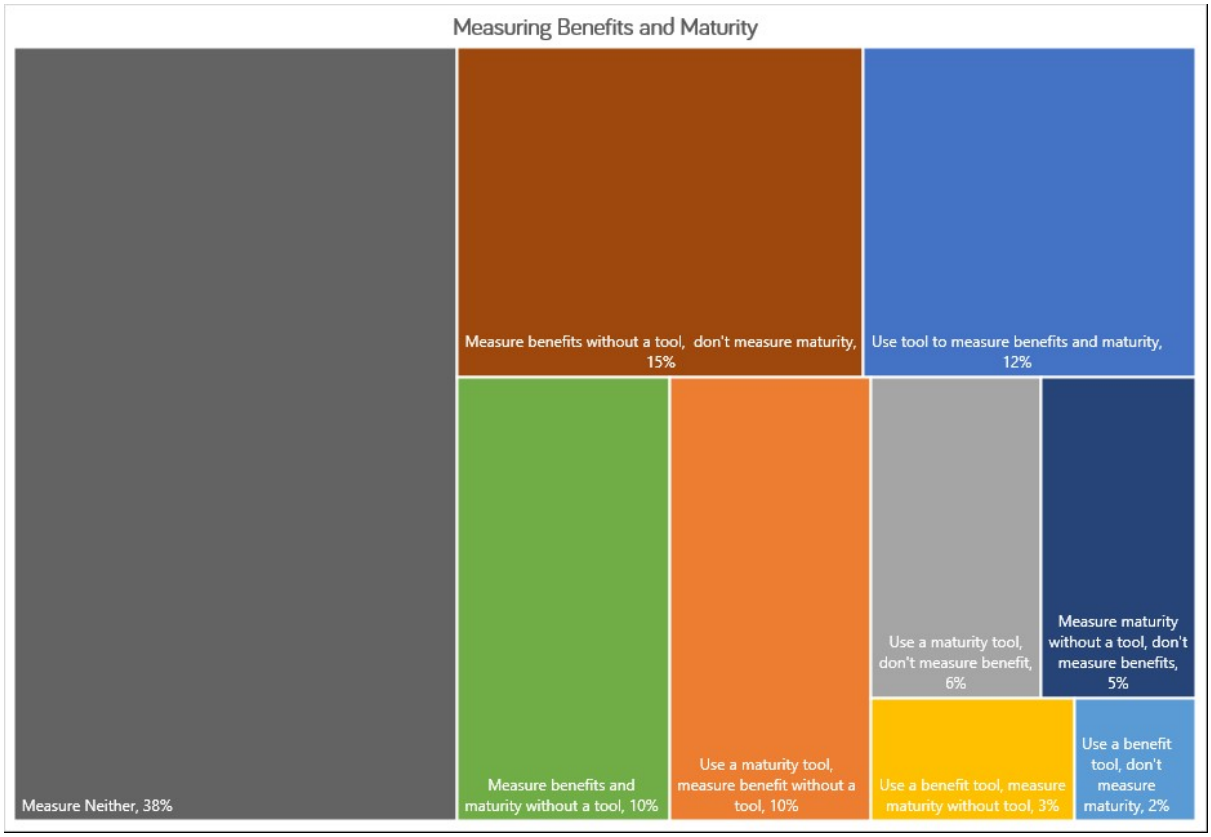



*Figure 8-14: Proportion of survey participants measuring BIM benefits and BIM maturity with tools*

Where respondents are measuring the benefits of BIM, they are generally more likely to agree that BIM delivers the potential benefits described in the next sub-section.

### 8.3.1 Measurement and realisation of BIM benefits

Where respondents are measuring the benefits of BIM (indicated by 'yes' in Figure 8-15), they are generally more likely to agree that BIM delivers the potential benefits described in Figure 8-8.

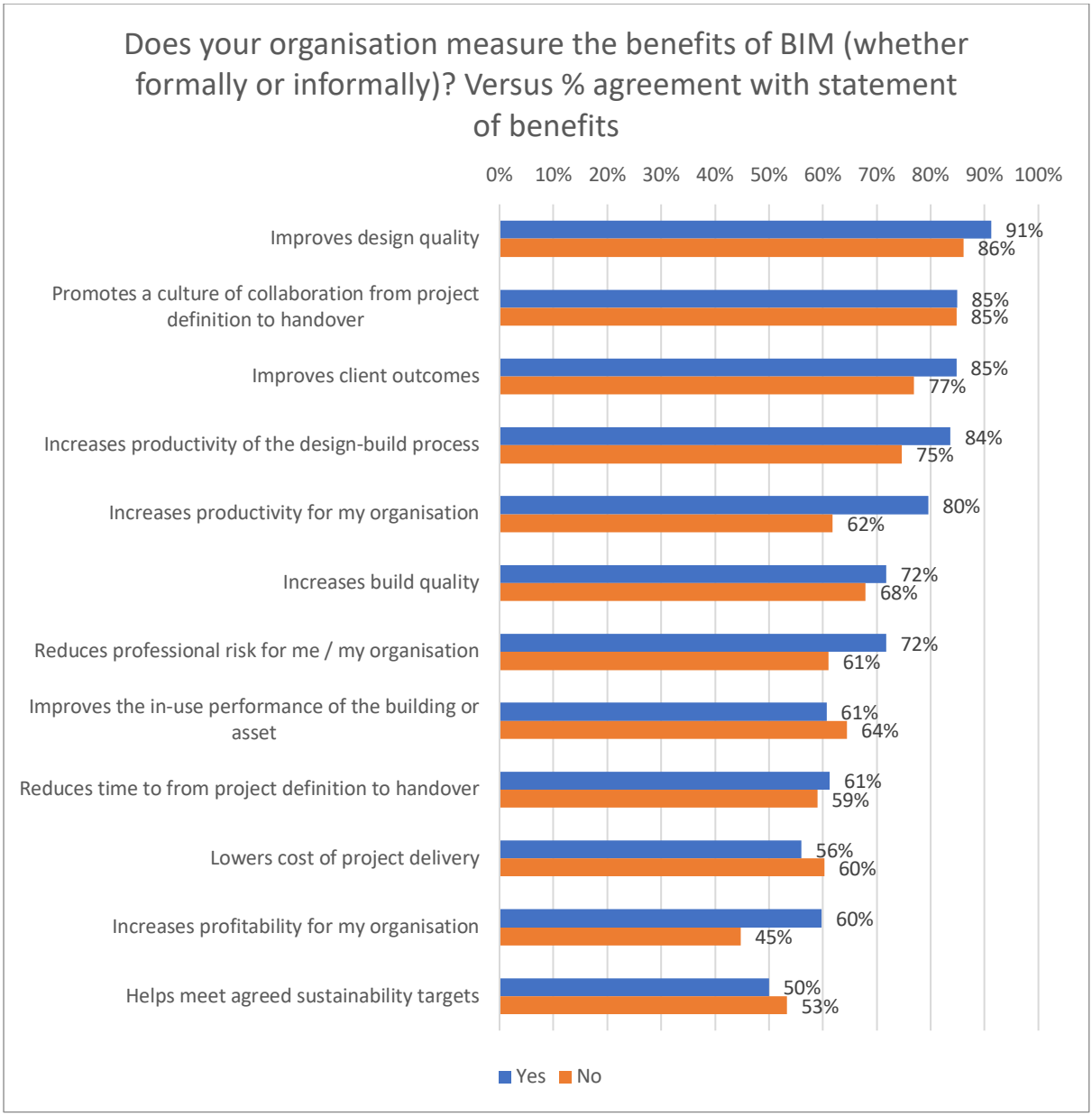



*Figure 8-15: Benefit measurement and perception of benefit*

Similarly, where respondents are measuring BIM maturity (indicated by 'yes' in Figure 8-16), they are more likely to agree that BIM delivers the potential benefits, as shown Figure 8-16. The three BIM benefits, where the agreement gap between those who assess maturity and those who do not is the greatest, are: 'increase productivity for my organisation'; 'reduce professional risk for me/my organisation'; and 'increase [the] profitability of my organisation'.

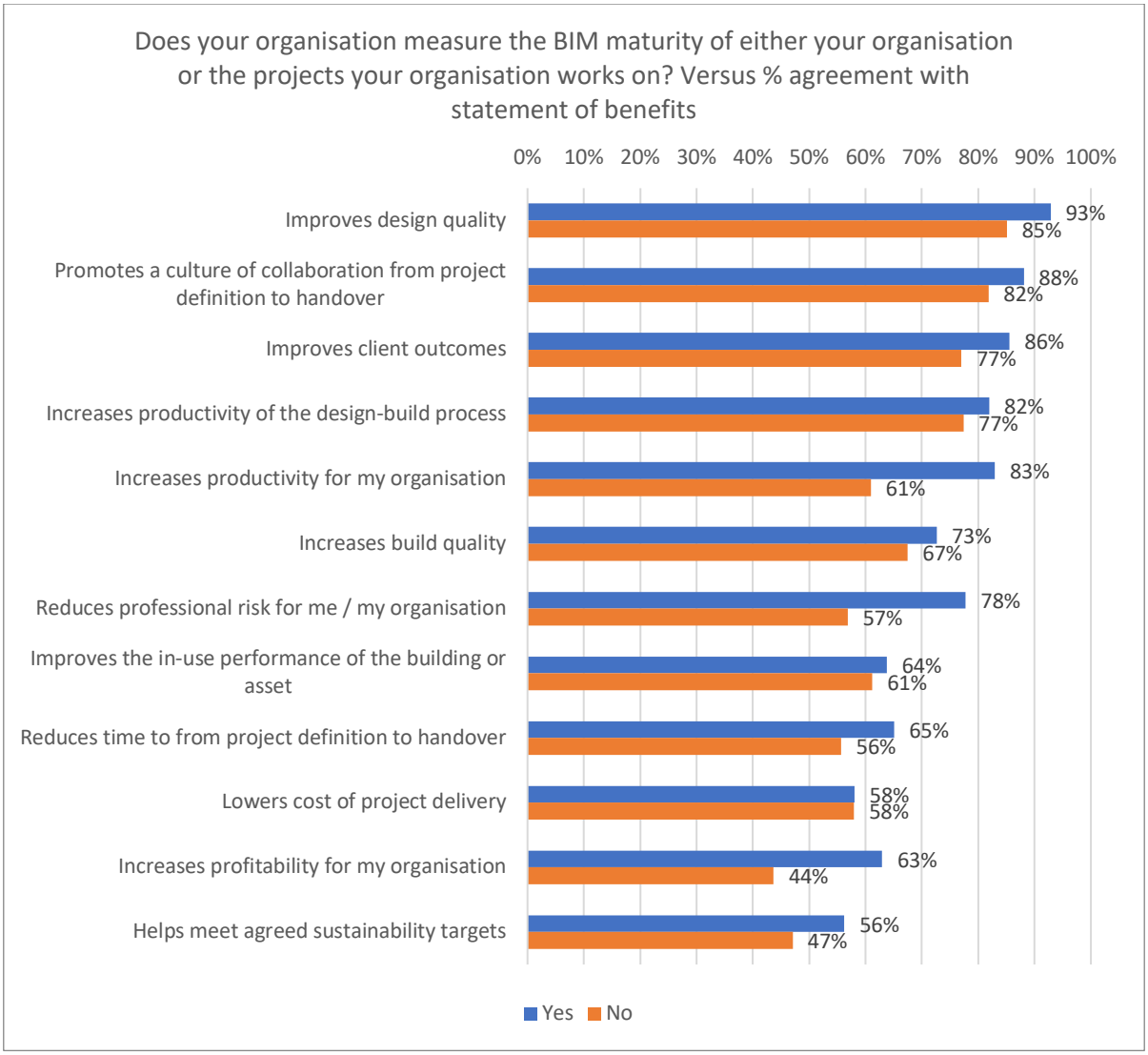



*Figure 8-16: Maturity measurement and perception of benefit*

## 8.4 Measuring BIM maturity

***Frequency of measuring BIM maturity***

Of the 46% of participants measuring BIM maturity within their organisations or the projects they work on, the survey went on to explore the frequency of those measurements (Figure 8-17).

For BIM maturity, 19% of respondents did not measure the BIM maturity of their organisation in the preceding 12 months. However, over 80% did. A total of 20% measured the maturity of the organisation only once, but 13% measured it more than 25 times. In total, 55% of respondents measured organisational BIM maturity between one and three times in the preceding year, and more than a quarter of respondents measured it more than six times.

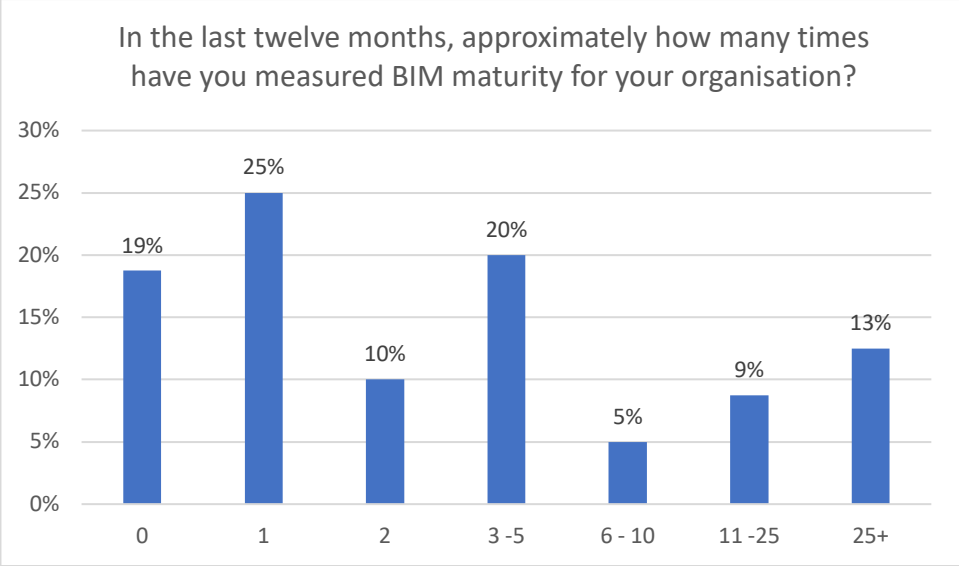



*Figure 8-17: Participants' frequency of measuring BIM maturity within their organisations*

Respondents tend to measure BIM maturity for projects more frequently than BIM maturity for their organisation. The number of design and construction projects exceeds the number of design and construction companies. Companies are likely to work on many projects throughout a year in which BIM is used, and they therefore need to measure BIM maturity multiple times.

Only 8% measured BIM maturity for no projects in the preceding 12 months, 53% measured BIM maturity on projects between one and five times, while 40% measured the BIM maturity of projects more than six times. The data is shown in Figure 8-18 below.

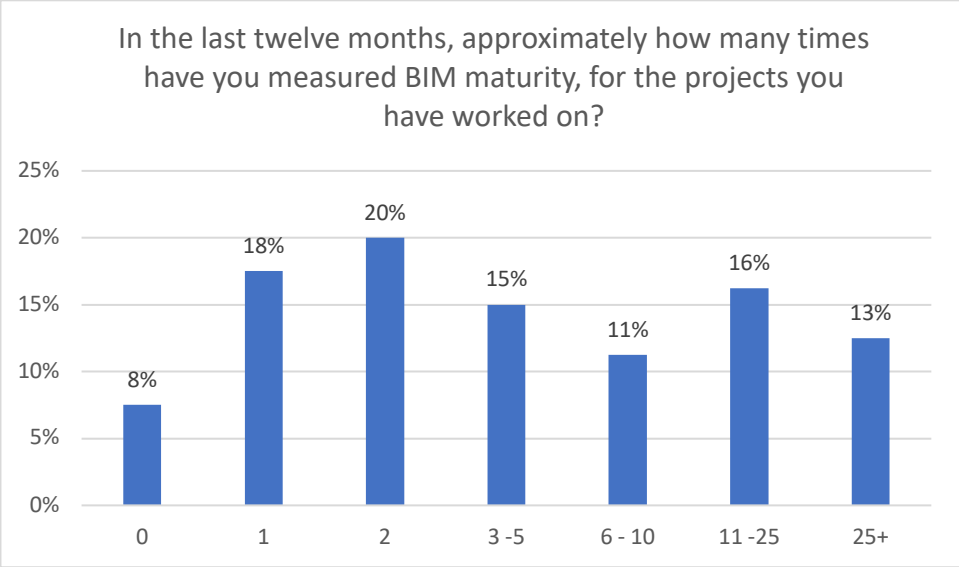



*Figure 8-18: Frequency of measuring BIM maturity for projects worked on in the preceding 12 months*

***Benefits of measuring BIM maturity***

A defined list of potential benefits of measuring BIM maturity was presented to those who measure it (whether for their organisation or their projects). The results suggest that measuring BIM maturity is beneficial.

The percentage that said measuring BIM maturity delivers a given benefit either 'completely' or 'to a great extent' are as follows, for the top three:

- 79% said that it 'identifies the BIM implementation challenges faced by our organisations'.
- 76% said that it 'helps us to develop improvement strategies'.
- 76% said that it 'helps us to see the effort and investment required to develop both staff and our systems or processes'.

The lowest ranking benefit (56%) of BIM maturity measurement was whether it 'improves predictability and forecasting'. The full data is shown in Figure 8-19.

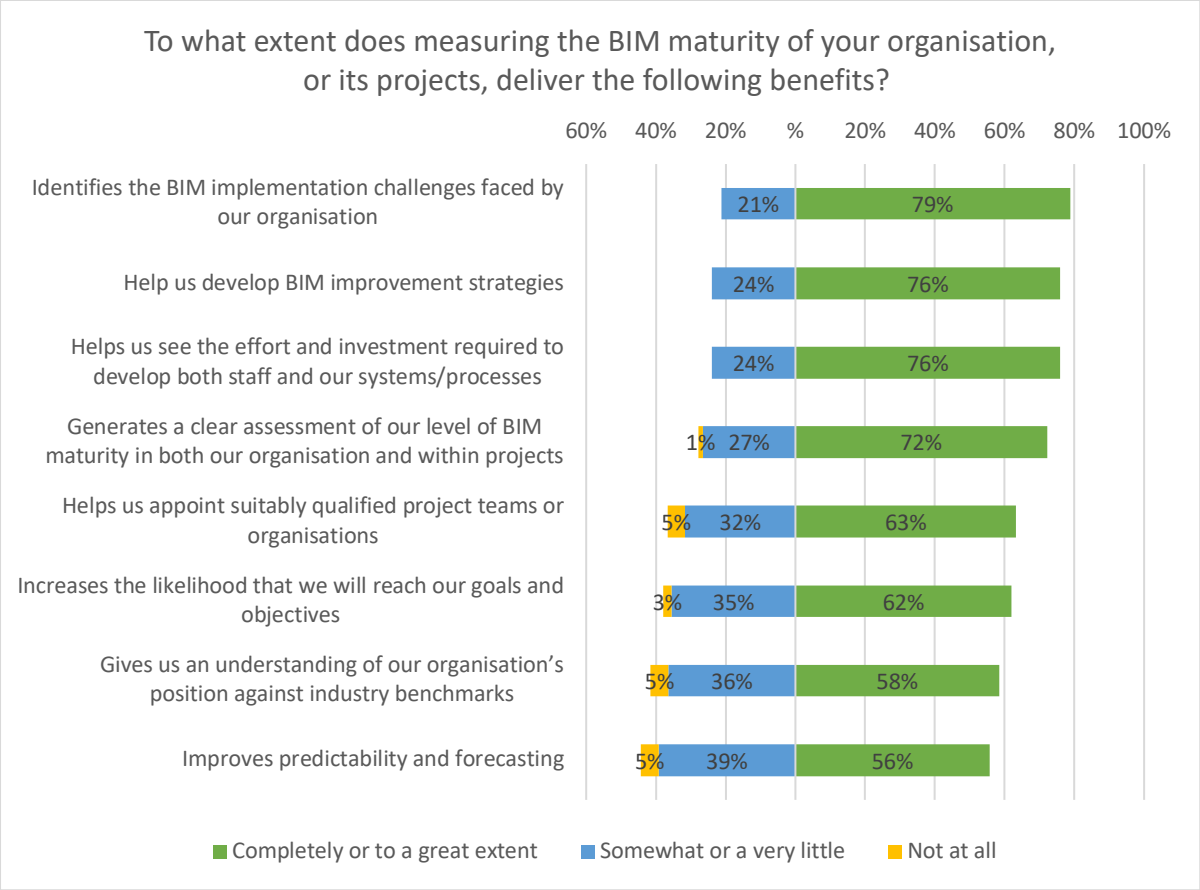



*Figure 8-19: The extent to which BIM delivers the proposed benefits*

***Tools used to measure BIM maturity***

A total of 28% of respondents use a tool to measure BIM maturity (Figure 8-20). The survey went on to ask these respondents which tool(s) they use. A wide variety of tools are in use. There is no small group of established tool providers (as encountered in geometrical modelling or specification writing, for example).

In total, 31% are using the *CPIx BIM Assessment Form*, 27% are using the *BIM Maturity Measure Model*, 12% are using *SFT's BIM Compass*, and 10% are using the *BIM Excellence Online Platform*.

Most notably, however, 45% described themselves as using something 'other'. The free text shows that these 'other' tools are almost entirely tools built in-house, sometimes complemented by non-industry specific software, such as Microsoft Power BI.

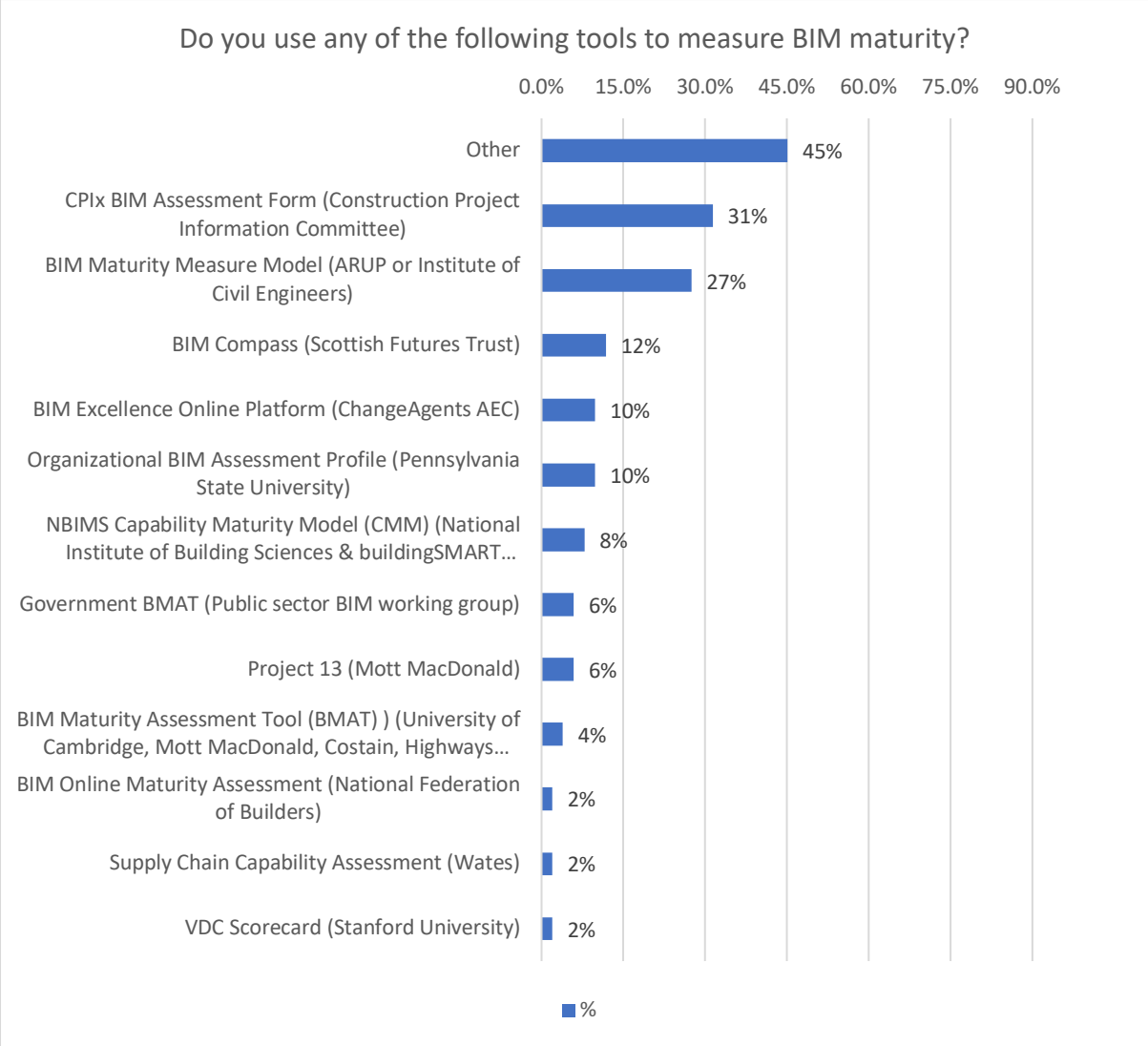



*Figure 8-20: Proportion of tools used by participants*

Where an organisation uses a tool to measure its BIM maturity, it is more likely to have carried out that measurement of organisational maturity in the last 12 months. A total of 81% of those who use a tool to measure BIM maturity have done so in the last 12 months, with more than half having measured maturity three times or more.

### 8.4.1 Project types to which maturity is being applied

In the survey, respondents were asked whether they were measuring BIM maturity and the benefits of BIM. Respondents were also asked what type of work they were engaged in to explore if there is any relationship between the project type and the occurrence of measurements.

***BIM maturity and project types***

A total of 45% of those engaged in projects for buildings other than infrastructure measure BIM maturity. In total, 53% of those engaged in infrastructure projects measure BIM maturity (Figure 8-21).

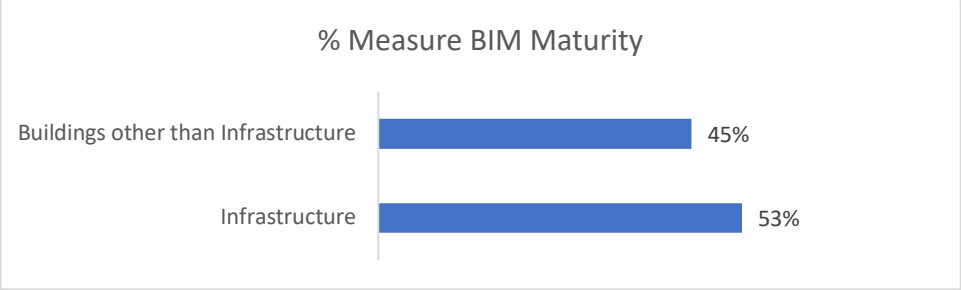



*Figure 8-21: Distribution of project types measuring BIM maturity*

Within the infrastructure sector, those engaged in gas or air projects are most likely to measure BIM maturity (85%), for harbours it is 73%, and for electricity it is 65%. A total of 59% of those engaged in rail projects measure BIM maturity, and it is the same proportion for road projects. 'Water and sewerage' has the lowest proportion, at 47% (Figure 8-22).

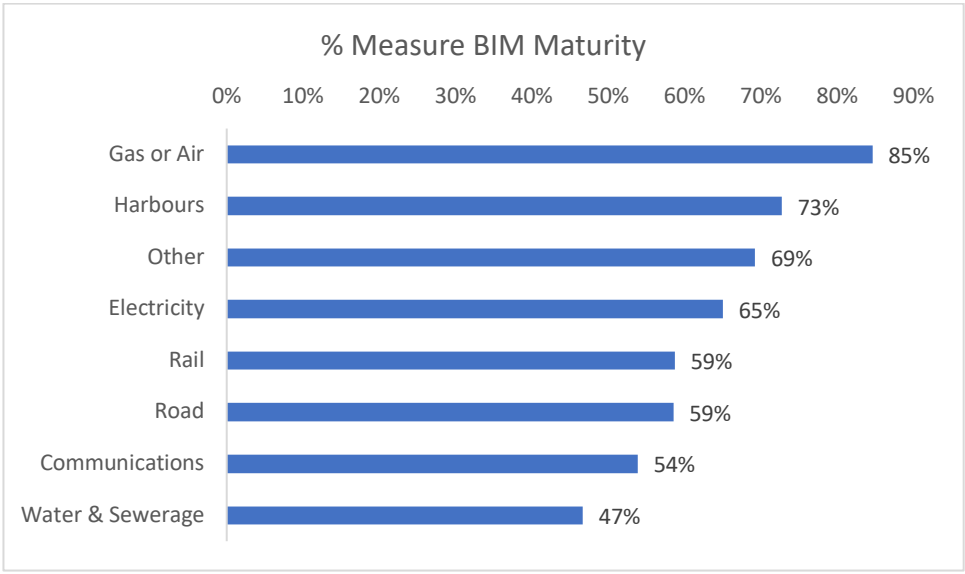



*Figure 8-22: Distribution of project types measuring BIM maturity within infrastructure*

For non-infrastructure work (Figure 8-23), organisations engaged in health projects have the highest percentage of those measuring BIM maturity (63%). At the other end, organisations engaged in small-scale work (e.g. 'one-off new house extension conversion or alteration') have the lowest percentage of those engaged in measuring BIM maturity, at 24%.

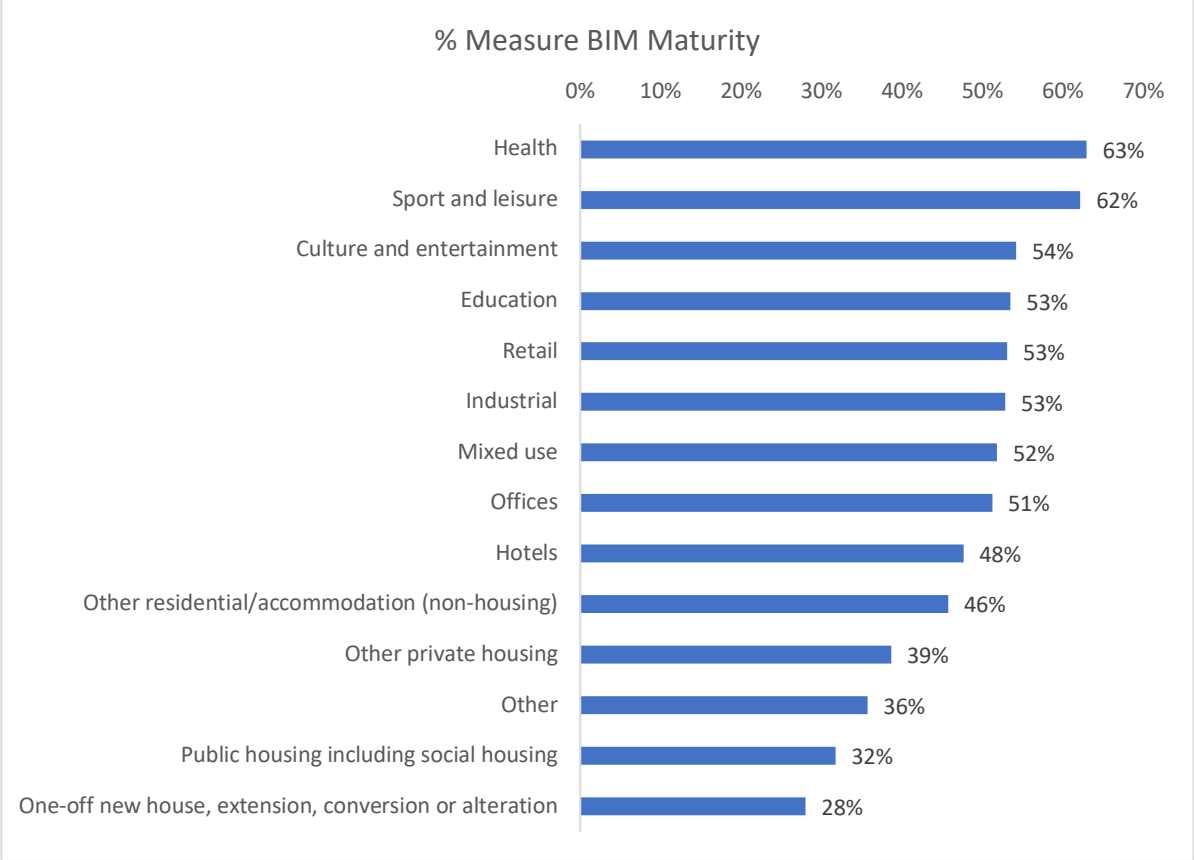



*Figure 8-23: Distribution of project types measuring BIM maturity outside infrastructure*

## 8.5 How organisations apply lessons learnt

- The survey identified several benefits of measuring BIM maturity. These include: 'identifies the BIM implementation challenges faced by our organisations'; 'helps us to develop improvement strategies'; 'helps us to see the effort and investment required to develop both staff and our systems or processes; and others that are listed in Figure 8-19. These are the same benefits that are appreciated more by those who measure BIM maturity compared to those who do not, which suggests there is a potential relationship between maturity assessment and benefits appreciation. [S]

- Workshop participants suggested that a consistent approach to assessing BIM maturity is helping them to achieve business-wide alignment, especially with the development of standardised processes to deliver BIM projects. Some workshop participants also recognised that contextualising BIM within the broader digital transformation and measuring BIM maturity helps to align developments with wider digital strategy. Some participants also suggested that this alignment could be expanded beyond the digital strategy to the wider business strategy. According to workshop participants, this alignment is helping them to achieve greater consistency in the technical capabilities among organisations' units and between project teams, such as the use of standardised information structures that translate from capital delivery into operational management. [W]

- There is an overall improvement in the digital maturity of the construction supply chain, and this is reflected in improved relationships between project parties. One workshop participant

shared that, 'in 2018 the rate of adjudications had dropped significantly, which could indicate that the de-risking associated with BIM had started to work'. [W]

## 8.6 Evaluation of how maturity tools can assist clients in appointing suitably qualified teams and/or organisations

- A total of 63% of the survey's respondents stated that BIM maturity assessment is helping them to appoint suitably qualified project teams and organisations. [S]
- It was suggested that if the PAS and the ISO series of documents, alongside other standards and specifications that have been developed to support the adoption of BIM, are used to develop a maturity assessment approach, and the assessment covers both the capital and operational stages of the built asset, these could be used to assess the maturity of projects and project teams. However, this is affected by the challenges discussed in Section 6.3. [W]
- Workshop participants suggested that BIM maturity assessment, when extended beyond internal organisations to include external suppliers, can help the overall digital maturity of the supply chain. Examples of clients encouraging Tier 1 contractors to assess their subcontractors' BIM maturity to identify gaps in their BIM performance and deliverables were offered by some participants. [W]
- Benchmarking of the BIM performance of suppliers was recognised as a way of building up competition between suppliers and was also found to improve interaction with clients. Easy-to-understand graphics and visualisations of the benchmarking scores were deemed to be important in enhancing engagement with stakeholders and motivating improvement. [W]

## 8.7 Evaluating BIM benefits

Evaluating BIM benefits is seen as important by respondents. Very few feel that measuring the benefits of BIM is either a waste of time or too difficult (Figure 8-24).

In total, 92% agree that measuring the benefits of BIM encourages an increasingly collaborative way of working. It is also of financial value; 83% agree that it is 'necessary to justify our further investment in BIM', 80% that it 'demonstrates the value of BIM in our bids', and 71% that it 'helps us demonstrate ROI'.

There is work to be done, however; 77% agree that measuring the benefits of BIM 'needs the support of better measurement tools'. It is not just the support of better tools that is needed though. While 55% agree that measuring the benefits of BIM 'is well supported by professional bodies', and 53% that it is 'well supported by the government', for both the statements one in five respondents disagree, and around a quarter are neutral.

Only 48% agree that measurement of the benefits of BIM is well supported by the industry.

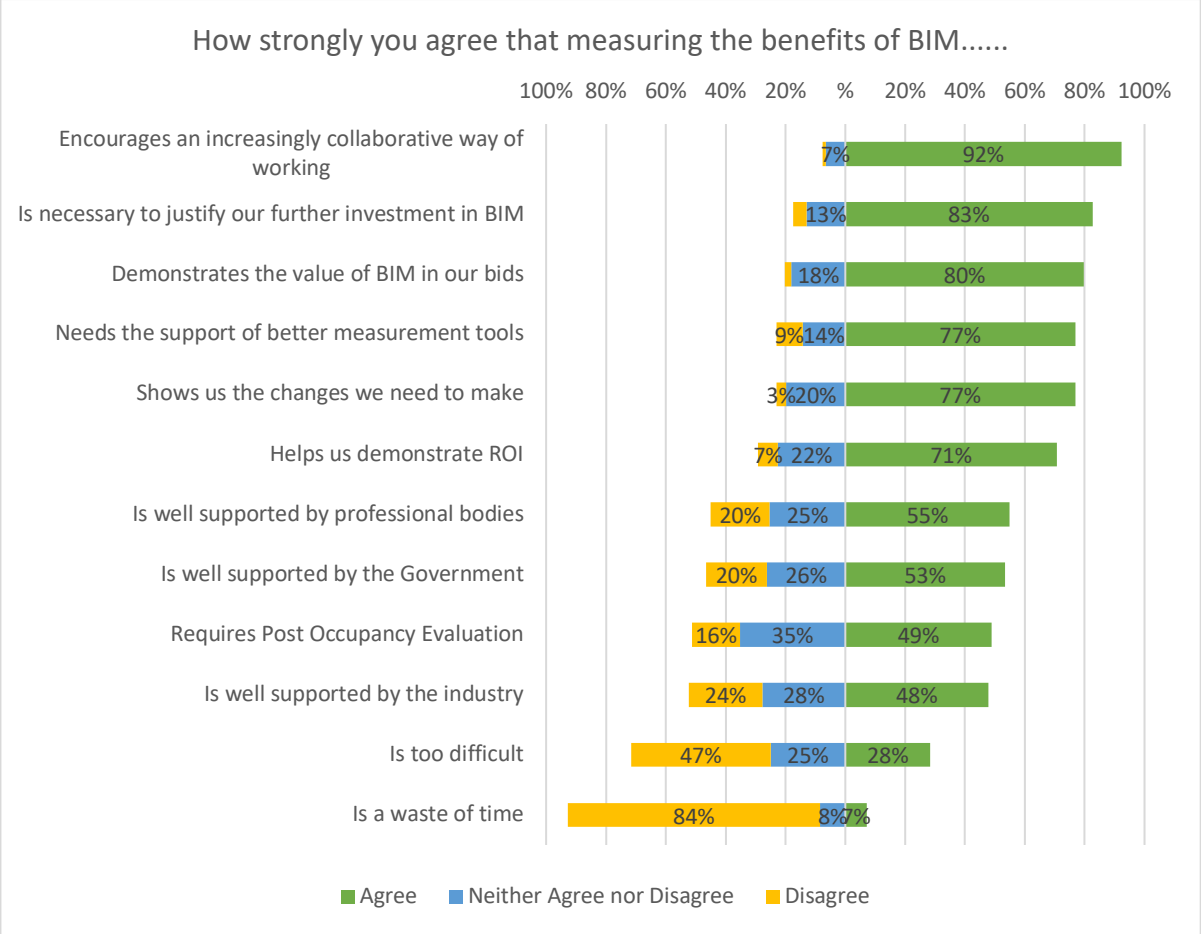



*Figure 8-24: Participants' views on the benefits of measuring BIM benefits*

***Realising the benefits of BIM***

Respondents were asked whether a series of statements were important or unimportant to the realisation of the benefits of BIM. Given the definition of BIM provided in the introduction, the realisation of benefits described below may be taken to be the realisation of the benefits arising from the adoption of a standard-based approach to information management, such as that of the UK BIM Framework.

The top factor in unlocking the BIM benefits is the ability to work in collaboration with others (97% 'important' or 'very important'), followed by integrated analysis (95%) and then documentation (95%). The importance of data to a model is underlined, with 91% agreeing that 'being able to access and manipulate data held in geometrical models' is either 'important' or 'very important'. For all statements, over 70% agreed that they were important to realising the benefits of BIM. Given the importance of these factors to benefits realisation, these factors should form topics and items for maturity assessment. The cross-analysis of BIM maturity tools for both organisations and projects, presented in Section 6.2, confirms that most of these factors are assessed in existing tools (scope, purpose and quality of assessment apart).

Figure 8-25 (below) shows the results of this question.

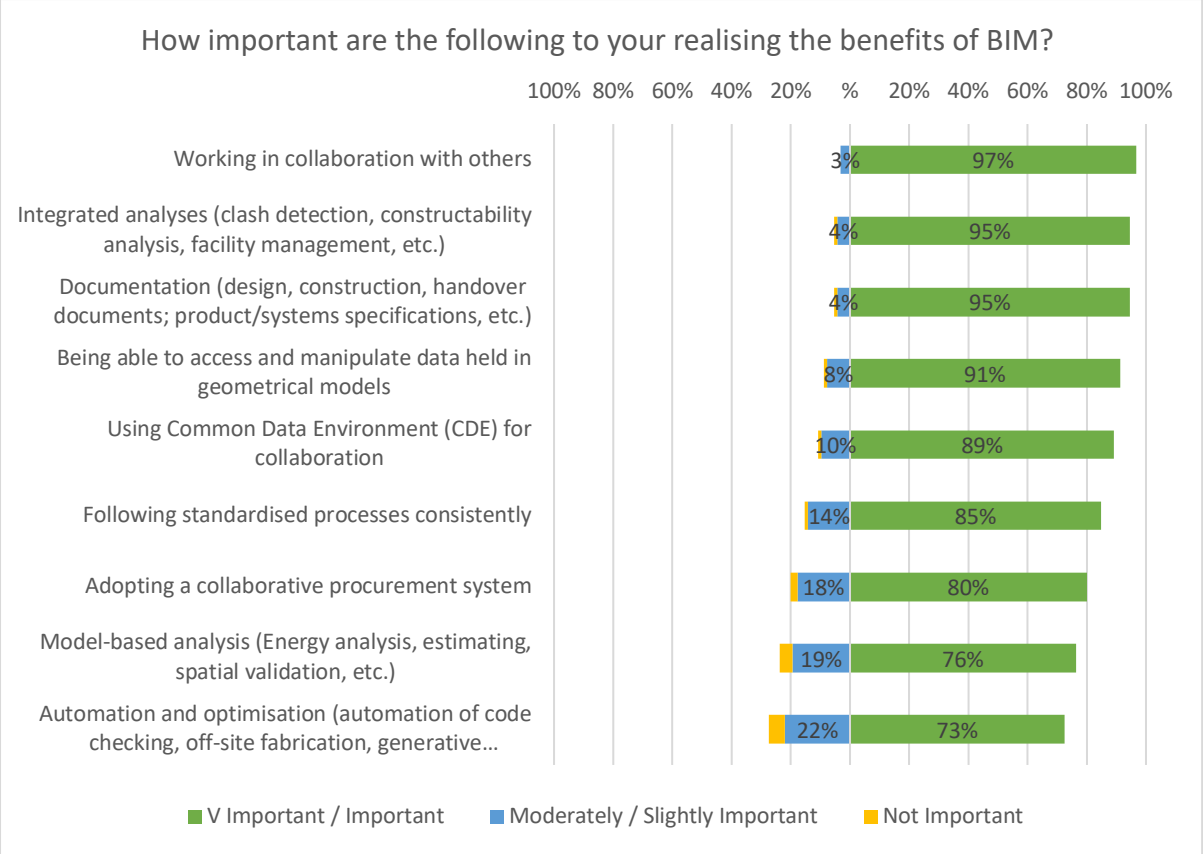



*Figure 8-25: Aspects that participants feel are important in realising the benefits of BIM*

***Tools used to measure the benefits of BIM***

Of the 16% of respondents who measure the benefits of BIM, and use a tool to do so, data was provided about which tool they use. The option 'other' referring to in-house developed tools or processes featured strongly. Of the tools reviewed, the *BIM Return in Investment Tool* provided by the Scottish Futures Trust is the most used (by 27%, or eight respondents), followed by *BIM Level 2 Benefits Measurement* from PwC. The only other two tools to feature were the *BIM Benefits* tool (University of Cambridge) and the *BIM Value* tool (NATSPEC) (Figure 8-26).

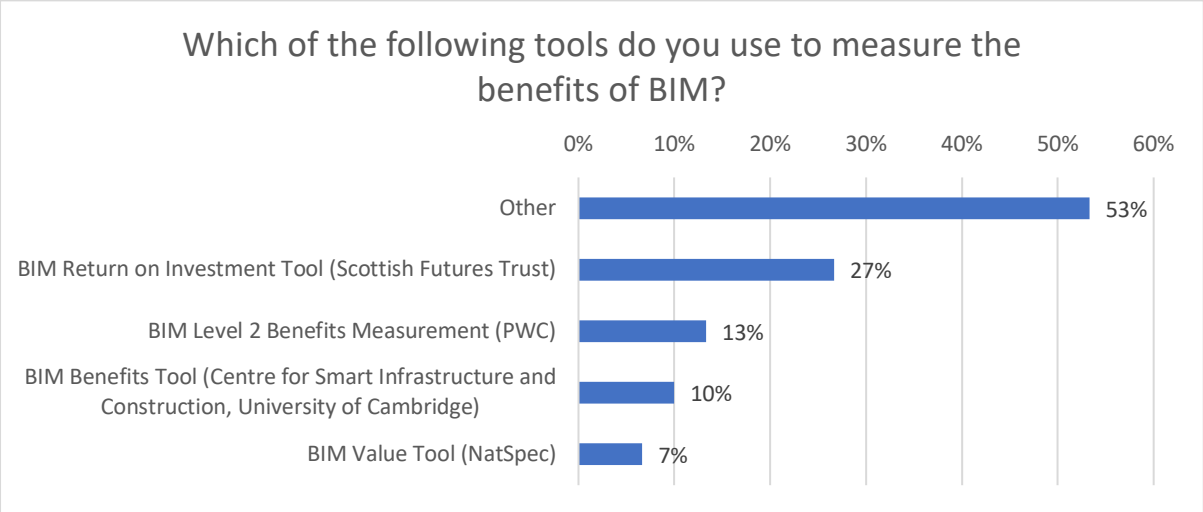



*Figure 8-26: Distribution of tools used to measure the benefits of BIM*

***BIM benefits and project types***

A total of 53% of those engaged in projects for buildings other than infrastructure measure the benefits of BIM. In total, 50% of those engaged in infrastructure projects measure the benefits of BIM (Figure 8-27).

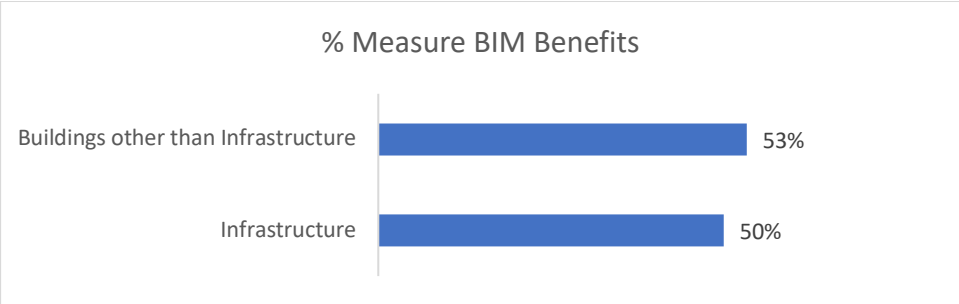



*Figure 8-27: Distribution of project types measuring BIM benefits*

Within the infrastructure sector, those engaged in gas or air projects were most likely to measure the benefits of BIM (85%), for communications it is 77%, and for electricity 55%. A total of 52% of those engaged in rail projects measure the benefits of BIM, and 51% of those engaged in road projects. 'Water and sewerage' has the lowest proportion, at 50% (Figure 8-28).

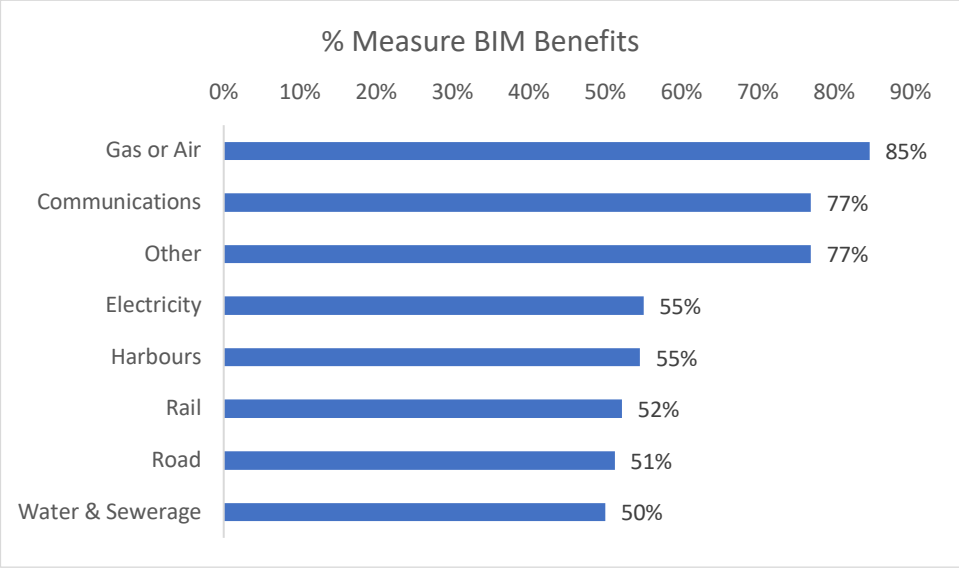



*Figure 8-28: Distribution of project types measuring BIM benefits within infrastructure*

For non-infrastructure work, organisations engaged in sport and leisure projects have the highest percentage of those measuring the benefits of BIM (63%). At the other end of the scale, again, those organisations engaged in small-scale work (e.g. 'one-off new house extension conversion or alteration') are least likely to measure the benefits of BIM, at 44% (Figure 8-29).

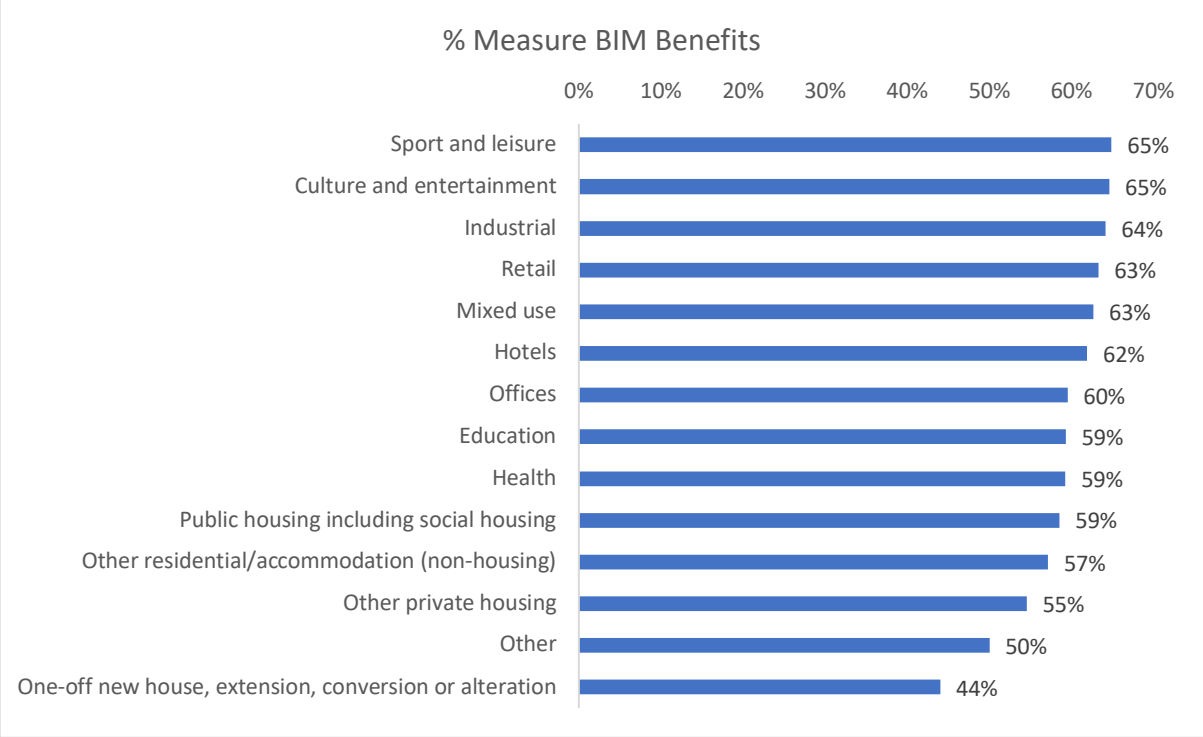



*Figure 8-29: Distribution of project types measuring BIM benefits for 'social infrastructure'*

# 9 Industry requirements and extent of support by existing tools

While it is challenging to capture an exhaustive list of requirements that is representative of all organisations and projects within construction and the built environment, an extensive list of key industry requirements and expectations was developed from the workshops and interviews. The extent of coverage of these requirements by existing BIM maturity tools and BIM benefits evaluation tools are discussed in the next two sub-sections, respectively.

## 9.1 BIM maturity assessment tools

- Industry practitioners argue that current approaches to BIM maturity assessment adopted in most of the existing tools and practices are not effective and do not produce an accurate representation of an organisation or individual's BIM maturity. They require BIM maturity assessment to focus more on people (one participant stated, 'We have a CDE but people keep using emails!') and on behaviours that promote collaboration (a relationship maturity assessment methodology developed by Heathrow Airport was mentioned as an example).
    - *Most of the tools were found to: focus on readiness and capability for either benchmarking or compliance purposes; offer a low granularity assessment, and have issues in the formulation of assessment items (from both content and syntax perspectives), which make the responses subjective and the assessment outputs either inaccurate or irrelevant.*
- Industry practitioners view the current assessment of BIM capabilities made at the '*invitation to tender'* and *'tender response'* stages to be rudimentary and to have little, if any, influence, on the project team that is actually appointed and mobilised. They require BIM maturity assessment practices to address the issue where organisations deploy their 'best-fit' individuals to perform the BIM assessment at the pre-appointment but then do not mobilise

the same individuals on the project (they called it 'Team A and Team B mentality'). Industry experts would like to see more weight given to BIM capability and maturity at the pre-appointment, but this must be accompanied by competency assurance at the appointment and mobilisation stages.

  - *The findings from the tools evaluation partially confirm this drawback, as the solicitation of evidence about the assessed BIM capability and maturity was lacking in most tools.*

- Industry requires greater clarity regarding what to assess for the different types of organisation within the construction supply chain (clients, contractors, suppliers and operators/FM) and the project's enterprise, and the metrics to be used. They acknowledge the challenges involved in developing a harmonised and consistent assessment that is relevant to all organisation types and project parties. However, they believe that such an approach remains beneficial, as it would enable benchmarking. This dilemma of a generic and wide-encompassing approach/tool versus a bespoke tool is perceived differently for projects and organisations, as explained in the next two bullet points.

- For organisational maturity, industry requirements are for a flexible approach that would allow adaptation to organisation objectives and wider business strategies.

  - *The findings from the tools' evaluation confirm that most of the tools offer rigid and fixed assessment that do not allow adaptation to different organisation objectives. One tool (i.e. BIMe OP) has a flexible approach but it is implemented as a consultation service instead of an off-the-shelf tool.*

- For project maturity assessment, a consistent and unified approach to BIM maturity assessment was perceived by industry to be less problematic to achieve than for organisations. However, industry requirements include adaptability to different project parties and project stakeholders, and continual updates in line with the advancement of technology and industry standards.

  - *Three of the tools analysed (i.e. BIM Maturity Assessment Tool BMAT, Dstl BIM Maturity Assessment Tool, BIM Working Group BMAT) offer such an approach to a certain extent. Two of these tools (Dstl BIM Maturity Assessment Tool, BIM Working Group BMAT) measure BIM capability (yes/no with compliance-focused propositions/statements/checklists) for the purpose of tracking compliance over the project life cycle and for compliance benchmarking purposes. One tool (BIM Maturity Assessment Tool – BMAT) assesses the maturity of projects at each stage of the project life cycle for different project parties. Its assessment is mostly focused on compliance topics/items (PQQ, EIR, BEP, etc.) but it also includes non-compliance topics/items (joint communication strategy, collaboration). It is intended to track the evolution of BIM compliance/maturity throughout the project life cycle. The accuracy of its assessment is challenged by the subjectivity of the rating options provided and the interdependence between stages and its effect on compliance (for full evaluation of this tool, refer to Appendix D.2). Finally, the industry seems to be unaware of such tools, or is unwilling to adopt them, as the survey showed that uptake is only 10% (5) among the 28% (50) of respondents who confirmed they assess BIM maturity.*

- Industry experts require BIM maturity assessment to shift from the current approaches, where maturity scores are not usually compared against aspirational BIM performance

targets, and they require the assessment to provide feedback for improving BIM performance towards those aspirational targets.

  - *The analysis of existing tools confirms that this requirement is not fulfilled by the existing tools. In most tools, measurements are either detecting capabilities (e.g. mere existing of certain abilities) or expressed as a compliance score (%). Most BIM assessment tools and practices – with the exception of those used as a consultation service such as BIMe OP – lack the ability to provide users with feedback and actionable advice that enable them to reach their performance target in a progressive manner.*

- Industry requires the BIM maturity assessment to be performed at the right time in projects to tacked current practices where project teams are often assessed late or at the handover of their deliverables. Industry requires the assessment to be more proactive and to play a role in continual improvement; however, challenges related to effort and cost of repetitive assessments were also raised.

  - Some of the available tools (e.g. *BIM Maturity Assessment Tool BMAT, Dstl BIM Maturity Assessment Tool, BIM Working Group BMAT*) partially fulfil this requirement by assessing the compliance and maturity of project teams across the project life cycle.

Recommendations will be proposed in Section 11 to address these requirements and gaps.

## 9.2 BIM benefits measurement tools

- Industry practitioners argue that BIM benefits evaluation should link the benefits to specific BIM activities and processes, as well as BIM outputs performed by people.

  - *Most of the BIM benefits tools and methods link end-benefits (e.g. cost reduction) to intermediate benefits (e.g. improved design coordination) that are achieved as a result of a BIM enabler (BIM activity).*

- Industry practitioners argue that benefits evaluation should be assessed holistically rather than looking at BIM in isolation. In organisations and supply chains, it was suggested that benefits evaluation should be extended to evaluate broader benefits related to embedding a digital culture, and increased supply chain digital maturity.

  - *BIM benefits tools and methods do not address these requirements directly. This scope is more likely to be addressed in benefits management strategies instead of BIM benefits evaluation tools.*

- Industry practitioners would like BIM benefits evaluation to assess the alignment between specification and deliverables across the project life cycle, from design through to construction and operation.

  - *Most tools and methods do not provide direct evaluation of such an alignment directly but some (BIM Benefits by the University of Cambridge) evaluate a wide range of intermediate and end-benefits whose realisation is an indication of potential alignment between specification and deliverables.*

- Industry practitioners argued that benefits evaluation should address the different value propositions of organisations. Some organisations may only be interested in the return on

CAPEX investments, as their business model is not involved in OPEX-related activities, while for others OPEX-related benefits may be far more critical. BIM benefits evaluation requires such a holistic approach.

    - *Existing tools (e.g. BIM Return on Investment Tool by the Scottish Futures Trust) that attempted to address both CAPEX and OPEX provide a very simplistic evaluation of the OPEX benefits that is generally trivial.*

- Industry participants from asset-owning organisations noted the need for longitudinal measurements. Their main driver for efficiency gains are the savings and improvement in the operation and service-delivery phase. They require benefits evaluation tools and approaches that address benefits at the operation and maintenance and service-delivery stages. However, they also noted that measurement should be widened to the benefits of broader digitalisation instead of just BIM. As one workshop participant noted, 'Benefits at the operation phase come more from advanced building management systems and not from BIM'.

    - *This requirement and its corresponding gap in the existing tools are the same as those cited in the previous point*.

- Industry practitioners claimed that if BIM benefits evaluation is progressive and continual, it will improve the assurance of benefits realisation and increase the likelihood of benefits happening at the handover stage. Such an approach to BIM benefits evaluation was also suggested as a way for automating benefits evaluation to reduce measurement costs in the future.

    - *Some of the tools reviewed, such as BIM Benefits by the University of Cambridge, use consistent metrics at set project stages that can be continually evaluated. However, such tools are challenged with the identification of the point in time at which the actual realisation of benefits occurs and rely on subjective opinions/forecasts of the benefits by users.*

- Industry participants were supportive of benefits benchmarking. However, they agreed that there are some important challenges to overcome: BIM benefits differ among organisations and individual organisations are creating their own evaluation tools set against internal organisational requirements.

    - *The survey confirmed this finding, where 53% of those evaluating benefits were found to be using their own tools. These bespoke tools were only relevant and suitable to that organisation, which reduced the opportunity for comparison with external organisations. Existing BIM benefits evaluation tools have the same shortcoming in relation to establishing benchmarking, as they refer to projects and situations not using BIM to estimate benefits. Existing tools are also unlikely to develop adequate benchmarking data, as they produce only 'forecast' benefits based on 'subjective' views that are not tracked in the future.*

- Industry participants noted that there is still a greater focus on return on investment (ROI) from investing in BIM. In such cases, some participants suggested that using situations and projects where BIM is not adopted as baselines was deemed to be acceptable and helpful for encouraging adoption – despite the above reservations about the accuracy in the quantification of expected benefits.

- *One tool (BIM Return in Investment Tool by the Scottish Futures Trust) serves this purpose. However, the accuracy of measurement offered by the tool is questionable.*

- The industry participants argue that there is a need to incentivise the delivery of certain benefits. One participant with an opposing view noted that, 'Realising benefits by doing things better is an ethical and moral duty. If we do not, we will never be able to share data that we can use to build a better power station in 50 or 100 years'. This concern was raised because of the varying benefits standpoints that usually exist in projects.
    - *None of the benefits evaluation tools capture individual benefits standpoints. Tools assume that individuals will implement the activities and the BIM enablers that are necessary to realise benefits. The researchers note that this challenge is more likely to be addressed in a benefits management strategy where there is usually a benefits management plan, explicitly identifying benefits owners with responsibility for their realisation. This approach was witnessed in the BIM Benefit Management Strategy of TfL.*
- Industry participants raised concerns that BIM benefits tools look downward (compare against a 'low' threshold – traditional processes not using BIM) instead of upward and thus cannot capture the opportunity gap that may exist between an optimal state (optimised processes) and the measured situation.
    - *None of the existing tools can address this challenge. This shortcoming is partly caused by the lack of established benchmarking data and reliable counterfactual situation, as explained earlier.*
- Industry participants noted that there is a potential relationship between benefits realisation and the digital maturity of the supply chain. Benefits evaluation should consider such influences.
    - *While none of the individual benefits tools can fulfil this requirement, two tools (BIM Maturity Assessment Tool, BIM Benefits), if used consistently across projects – difficulty and accuracy of measurements apart – can 'theoretically' capture this potential relationship over time.*
- Industry participants require tools to be flexible and adaptable to varying levels of complexity that can be found in projects.
    - *All BIM benefits tools are rigid and not easily adaptable.*
- Industry participants raised the importance of a good understanding of benefits by clients, as they consider it a determinant of benefits realisation.
    - *The BIM Benefits tool by the University of Cambridge captures activities reflecting clients' requirements, such as development of EIR, AIR and OIR.*
- Industry participants warned that focusing on BIM benefits measurement in isolation may create the misperception that it is a 'bolt-on' to project delivery, thus hindering benefits realisation instead of enabling it. They argued that benefits evaluation should involve whether the client received the outcomes they invested in instead of solely focusing on digital outputs.
    - *The BIM Benefits tool (by the University of Cambridge) assesses several end-benefits (cost savings, time savings, improved asset quality) that are important to the client.*

*However, these are 'forecast benefits', and the tool is not explicit about who owns the benefits.*

- Industry participants expressed concerns over the availability of individuals with the skill set to measure BIM benefits. They questioned how the assessor can identify what 'good looks like'.

- Industry participants require clarity about what metrics to measure and when to measure them in order to understand the actual benefits of BIM on a project. For the measurement to be noteworthy, they identified the following factors for consideration in the evaluation exercise:

    - The convoluted nature of BIM benefits evaluation: Benefits are the result of a number of interacting factors, and it is challenging to distil the effect of certain BIM enablers from those of other activities (one participant gave the example of 'reduced health and safety risks'). The researchers note that some of the existing tools (*BIM Benefits* by the University of Cambridge) and methods (*BIM Level 2 Benefits Measurement Methodology* by PricewaterhouseCoopers) partially address this challenge by adopting the benefit pathways concept (activity → BIM enabler → intermediate benefit → end-benefit). These tools acknowledge the challenges of linking BIM benefits to specific BIM enablers and their quantification.

    - The long life span of projects and the time lag between performing an activity (enabled by BIM) and the materialisation of the corresponding benefit: In some cases certain project activities may take years after the BIM activity has been performed. The researchers note that this challenge is generally not clearly addressed by any BIM evaluation tool. One method, the *BIM Level 2 Benefits Measurement Methodology* by PricewaterhouseCoopers, partially addresses this challenge by separating the timing of when a benefit is enabled and when it will be realised.

    - Frequent changes encountered in most projects complicate the update and tracking of both enablers and benefits. The researchers note that none of the tools is capable of capturing and considering the changes in benefits evaluation.

    - Measures of success continually change over lengthy project life spans as the enabling technologies and process and the industry mature.

    - Limited availability of data, and reliability of existing data: Participants noted that this as a challenge that is making the evaluation of benefits a resource-intensive process and is limiting the opportunity for both benchmarking and automation of measurements.

  Together these factors are limiting the ability to understand what benefits are being measured, what baselines they are assessed against, and how/if the measures are updated. These factors recognise that the evaluation of BIM benefits is a dynamic process and metrics should remain 'coupled' with the project and its wider context to ensure that measurement remains useful and relevant. The researchers note that none of the existing tools and methods address these challenges. These challenges are more likely to be addressed in a holistic benefits management strategy instead of standalone BIM benefits tools.

## 10 Possible correlations between maturity levels and beneficial outcomes

To discuss a potential correlation between BIM maturity and benefits realisation, it is important to first assume a clear position about the terminology used, especially the 'benefit' terminology.

The interpretation of the term '*benefit*' is still subject to significant debate despite the everyday use of the term. Generally, there are two main stances: one stance associates the term with either the outcomes (during or just after the project as a result of delivering the project's outputs and the use of the outputs by the intended end-users) or impact (long-term consequences for the system or society using the project's outputs). Another stance distinguishes between 'intermediate benefits' and 'end-benefits'. An intermediate benefit is generally the direct consequence of an activity (e.g. an information management activity) that is enabled by BIM, and the end-benefit is the ultimate result linked to the intermediate benefit. One or more intermediate benefit(s) can lead into the same end-benefit, and one intermediate benefit can contribute to more than one end-benefit. An example is the following: 'improve construction quality control' (*activity*) > 'implement mobile BIM on-site and associated information management activities for site inspection' (*BIM enabler*) > 'easier-to-spot clashes between contractors/subcontractors works' (*intermediate benefit*) > 'time savings in build and commission' (*end-benefit 1*) and 'material saving in build and commission' (e*nd-benefit 2*), etc. The latter stance is the one that is adopted in most BIM benefits evaluation tools and methods, including the PricewaterhouseCoopers' *BIM Level 2 Benefits Measurement Methodology*.

Provided that the metrics and scoring model used to assess BIM maturity are reliable, higher 'maturity' scores are an indication of more advanced BIM capabilities. As these BIM capabilities have direct links with many intermediate benefits, it is reasonable to assume that a relationship between maturity levels (enabled through the corresponding BIM capabilities/competencies) and intermediate benefits realisation exists. Within this relationship, maturity assures benefits to clients but does not create them.

Interestingly, the survey found a relationship whereby those measuring the maturity of BIM are more likely to appreciate a wider range of BIM benefits compared to those who do not measure BIM maturity. Although this is not direct evidence of the correlation issue posed in this section, it does express another interpretation (that of benefits appreciation) of this potential correlation between BIM maturity and BIM benefits realisation.

During the workshops, participants were encouraged to share their views about the potential synergies between BIM maturity and benefits. This resulted in a fervent debate and opposing views. These were partially driven by the different interpretations of the 'benefit' term. Those who interpreted the benefit term as the project's outcome or impact argued that such a relationship is neither clear nor existent. Some argued that project teams with a low BIM maturity score can still realise benefits, and vice versa. However, they are neglecting in their interpretation of 'maturity' a key concept, which is consistency and degree of repeatability in achieving an outcome/benefit. They also argued that the collection of outputs (referring to end-benefits) does not always lead to better outcomes (referring to long-term impact). They also questioned that even the realisation of the end-benefits depends on a wider set of enablers beyond those directly linked with BIM capabilities/enablers. Incentivisation was one example given by workshop participants who posed the question about how to incentivise the delivery of certain project benefits given the multi-standpoint nature of benefits. Others had a totally opposing stance and argued that maturity assessment is more important than benefits evaluation and that this is what the industry should be focusing upon. According to these participants, if the project team has the right BIM capabilities and maturity, the benefits will be a 'by-product'.

## 11 Key findings and recommendations

Based on the requirements and gaps identified in Sections 9 and 0, this section presents the recommendations for the maturity assessment tools and BIM benefits evaluation tools. Wherever a recommendation is not based on the gaps identified in Sections 9 and 0, it is accompanied by a corresponding justification.

### 11.1 Recommendations for maturity assessment tools and approaches

For the maturity tools, there was clear evidence from all the work items conducted for this study that there is a need for BIM maturity assessment. However, the study exposed several gaps in the existing tools against the industry requirements and expectations. The recommendations and corresponding gap(s) they address are explained hereafter.

***Recommendation 1:*** *BIM maturity assessment should be encouraged to preserve and further progress the benefits experienced by those assessing BIM maturity*.

**Justification:** There was clear evidence from across all of this study's work items that there is a need for maturity assessment. Those who are assessing BIM maturity are experiencing important benefits, including: help identifying the BIM implementation challenges faced by their organisations; informing improvement strategies, including the effort and investment required to develop both staff and systems or processes; and helping to appoint more qualified project teams and organisations. They also have a better appreciation of benefits compared to those who do not measure BIM maturity. BIM maturity assessment is perceived as being more important than benefits evaluation, as industry experts argue that the latter will be a by-product if the supply chain has adequate BIM capabilities and maturity.

***Recommendation 2:*** *The gaps in BIM maturity assessment tools and practices for both organisations and projects need to be addressed in order to fulfil the industry requirements and expectations.*

**Justification:** The discussion in Section 9 exposed several gaps (e.g. rigid tools – one-size-fits-all; inaccurate and low granularity assessment; binary (yes/no) assessment focused on readiness and capabilities for compliance purposes; overlooking collaborative behaviour; inappropriate baselines and timing used in assessment) in the existing tools against industry requirements and expectations. The shortcomings of the existing tools are driving many organisations to develop their own internal BIM maturity assessment approaches. The survey showed that 45% of respondents who are assessing maturity have developed their own internal tools. This is likely to limit the widespread adoption of maturity assessment within the industry and limit its ability to develop benchmarks.

***Recommendation 3:*** *BIM competencies should play a greater role in 'invitation to tender', 'tender response', 'appointment' and 'mobilisation'. More attention should be paid to BIM competency assurance[24] during the transition across these stages. The competencies should be extended beyond readiness and capability to include maturity. This process can be assisted by adopting the ISO 19650-2:2018 approach, which has enabling requirements throughout: invitation to tender (i.e. 'Clause 5.2.3 establish tender response requirements and evaluation criteria'); tender response (i.e. 'Clause 5.3.3 assess task team capability and capacity', 'Clause 5.3.4 establish the delivery team's capability and capacity, and 'Clause 5.3.5 establish the delivery team's mobilisation plan'); appointment (i.e. 'Clause*

[24] In this context, 'assurance' refers to ensuring that the assessed BIM competencies at appointment are also available after the start of a project and that emerging competency requirements during the project are met.

*5.4.1 confirm the delivery team's BIM execution plan'); and mobilisation (i.e. 'Clause 5.5.1 mobilise resources').*

**Justification:** There is concern about the timing of BIM maturity assessment in projects, which, according to industry experts, is affecting the underpinning rationale behind the assessment. Project teams are often assessed late or at the handover of their deliverables. Industry requires the assessment to be more proactive and to play a role in continual improvement. There is also a trend whereby many organisations deploy their 'best-fit' individuals for the BIM assessment at tender stage, but these are not necessarily the same individuals who are then deployed on the project (Team A and Team B mentality). Solicitation of evidence when assessing BIM maturity is lacking across most of the existing tools. Industry experts would like to see more weight given to BIM capability and maturity at the tender stage, but this must be accompanied by competency assurance at both the appointment and mobilisation stages.

***Recommendation 4:*** *For organisation BIM maturity assessment, a multi-level framework should be developed to provide a common approach to BIM maturity assessment at industry level. The framework should identify a comprehensive range of BIM competencies required and propose metrics for their assessment. A common level of the framework should be relevant to all disciplines within the construction sector and should be adaptable to specific organisations. This should be complemented by additional levels that are specific to the different disciplines. The approach should not be focused on compliance assessment alone and should increase the focus on individuals/people and collaborative behaviour.*

**Justification:** There is a concern within the industry that the current approaches to BIM maturity assessment in most of the existing tools and practices are not effective and do not produce an accurate representation of an organisation or project team's BIM maturity. They are rigid, with binary (yes/no) inputs from users largely focusing on readiness and capability. Industry experts would like to see a greater focus on people and behaviours that promote collaboration in the assessment. A 'one-size-fits-all' for organisational assessment was conceived by industry experts to be too rigid. Such an approach would make it difficult to capture varying organisational objectives and consider wider digital transformation and business strategies of organisations, as these vary significantly across organisation types and sizes.

***Recommendation 5:*** *For project BIM maturity assessment, a BIM assessment method should be developed, based on the UK BIM Framework (including the ISO 19650 Series) and the additional topics and items identified during analysis of the existing tools in this report. The assessment method should ensure flexibility and adaptability to suit different actor and project types. The method and tool should remain current and relevant through periodic review and updating against the UK BIM Framework and technological advances. The tool should not be focused on compliance assessment alone but should also focus on people and collaborative behaviour. The tool needs to support proactive assessment (as opposed to reactive at the time when suppliers hand over the deliverables) and provide feedback for improvement.*

**Justification:** Industry experts argued for a consistent and unified approach to BIM maturity assessment within projects. However, industry requirements include flexibility and adaptability to different project parties and project stakeholders, and the method should be kept updated in line with advancement of industry standards and technology. The ISO 19650 Series and other related standards within the UK BIM Framework could be used as a guiding framework for the development of this

assessment method. Existing tools fulfil this approach to a limited extent but they are not without challenges, as explained in Section 9.1. The industry also seems to be unaware of such tools or unwilling to adopt them, as evidenced by the survey.

***Recommendation 6*** *Improve awareness and provide learning and professional development opportunities about the importance of BIM maturity assessment as an internal function for business and project improvement.*

***Justification:*** There is limited appreciation of the nuances around BIM maturity terminology. In many instances, several participants proposed rationales such as: 'Clients would not pay for a higher level of BIM maturity'; 'There are no incentives to reach levels of maturity that are not required within the market'; 'There are maturity blind spots within the supply chain, which disincentivises others from reaching higher levels of maturity'. Few in the industry perceived BIM maturity to be an internal performance improvement exercise.

## 11.2 Recommendations for benefits evaluation tools and practices

Several shortcomings affecting the evaluation approach (metrics, baselines, assumptions, type of benefits measured, granularity of evaluation) adopted in BIM benefits tools were identified. BIM benefits evaluation was a more contentious topic among industry participants than BIM maturity assessment. The need for formal evaluation of BIM benefits was questioned, and the viability of BIM benefits evaluation was subject to significant scrutiny by the participants of the workshops and interviews. These contentious views are partly driven by several challenges that a BIM benefits evaluation approach needs to address in order to be meaningful and relevant. However, the survey data suggests that there is important value to be derived from BIM benefits evaluation approaches and tools.

The recommendations made for BIM benefits evaluation acknowledge these varying views and consider the findings from across all of the study's work items.

***Recommendation 1:*** *BIM benefits evaluation should be extended to address broader benefits related to embedding a digital culture and increased supply chain digital maturity.*

**Justification:** Industry practitioners argued that benefits evaluation should be assessed holistically rather than looking at BIM in isolation. In organisations and supply chains, it was suggested that benefits evaluation should be extended to evaluate broader benefits related to embedding a digital culture, and increased supply chain digital maturity. This recognises that: 1) the benefits achievable are associated with the digital (not just BIM) maturity of supply chains; and 2) the benefits achievable are interlinked with the digital maturity of the whole supply chain, not just individual organisations.

***Recommendation 2:*** *BIM benefits evaluation should evaluate the degree of fulfilment of project requirements by corresponding deliverables across the project life cycle at set stages, from design through to construction and operation. BIM benefits evaluation for asset owners and operators should be widened beyond BIM to the benefits of broader digitalisation of asset operation, management and service delivery, and it requires longitudinal measurements.*

**Justification:** Industry experts suggested that benefits should be assessed against whether the client (or other project actors) received the 'outcomes' they invested in, instead of specific digital outputs (digital outputs are generally considered an enabler of intermediate benefits). As 'outcomes' are the

result of a combination of different factors that are not all attributable to BIM, this presents a challenge to measuring BIM benefits. Industry participants from asset-owning organisations noted that their main driver for efficiency gains are the savings and improvement in the operation and service-delivery phase, which are usually attributable to broader digitalisation, not just BIM (e.g. building management systems). These benefits require longitudinal measurement approaches for meaningful analysis and understanding.

***Recommendation 3:*** *BIM benefits metrics (e.g. key performance indicators) should be established at the outset of a project and then consistently and periodically measured against 'targets' to improve assurances of benefits realisation, including at handover stage and into operation and management of assets.*

**Justification:** If BIM benefits evaluation is progressive and continual, it will improve the assurance of benefits realisation and increase the likelihood of benefits occurring at the handover stage, according to industry experts. The availability of metrics, together with a clear plan determining when/how to measure, was also suggested as a way of automating benefits measurement and reducing measurement costs in future. Some of the tools reviewed, such as BIM Benefits by the University of Cambridge, use consistent metrics at set project stages that can be continually evaluated. However, this relies on users' subjective opinions/ratings to evaluate 'forecast benefits' linked to information management activities.

***Recommendation 4:*** *The benefits evaluation process and metrics involved should be approached as dynamic and change as projects progress. The metrics should remain 'coupled' to project requirements and context so that measurement remains useful and relevant. The benefits evaluation process and metrics need to address the challenges identified in this research, including: the convoluted and confounding nature of benefits realisation, lengthy project lifetime, time lag between performing an activity and manifestation of the corresponding benefit, frequent changes encountered in projects, evolution of success measures, evolution of benefit-enabling technology and processes, and limited availability of benchmarking data.*

**Justification:** This recommendation embeds many of the requirements and challenges captured during the workshops and interviews. Industry participants argue that, in order for the BIM measurements to be meaningful and noteworthy, they should address challenges such as: changing project requirements, which affect both the benefits metrics and the measured benefits; long project lifespans that increase the likelihood of changes in requirements; development of benefits-enabling technologies and process; the time lag between implementing a BIM enabler and the manifestation of its benefits in future; the contribution of several BIM and non-BIM enablers into the same benefit; and the lack of data for benchmarking benefits. These challenges are not currently addressed by the existing tools, which mainly estimate forecast benefits linked to BIM enablers/activities.

***Recommendation 5:*** *Introduce the 'benefit owner' concept[25] into the evaluation process and metrics to assign responsibility for benefits realisations to specific individuals and teams.*

**Justification:** As a result of the different benefit standpoints that usually exist among project participants, industry experts argued that there is a need to incentivise the delivery of certain benefits.

[25] A 'benefit owner' is an individual or a team who takes responsibility for a benefit, or set of benefits, associated with a project.

The evaluated BIM benefit tools assume that individuals will implement the activities and BIM enablers that are necessary to realise benefits. None of the tools evaluated capture benefits from multiple actors' standpoints. This challenge is more likely to be addressed in a benefits management strategy, where there is a benefits management plan with explicitly assigned owners with responsibility for benefits realisation, instead of in a standalone BIM benefits tool.

***Recommendation 6:*** *BIM benefits evaluation methods should compare against optimal targets as baselines rather than the current approaches that compare against counterfactual situations where BIM is not used.*

**Justification:** BIM benefits tools look 'downward' (e.g. compare with a 'low' threshold – traditional processes not using BIM) instead of 'upward' and thus cannot capture the opportunity gap that may exist between an optimal state (optimised processes) and the measured state. This shortcoming is partly caused by the lack of established benchmarking data and a reliable counterfactual situation.

***Recommendation 7:*** *The BIM benefits evaluation method should be adaptable and flexible to varying levels of complexity and requirements of projects.*

**Justification:** Industry participants argued that the current tools and approaches to BIM benefits evaluation are rigid, with a pre-defined list of benefits enablers and benefits metrics, which cannot be relevant to all projects with different requirements and varying levels of complexity.

***Recommendation 8:*** *The BIM benefits evaluation approach should be infused across the project stages (from 'assessment and need', through to 'invitation to tender' … and 'project closeout'), and should raise awareness of the importance of performing the activities/BIM enablers that unlock the benefits; and they should provide guidance to avoid the risk that the BIM benefit evaluation is perceived as a 'bolt-on' to project processes.*

**Justification:** Industry practitioners argued that BIM benefits evaluation should be able to assess whether deliverables fulfil the requirements across the whole project life cycle. The researchers found that most of the tools and methods analysed do not directly address this scope. One tool (*BIM Benefits* by the University of Cambridge) evaluates a wide range of intermediate and end-benefits whose realisation can be seen as an indication of potential alignment between specification and deliverables. Industry participants warned that focusing on BIM benefits measurement in isolation, or as a standalone process, may create the misperception that it is a 'bolt-on' to project processes, thus hindering benefits realisation instead of enabling it. This creates the need to both infuse and align the evaluation of benefits across the project stages.

***Recommendation 9:*** *Training and skills programmes should be developed to ensure that the industry has a suitably skilled workforce to engage in BIM benefits evaluation.*

**Justification:** Industry experts expressed concerns over access to, and the availability of, individuals with the skill set to manage the BIM benefits evaluation process. It is challenging for such individuals to know what 'good looks like' in the absence of reliable benchmarking data and relevant baseline/counterfactual situations.

# 12 Conclusions

This study evaluated the existing tools for BIM maturity assessment and BIM benefits evaluation. The aim was to understand their level of adoption in the construction and asset management industries, and their applicability; to identify strengths, weaknesses and challenges; and to provide recommendations for their future development.

The first step involved a desktop-based evaluation of tools and methods that are publicly available and tools that were made available to the researchers for the purposes of this study. This step utilised an information extraction card that helped to analyse the general characteristics of the tools identified, the topics and items assessed by each tool, and the quality of assessment measurement enabled by the tools. Completion of the information extraction card was undertaken by simulated use of the tools, analysis of supporting documents, and/or interview with the tools' developer/owners. The results from the application of the information extraction card on each tool were then used in the cross-analysis of all tools. For the project BIM maturity tools, an analysis against the ISO 19650-2:2018 was also performed by relating the topics and items assessed in each project BIM maturity tool to the corresponding ISO 19650-2:2018 Clause(s). The aim was to understand the relevance of the assessment offered by a BIM maturity tool to the corresponding ISO standard and the extent of its coverage of a standard-based approach to information management

This cross-analysis identified commonalities and differences between the tools. For the maturity assessment tools, it helped to: (1) identify a common list of BIM maturity assessment topics; and (2) develop an understanding of the actual scope of assessments (assessment of readiness, capability, and/or maturity) and intended use offered by the tool (benchmarking and/or compliance).

For the benefits evaluation tools, the cross-tool analysis provided a comparison of: (1) the benefits measurement addressed by each tool; and (2) the approach adopted to perform the measurement (benefit management strategy, type of benefits, pathways to benefits, baseline/counterfactual situation, monetisation).

The results from the desk research were supplemented by a survey of 184 respondents, interviews with 8 industry professionals, and 3 workshops with a total of 37 experts. The aim of the survey was to assess the uptake of BIM benefits evaluation tools and BIM maturity assessment tools within the construction industry and to understand the business implications of their use. Three industry workshops (one in Newcastle upon Tyne, and two in London) were held with organisations and experts from the UK construction sector to understand the current applications of these tools in organisations and projects and the implications of their use. The aim of the workshops was to understand the strengths, weaknesses and gaps of BIM maturity and BIM benefits tools and methods, as perceived by industry experts. The interviews addressed the same scope of the workshops with either respondents who were not able to attend the workshops or respondents identified at the workshops as implementers and users of BIM maturity tools and/or BIM benefits evaluation tools. Information from across the different work items was synthesised to develop gap analysis between industry requirements/expectations and the extent to which existing tools and methods address such requirements. From these findings, the researchers have drawn up a list of recommendations for BIM maturity and BIM benefits tools and methods.

The list of key findings from the workshops and interviews is extensive and is used across the different sections of the report, in particular, Sections 6.3 and Section 7.4. Section 9 also uses the findings from the interviews and the workshops to identify a list of key industry requirements for BIM maturity assessment and BIM benefits evaluation, and it explains the extent to which the existing tools fulfil

such requirements. This analysis identified a number of important gaps between the requirements of the industry and the capabilities of the existing tools. Recommendations to address these gaps are provided in Section 11.

For the maturity tools, there was clear evidence from across all work items conducted for this study (desk research, workshops, interviews, survey) that there is a need for BIM maturity assessment. Those who are assessing BIM maturity are experiencing important outcomes, including: help identifying the BIM implementation challenges faced by their organisations; informing improvement strategies, including the effort and investment required to develop both staff and systems or processes; and helping to appoint more qualified project teams and organisations. The study exposed several gaps in the existing tools against industry requirements and expectations. Recommendations are given to address these shortcomings.

BIM benefits evaluation was a more contentious topic among industry participants than BIM maturity assessment. The need for formal evaluation of BIM benefits was questioned, and the viability of the BIM benefits evaluation process was subject to significant scrutiny. This was partly reflected by the small percentage of survey respondents 16% (29) who perform BIM benefits evaluation, and the large number of respondents (77% – 141) who agree that 'there is a need for better measurement tools'. However, most respondents (92% – 168) appreciate the importance of measuring benefits and strongly agree that 'measuring BIM benefits encourages an increasingly collaborative way of working', among several other positive outcomes. This discrepancy in the views about BIM benefits evaluation may have been fuelled by the several technical and procedural challenges associated with BIM benefits evaluation. Hence, the recommendations made for BIM benefits evaluation acknowledge the contentious nature of the topic and provide recommendations that consider these varying views, as well as industry requirements.

## Appendices

Appendix A: Workshop Participants

Appendix B: Interviews

Appendix C: Individual Evaluations: Organisation BIM Maturity Tools

Appendix D: Individual Evaluations: Project BIM Maturity Tools

Appendix E: Individual Evaluations: BIM Maturity Methods

Appendix F: Individual Evaluations: BIM Benefits Tools

Appendix G: Individual Evaluations: BIM Benefits Methods

## Appendix A: Workshop participants

| | |
|---|---|
| Anonymous | |
| Anonymous | |
| Ammar Azzouz | ARUP |
| Colin Bell | Sir Robert McAlpine |
| Aurelie de Boissieu | Grimshaw Architects |
| Marzia Bolpagni | Mace |
| Mathew Brett | Transport for London |
| Peter Brogan | Institute of Workplace and Facilities Management (IWFM) |
| Cassie Burgess-Rose | Xsite Architecture |
| Ian Bush | Black and Veatch |
| Nicholas Deeming | Faulkner Browns |
| Paul Dodd | Scottish Futures Trust |
| Peter Dorrell | Skanska |
| Daniel Dyer | MawsonKerr |
| Javed Edahtally | Public Health England |
| Steven Ford | Ryder Architecture |
| Ciaran Garrick | Allies and Morrison |
| Christine Gausden | UK BIM Alliance / University of Salford |
| Tom Jarman | Waterstons |
| Sean Kearney | Mott MacDonald |
| Alistair Kell | BDP (Building Design Partnership Ltd) |
| Nick Leach | Sir Robert McAlpine |
| Thomas Lindner | NittyGritty |
| Vicky McCombe | Womble Bond Dickinson |
| Ashley Murray | Sir Robert McAlpine |
| Nick Nisbett | AEC3 |
| Alan Proctor | Environment Agency |
| Constance Ridout | ARUP |
| Richard Saxon | Deploi BIM Strategies Ltd / Joint Contracts Tribunal (JCT) |
| Dale Sinclair | AECOM |
| Taylan Tahir | Mata Architects |
| Peter Vale | Thames Tideway |
| James Wakefield | Environmental Essentials |
| Mark Warren | Bowmer + Kirkland |
| Stephen Weddle | TGA Consulting Engineers |
| Paul Wilkinson | PWcom |
| May Winfield | Buro Happold |

## Appendix B: Interviews

**Structure of the Interviews**

The general structure of the interviews were based on the information extraction cards for the tools. However, there were variations introduced to capture as much relevant information as possible to supplement the data gathered through desk-based research and workshops.

**Purpose of the interviews:**

If the interviewee had used a tool of their own – tool details were gathered using the extraction cards parameters like:

- Objectives behind using the tool/Intended Use
- Intended users/underpinning benefits management strategy/benefits management approach/baselines
- Benefits/KPIs measured
- Etc.

If they did not have a tool of their own or had use one then the objective was to establish:

- current maturity and benefits measurements approach within their organisation
- maturity assessment approach - Compliance (level 2), capability, capability maturity

Finally an assessment of their thoughts/ideas on *gaps* in the existing crop of tools were gathered.

Some specific quotes from individuals were also captured.

Some variations/additions from the information cards that were used in formulating the questions for the interviews. For example:

- The Information Cards collect information pertaining to Projects and Organisations. However, at least in some cases the organisations were interested in assessing their Supply-chain's maturity/capability and chart out a roadmap for the entire supply chain's upskilling.
- In case of large asset owners, the *complexity of their estate* also has a bearing on the kind of capability and benefits that may be relevant for them to measure.
- Depending on the type of organisation the interviewee may represent, the interview questions were to be slanted accordingly.
- The interviews were *open-ended* and semi-structured allowing for flexibility in the direction that needed to be traversed during the interviews.
- In O&M, how was the longitudinal aspect dealt with any evaluation of benefits (with or without BIM)?
- Establishment of relationship between maturity and benefits – a mature organisation has the potential to make smaller returns than a 'less mature' one.
- Establishment of relationship between Organisational/business model and required maturity and target benefits.
- Addressing the question whether there can be a single ideal tool that 'fits all'?

Overall objectives of the interviews were to establish:

- Purpose behind measurement of maturity/benefits
- Challenges in measurements
- Gaps in current/existing tools
- Vision for an ideal tool

Table B-1: A bird's eye view of the interviews' key responses in relation to maturity tools

| ID | Role/Expertise | Sector | Direct experience of using maturity tools | Awareness of other maturity tools | Internal (I) or external (E) | Project level | Organisation level | Public access |
|---|---|---|---|---|---|---|---|---|
| P1 | Senior Management | Client/ Client Rep | N | Y | Tool Developer | Y | N | Y |
| P2 | Senior Management | Construction/ Contractor | Y | Y | I | Y | Y | N |
| P3 | Owner/Senior Manager | Service Provider | N | Y | N/A | Y | Y | N/A |
| P4 | Mid-level Manager /information Manager | Design Consultant | N | Y | E | Y | Y | Y |
| P5 | Mid-management | Service Provider | N | Y | N/A | Y | Y | N/A |
| P6 | Owner/Director | Architect | N | Y | N/A | N/A | N/A | N/A |
| P7 | Mid-management | Construction/ Contractor | Y | Y | I | Y | Y | N |
| P8 | Senior Management | Client | N | Y | E | Y | N | Y |

Table B-2: A bird's eye view of the interviews' key responses in relation to benefits tools

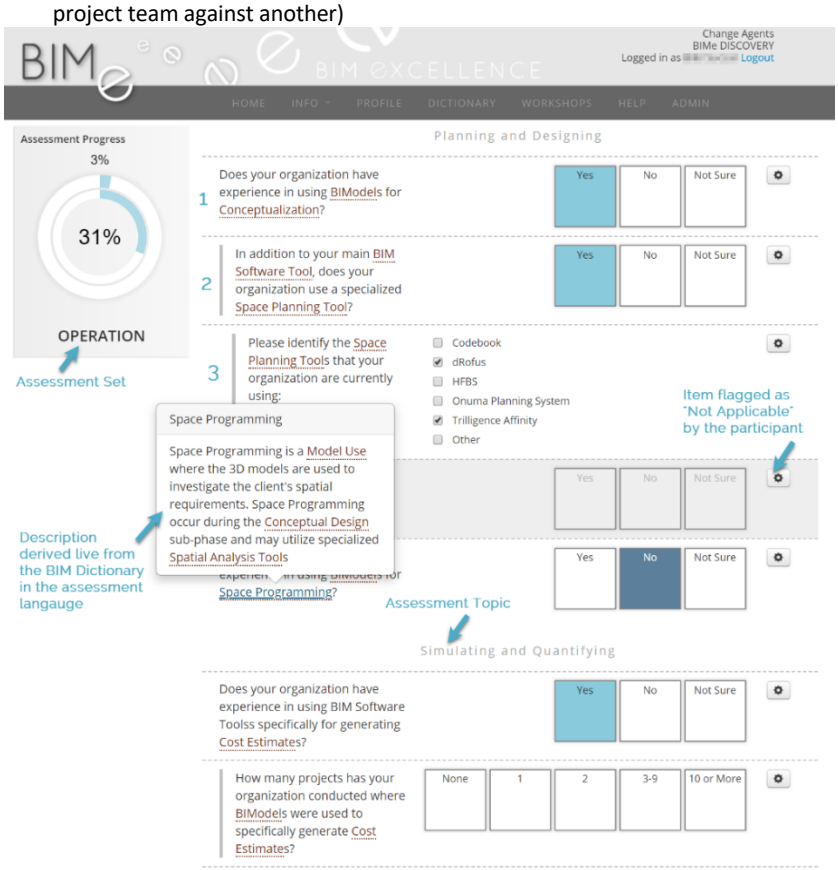
| ID | Role/Expertise | Sector | Direct experience of using benefits tool | Awareness of other benefits tools | Internal (I) or external (E) | Project level | Organisation level | Public access |
|---|---|---|---|---|---|---|---|---|
| P1 | Senior Management | Client/Client Rep | Y | Y | Tool Developer | Y | N | Y |
| P2 | Senior Management | Construction/ Contractor | Y | Y | I | Y | Y | N |
| P3 | Owner/Senior Manager | Service Provider | N | Y | N/A | Y | Y | N/A |
| P4 | Mid-level Manager /information Manager | Design Consultant | N | Y | E | Y | Y | Y |
| P5 | Mid-management | Service Provider | N | Y | N/A | Y | Y | N/A |
| P6 | Owner/Director | Architect | N | Y | N/A | N/A | N/A | N/A |
| P7 | Mid-management | Construction/ Contractor | N | Y | I | Y | Y | N |
| P8 | Senior Management | Client | N | Y | E | Y | N | Y |

# Appendix C: Individual evaluations: organisation BIM maturity tools

## Appendix C.1 BIM Excellence Online Platform

### Information Extraction Card

| Name of Tool/method | BIM Excellence Online Platform (BIMe OP) | | | |
|---|---|---|---|---|
| **Author / owner** | ChangeAgents AEC | | **Country/Origin** | Australia |
| **Link to tool** | http://bimexcellence.com/organizations/ | | | |
| **Supporting document(s)** | Succar, B, Sher, W, & Williams, A (2013). An integrated approach to BIM competency assessment, acquisition and application. Automation in Construction, 35, 174–189. | | | |
| **Date of release, and version assessed** | The researchers did use the tool themselves (http://bimexcellence.com/organizations/) as it requires customisation to be developed to meet each client's requirements. The researcher held a video interview with the tool owner, Bilal Succar of ChangeAgents AEC, who demonstrated parts the organisational assessment and explained its methodology. He also provided screenshots of one assessment module with explanatory notes and clarifications of the scoring method. | | | |
| **Tool used to assess** | Organisation ☒ | Project ☒ | Other: **also assesses project teams and individuals** | |
| **Sector** | Building ☒ | Infrastructure ☒ | Other: **Not specified** | |
| **Applicability** | Generic ☒* | Market-specific ☐ | Discipline-specific ☐ | |
| | *The assessments can be also made specific to a market or discipline (e.g. one focuses on Engineering Organisation in Australia, another on Construction Supply Chain in the UK, and a third is a generic profile for benchmarking purposes). | | | |
| **Definition of maturity adopted** | The tool includes different assessment metrics. Maturity is one of them. According to the assessment Method, BIM Maturity is the gradual and continual improvement in quality, repeatability and predictability within available BIM Capability. BIM Maturity is the third phase of BIM Implementation (Readiness, Capability, Maturity) and is expressed as BIM Maturity Levels (or performance improvement milestones) that organizations, teams and whole markets aspire to. Other metrics are described below. | | | |
| **Implicit assumptions** | - The underpinning method must be adaptable to different scales ranging from organisations, through organisational units and teams, to individuals.<br>- Maturity can cover Staged (performance targets are defined in clear stages and fixed steps irrespective of who is being assessed) and Continuous (performance targets are set as part of the assessment process and are continually updated over time) assessment approaches. Staged approach covers capability/maturity and excludes readiness; the continuous approach addresses readiness and all other metrics as needed.<br>- Staged approach, usually assessed using a maturity matrix (with low to medium granularity) which is better completed in a workshop setting guided by an assessment expert (not BIM expert)<br>- Continuous assessment does not have a right/wrong answer – i.e. it is performed against a target set up by the organisation being assessed for the different topics assessed.<br>- Scoring from across the different assessed topics should not be amalgamated into a single overall score for the organisation/project as it loses its meaning.<br>- Succar proposes that "Assessing organisational systems and the competence of organisational members are interdependent. Assessing one without the other will only yield an incomplete picture" | | | |
| **Intended use** | - To assess the BIM and digital performance (competency, capability/maturity, compliance, conformance, and compatibility) of organisations involved in the design, construction and operation of facilities.<br>- To measure the performance of design and construction projects. | | | |
| **Intended users** | - External Agents (Consultants conducting assessments for their clients in order to tailor and support their implementation services).<br>- Internal Agents (informed individuals within design/construction/FM organisations wishing to assess their own organisation and plan implementation actions). | | | |
| **Use setting** | Online questionnaire followed by confirmation workshops | | | |
| **What maturity level/index is used? Number of levels?** | Questions can take the form of propositions (yes/no), Likert scale, multiple choice, qualitative with free-flow text or quantitative. The type of question and options given depends on what is being assessed (See next field in this table). | | | |

| | |
|---|---|
| **Topics and items assessed, and number of measures?** | There are currently eight "competency sets" assessed with 57 "topics". The eight sets are:<br>• Managerial (Primary)Administration<br>• Functional (Primary)<br>• Operation<br>• Technical (Primary)<br>• Implementation<br>• Supportive (Primary)<br>• Research & development<br>The topic covered across the eight sets can be found here: https://bimexcellence.org/201in/<br>And a simplified explanation can be found here:<br>https://www.bimthinkspace.com/2012/08/episode-17-individual-bim-competency.html<br>Based on organisational objectives (established at a Scoping Phase), the assessment items can be configured. BIMe OP assesses for the purposes of:<br>• **Compliance** (i.e. comply against national/international standards) – example: "Does your organisation name its containers (files) according to the syntax specified in <<Standard Number>>?"<br>• **Capability** (i.e. comply and perform against a pre-specified performance outcome) – example: "Does your organisation conduct regular training of non-technical staff covering [[BIM Protocol]]s?"<br>• **Conformance** (conforming to internal protocols, which is a challenge in large organisations) – example: "Does your <<Organisational Unit>> follow the directives for User Information Privacy set in <<Document Number>>?"<br>• **Competency** (against a competency target) – example: "What are the [Model Uses] that your <<Organisational Unit>> has delivered as part of <<Project Number>>? – Please select:"<br>• **Compatibility** (measure performance of one organisation within supply chain or project team against another)<br>  |
| **Scoring model** | Each Competency Item (question) may have a Total Attainable Score of 2, 5, or 10 (depending on the type of item being assessed) and attainment is converted to percentage points. These scores are then collated/summed by Competency Topic (56 maximum topics) and again by Competency Set (8 maximum sets). Scores are relative (to the assessment profile developed during the Scoping Phase) then presented as |

| | |
|---|---|
| | percentages where 100% means full satisfaction of profile requirements, and 0% means no/null satisfaction. Items flagged as Not Applicable by the user are manually inspected and if true, the Item is removed from the scoring pool. Textual answers are not scored but are reported as is. |
| **Level of Evidence [Required/requested?]** | Documentation relevant to the specific questions asked (i.e. certifications to demonstrate compliance, models to demonstrate information uses) can be uploaded into the tool. In the follow-up/confirmation workshop, users may be asked to provide the document in hard copy, for online assessment, users upload the documentation and are then audited on the context of the question being asked. The type of documents to be presented and how these are assessed depends of the Level of Evidence (LoE) set during the Scoping Phase. |
| **Assessor Requirements** | - First assessment is conducted online – setting up the assessment requires an experienced assessor who receive training from ChangeAgents<br>- Confirmation assessments are conducted onsite – delivering the workshop requires an experienced consultant familiar with the assessment method. |

**Quality of assessment offered by the tool in terms of good practice of performance management**

- **Accuracy and applicability of metrics**
- **Attainability of benchmarks and logical progression towards benchmark targets**
- **Flexibility and consistency of assessment**
- **Neutrality of metrics**
- **Use of assessment outcomes to provide informative feedback for improvement**

Questions have different granularities depending on the responses to the earliest questions. Follow up questions are used to drill down more specifics about the main question to discover the extent of certain capabilities/competencies.

Questions can take the form of propositions (yes/no), Likert scale, multiple choice, qualitative with free-flow text or quantitative. The type of question depends on what is being assessed (i.e. capability questions typically have a proposition question, readiness questions might use a Likert scale and maturity questions may use multiple choice or free-flow text) as provided in the examples earlier.

Each competency set has their own number of topics and organisations are not usually assessed against all sets/topics. Hence, the tool is generally used to benchmark one organisation against itself at different point in time. However, the tool can be used to benchmark organisational units of a parent organisation or organisations within the supply chain of an employer or client, or within a market if there are compliance or capability established for a market. Information management items are mainly in “operation” and “technical” sets.

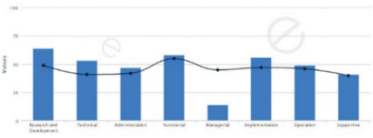
As the tool requires a tailored configuration for each organisation need, the researchers were not able to access an extensive inventory/list of questions used in the tool. This assessment is based on the interview that was held with the tool developer, Dr. Bilal Succar. Hence, it is not possible to evaluate tool against the different criteria of quality of assessment except the flexibility criteria. The tool is certainly flexible and adaptable, and these characteristics are inherent in its underpinning BIMe assessment method.

The tool is also expected to perform well across the other criteria based on the info given/shown during the interview and its underpinning method that is partially exposed in the supporting document.

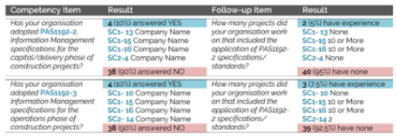
The assessment, however, is time consuming (See [Completion effort/time] field) and requires a significant support of the tool developer.

## Reporting Modules - *samples*

BIM Excellence assessments generate different types of reports with varied *reporting modules*: online module reflect **quantitative data** as charts and comparative tables; while offline modules provide detailed **gap analysis** and **qualitative recommendations**. Below are sample reporting modules:



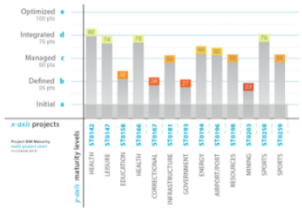
Competency scores against Competency Benchmark



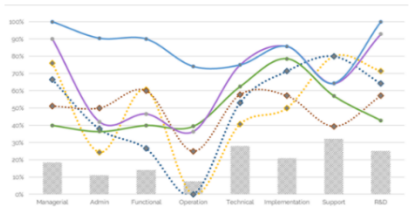
Compliance Test against established standards

| Geography Group | Code | Administrat.. | Functional | Implementa.. | Managerial | Operation | Research & .. | Supportive | Technical |
|---|---|---|---|---|---|---|---|---|---|
| AIME - Asia | G7 D1 R1 - 18 | 13% | 5% | 14% | 16% | 6% | 21% | 14% | 16% |
| | G7 D1 R2 - 178 | 6% | 11% | 12% | 6% | 6% | 17% | 20% | 13% |
| | G7 D1 R6 - 61 | 27% | 31% | 35% | 25% | 5% | 27% | 25% | 36% |
| | G7 D1 R6 - 95 | 21% | 31% | 31% | 22% | 3% | 12% | 11% | 38% |
| | G7 D2 R5 - 93 | 11% | 4% | 6% | 36% | 22% | 38% | 20% | 33% |
| | G7 D2 R6 - 195 | 29% | 30% | 27% | 19% | 15% | 15% | 23% | 43% |
| AIME - Middle East | G8 D1 R1 - 14 | 24% | 2% | 20% | 23% | 1% | 37% | 2% | 7% |
| | G8 D1 R6 - 126 | 31% | 26% | 35% | 17% | 17% | 21% | 48% | 67% |
| | G8 D2 R2 - 58 | 11% | 11% | 4% | 17% | 5% | 0% | 7% | 18% |
| | G8 D2 R3 - 140 | 14% | 11% | 50% | 36% | 13% | 31% | 50% | 29% |
| | G8 D3 R6 - 26 | 79% | 81% | 79% | 73% | 20% | 56% | 50% | 79% |
| | G8 D3 R6 - 99 | 68% | 65% | 62% | 61% | 16% | 46% | 61% | 67% |
| North America | G5 D2 R3 - 72 | 62% | 86% | 87% | 77% | 36% | 75% | 50% | 91% |
| | G5 D2 R3 - 74 | 16% | 32% | 35% | 30% | 29% | 21% | 41% | 40% |
| | G5 D2 R3 - 201 | 0% | 11% | 12% | 5% | 1% | 12% | 9% | 15% |

Capability distribution across offices



Collated Capability/Maturity across Business Streams



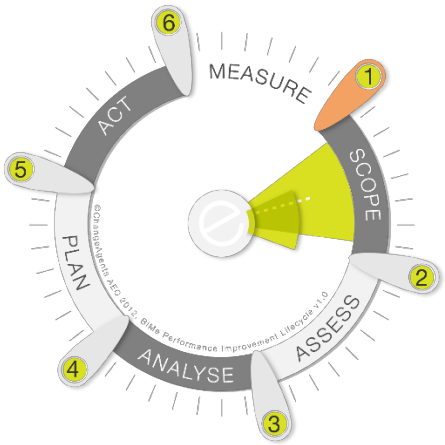
Comparative Capability within a Supply Chain

**Note**: the reporting modules are combined into **Analysis Reports** that include textual explanations, detailed Gap Analysis, and contextual recommendations.

| **Granularity of assessment** | Low ☐ | Moderate ☐ | High ☒ | Very High ☐ |
|---|---|---|---|---|

| **Usability of tool/model** (1=low, 5=high) | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Ease of use | ☐ | ☐ | ☐ | ☒ | ☐ |
| Quality/aesthetics of UI | ☐ | ☐ | ☐ | ☒ | ☐ |
| Help, dictionary, support | ☐ | ☐ | ☐ | ☒ | ☐ |

| **Completion effort/time** | BIMe assessments may take 3 months (even more for large organisations):<br>1. Scoping 2 weeks<br>2. Assessment 2 to 4 weeks<br>a. Online Discovery 2 weeks<br>b. Onsite Evaluation 2 weeks<br>3. Analysis 2 weeks<br>a. Clarifications<br>b. Reporting<br>4. Planning (by others)<br>5. Acting (by others)<br>6. Measuring (re-assessment) – 2 weeks |
|---|---|

| | |
|---|---|
| |  |
| **Case studies/research demonstrating application of the tool/model** | Case studies not available publicly.<br>The method is partially exposed in: Succar, B, Sher, W, & Williams, A (2013). An integrated approach to BIM competency assessment, acquisition and application. Automation in Construction, 35, 174–189. |
| **License to use** | Yes |
| **Additional information** | Usually takes a 1 day to be trained on the method tool |

## Categorisation of items (as an organisation tool)

(See Appendix D.1 for categorisation against the ISO 19650-2:2018)

| **Tool** | **BIM Excellence Online Platform,** ChangeAgents AEC |
|---|---|
| **Strategy** | Strategic Planning [Managerial] |
| | Partnership and Alliancing [Managerial] |
| | Strategy development and planning [R&D] |
| | Knowledge management and engineering [R&D] |
| | Change management [R&D] |
| **Mobilization and management of resources** | Human Resource Management [Administration] |
| | Performance Management [Administration] |
| | Technical training [Implementation] |
| | Teaching and coaching [R&D] |
| | Leadership [Managerial] |
| **Mobilization and management of technology** | Software systems [Technical] |
| | Hardware and equipment [Technical] |
| | General IT [Technical] |
| | General IT support [Supportive] |
| | Equipment support [Supportive] |
| | Software support [Supportive] |
| | Software and Web development [Supportive] |
| **Procurement** | Tendering and procurement [Administration] |
| **Generation and delivery of information** | Component development [Implementation] |
| | Guides and manuals [Implementation] |
| | General modelling [Operation] |
| | Capturing and representing [Operation] |
| | Planning and designing [Operation] |
| | Simulating and quantifying [Operation] |
| | Constructing and fabricating [Operation] |
| | Operating and maintaining [Operation] |
| | Monitoring and controlling [Operation] |
| | Linking and extending [Operation] |
| | Custom modelling [Operation] |
| | Modelling [Technical] |

| | |
|---|---|
| | Documentation [Technical] |
| | Presentation and animation [Technical] |
| **Assurance** | Risk management [Administration] |
| | Quality management [Administration] |
| | Document management [Technical] |
| | System and process testing [Implementation] |
| | Standardization and templates [Implementation] |
| **Organisational processes and management** | Marketing [Administration] |
| | Administration, policies and procedures [Administration] |
| | General Management [Managerial] |
| | Organizational Management [Managerial] |
| | Business Development and Client Management [Managerial] |
| | Functional basics [Functional] |
| | Finance, accounting and budgeting [Administration] |
| | General research and development [R&D] |
| | Research and analysis [R&D] |
| | Industry engagement and knowledge sharing [R&D] |
| **BIM processes** | Collaboration [Functional] |
| | Facilitation [Functional] |
| | Team and workflow management [Functional] |
| | Implementation fundamentals [Implementation] |
| | Contract management [Administration] |
| | Project management [Functional] |
| | Model management [Technical] |
| | Library management [Implementation] |
| | Data and network support [Supportive] |
| | Data management [Technical] |

## Appendix C.2 BIM Supporters' BIM Compass

### Information Extraction Card

| Name of Tool/method | BIM Compass | | | | | |
|---|---|---|---|---|---|---|
| **Author / owner** | BIM Supporters | | | **Country/Origin** | Netherlands | |
| **Link to tool** | https://app.bimsupporters.com/compass/ | | | | | |
| **Supporting document(s)** | – Sebastian, R. and van Berlo, L. (2010) 'Tool for Benchmarking BIM Performance of Design, Engineering and Construction Firms in The Netherlands', *Architectural Engineering and Design Management*, 6, pp. 254–263. doi:10.3763/aedm.2010.IDDS3. http://app.bimsupporters.com/knowledge-base/wp-content/uploads/sites/5/2018/07/BIM-Quickscan-paper-AEDM-IDDS.pdf<br>– van Berlo, L., Dijkmans, T., Hendriks, H., Spekkink, D. and Pel, W. (2012) '*BIM quickscan: Benchmark of BIM performance in the Netherlands'*, Proceedings of the 29th CIB W78 2012 Conference, pp. 214-223. http://itc.scix.net/data/works/att/w78-2012-Paper-30.pdf | | | | | |
| **Date of release, and version assessed** | 2019, current online version (self-scan) assessed (7 October 2019). | | | | | |
| **Tool used to assess** | Organisation ☒ | | Project ☐ | | Other: | |
| **Sector** | Building ☒ | | Infrastructure ☒ | | Other: **Not specified** | |
| **Applicability** | Generic ☒ | | Market-specific ☐ | | Discipline-specific ☐ | |
| **Definition of maturity adopted** | Cites "Succar (2009) distinguishes BIM capability from BIM maturity. BIM capability is the ability to generate BIM deliverables and services. BIM maturity addresses the extent, depth, quality, predictability and repeatability of these BIM deliverables and services" (Sebastian and van Berlo, 2010, p. 524). | | | | | |
| **Implicit assumptions** | There is an assumption that general BIM capability "maturity" increases year on year so if a company does not improve, their score stays the same but the value of that score decreases. The increase in the maximum score may rise in time as the state of the art of BIM advances. Therefore "the potential, or the performance gap to be bridged, can grow larger in time when the BIM level of a certain company remains the same" (van Berlo et al., 2012, p. 215). | | | | | |
| **Intended use** | "The instrument aims to provide insight into the current BIM performance level of firms using BIM. The purpose is to raise awareness and establish a strategy for innovation with BIM, as well as to justify the qualification of the parties to be commissioned for projects. The benchmarking instrument is based on a quick measurement method. It combines quantitative and qualitative assessments of the 'hard' and 'soft' aspects of BIM." (https://app.bimsupporters.com/knowledge-base/kb/what-is-the-bim-compass/)<br>The BIM Compass is intended to be used hand in hand with the BIM Execution Plan Generator which "gathers preferred working methods, data requirements and skills from project partners and aggregates them to identify overlaps and pitfalls in a very early phase of your project." (https://app.bimsupporters.com/executionplan/). The BIM Execution Plan Generator is not within the scope of this study. | | | | | |
| **Intended users** | Organisations implementing BIM | | | | | |
| **Use setting** | Option 1: Online questionnaire, the results of which remain private.<br>Option 2: Conducted by a certified consultant who visits the organisation to see how they work, and asks questions to the organisation. The final report made by the consultant is made public and further data is provided to the organisation to help them with results comparison – benchmarking. The consultant can also help prepare a BIM development roadmap for the organisation. | | | | | |
| **What maturity level/index is used? Number of levels?** | Scores are plotted in the Bew-Richards BIM maturity model indicating where the organisation sits on the scale from level 1 to level 3+.<br>Multiple-choice questions (with a number of options ranging between three and six in most cases) are used to assess readiness (e.g. preparedness towards adopting a BIM capability) or BIM capability (existence of a certain BIM capability / frequency of using that capability). In a few metrics (e.g. richness of information produced) capability maturity is assessed. | | | | | |
| **Topics and items assessed, and number of measures?** | 4 Chapters (i.e. topics) representing both *hard* and *soft* aspects of BIM based on Sebastian and van Berlo (2010, p. 259). Each chapter has 6 measures (called KPIs). In addition, there are 10 "Aspects". | | | | | |

| | |
|---|---|
| | **Chapter 1: Organization and management** – KPIs:<br>• Vision and strategy;<br>• Distribution of roles and tasks;<br>• Organization structure;<br>• Quality assurance;<br>• Financial resources; and<br>• Partnership on corporate and project level<br>**Chapter 2: Mentality and culture** – KPIs:<br>• BIM acceptance among the staff and workers;<br>• Group and individual motivation;<br>• Presence and influence of the BIM coordinator;<br>• Knowledge and skills;<br>• Knowledge management; and<br>• Training.<br>**Chapter 3: Information structure and information flow** – KPIs:<br>• Use of modelling;<br>• Open data standards;<br>• Object libraries;<br>• Internal and external information flow;<br>• Type of data exchange; and<br>• Type of data in each project phase.<br>**Chapter 4: Tools and applications** – KPIs:<br>• Use of model server;<br>• Type and capacity of model server;<br>• Type of software package;<br>• Advanced BIM tools;<br>• Model view definitions; and<br>• Supporting rules.<br>**Aspects**:<br>• Company culture,<br>• Employee education;<br>• Employee mentality;<br>• Internal information flow;<br>• Organization;<br>• Partners;<br>• Resources;<br>• Strategy;<br>• Use and application of open standards; and<br>• Use of tools. |
| **Scoring model** | Some questions asked are not applicable to small organisations and so are not taken into account in the final score for small organisations.<br>This tool uses qualitative measure and expert opinion to calculate a BIM maturity score. For each KPI, different answers provide different scores and have different weightings. However, no indication of these weightings is provided. Combining the partial KPI scores equates to a total score of BIM performance for the organisation. The questionnaire is intended to be completed by a Certified BIM Consultant to avoid misinterpretation of KPIs or questions, however, it can also be completed by individuals within the organisation being assessed.<br>The assessment involves answering 45 multiple choice questions across the four chapters; the first question asks about the type of organisation, the remaining 44 cover the four chapters. After completion of the questions, a report is generated and displayed for private use shown graphically (radar diagram for the 10 aspects and bar chart for the 4 chapters) and in tables for individual chapters and aspects.<br>Chapter 1 – 13 questions; Chapter 2 – 10 questions; Chapter 3 – 12 questions; Chapter 4 – 8 questions.<br>Questions have between two and six options (a, b, c, d, e, f). Some questions have follow on questions.<br>Once submitted, the results of where the organisation scores across the four chapters are displayed on the Bew-Richards BIM Maturity Model (Level 0, Level 1, Level 2 etc.) and a numerical score displayed as a decimal is generated as an overall score and a score for each chapter. The ten aspects are displayed on a radar diagram and by percentages in a separate table. The answers given are shown in a list on the results page. |
| **Level of Evidence [Required/requested?]** | None for simplified, online version. Not specified for the consultation method. |
| **Assessor Requirements** | No requirements for the simplified free online version.<br>A Certified Consultant to conduct a full consultation in person/onsite. |
| **Quality of assessment offered by the tool in terms of good practice of performance management**<br>- **Accuracy and applicability of metrics**<br>- **Attainability of benchmarks and logical progression towards benchmark targets**<br>- **Flexibility and consistency of assessment**<br>- **Neutrality of metrics**<br>- **Use of assessment outcomes to provide informative feedback for improvement** | |

KPIs carry a weighting but no explanation nor justification for the distribution is provided. In the actual evaluation of the tool (Sebastian, R. and van Berlo, 2010), weighting was used to adjust discrepancies in the assessment outcomes carried out by different consultants.
The tool works like a questionnaire/survey and is intended for benchmark. Only for a few of the items assessed, the options given to the question are conceived in a way that captures the maturity of the corresponding item in progressive/logical manner. In most cases, the assessed items combine within each individual question's options identifying readiness (for example, "we are still looking for effective ways to do this if we are busy or facing a deadline" with either an unknown maturity level ("we always do") and a maturity at a certain level (e.g. information flows are "according to the company's own structure" which usually corresponds to a Defined maturity level. These options affect the accuracy of assessment. However, the consistency is achievable as the options are clearly separate.
Most of the questions are aimed to assess either the BIM awareness/readiness and capabilities available within organisations with a very few items whose assessment inherently embed some maturity levels. According to the tool developer, results of the assessment can be used "to benchmark the performance of one organisation against those of another – i.e. two organisations with the same score are considered to have the same BIM performance". Improvement plans from self-assessment are not possible. However, according to tool's developers, a certified consultant performing the assessment in person with more depth will provide a BIM roadmap for improvement for the organisation. There is encouragement to pay for the consultant analysis; the simplified version is designed to implement that encouragement (see the "additional information" field below). The tool owner indicated that the BIM Compass is intended to be used alongside the BIM Execution Plan Generator.

| **Granularity of assessment** | Low ☐ | Moderate ☒ | High ☐ | Very High ☐ |
|---|---|---|---|---|

| **Usability of tool/model** (1=low, 5=high) | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Ease of use | ☐ | ☐ | ☐ | ☒ | ☐ |
| Quality/aesthetics of UI | ☐ | ☐ | ☐ | ☒ | ☐ |
| Help, dictionary, support | ☐ | ☐ | ☐ | ☒ | ☐ |

| | |
|---|---|
| **Completion effort/time** | Sebastian and van Berlo (2010) says maximum time for completion is one day for the consultation version.<br>A self-scan can be completed in less than one hour by someone with knowledge of the organisation's BIM adoption/use. |
| **Case studies/research demonstrating application of the tool/model** | van Berlo, L., Dijkmans, T., Hendriks, H., Spekkink, D. and Pel, W. (2012) 'BIM quickscan: Benchmark of BIM performance in the Netherlands', Proceedings of the 29th CIB W78 2012 Conference. |
| **License to use** | No fee for the free assessment. There is a fee for the certified consultant version. |
| **Additional information** | "The report produced from a QuickScan performed by a certified consultant gives a complete overview of the BIM level in the company. The consultant knows, from the instruction, how to interpret the results of the BIM QuickScan and can give advice on future improvements of the company's BIM level. The report from a QuickScan taken by a certified consultants is much more comprehensive than a report from the self-scan" (van Berlo et al., 2012, p. 215).<br>"The self-scan is an online survey that is freely available (TNO, 2010). The questions are the same as the questions in the instrument used by certified consultants. In a period of 25 months, from May 2010 to May 2012, a total of 682 self-scans were completed and the results were stored in a database. The algorithm that calculated the result is the same as the official QuickScan. The presented results from the self-scan were less extensive, only showing one graph of results per chapter. The goal of the self-scan is to show users that the term BIM is more than they expect. It should convince them to think broader about BIM and take a scan from a certified consultant" (van Berlo et al., 2012, p. 215). |

## Categorisation of items

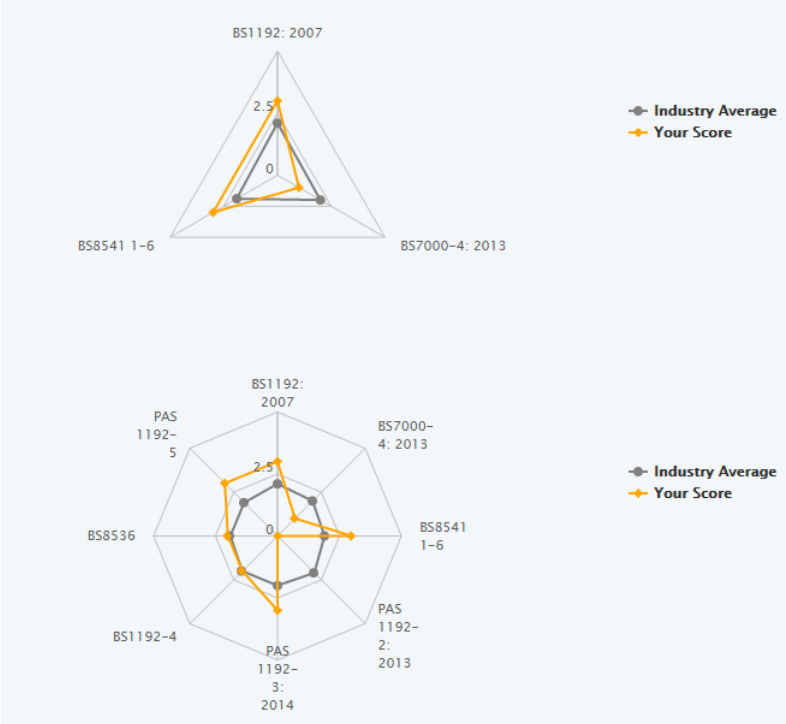
| **Tool** | BIM Compass, BIM Supporters |
|---|---|
| **Strategy** | Company culture [Aspects] |
| | Vision and strategy [Org&Mgmt] |
| | Knowledge management [Mentality&Cult] |
| | Strategy [Aspects] |
| | Partnership on corporate and project level [Org&Mgmt] |
| **Mobilization and management of resources** | Employee mentality [Aspects] |
| | BIM acceptance among the staff and workers [Mentality&Cult] |
| | Group and individual motivation [Mentality&Cult] |
| | Knowledge and skills [Mentality&Cult] |

| | |
|---|---|
| | Partners [Aspects] |
| | Distribution of roles and tasks [Org&Mgmt] |
| | Presence and influence of the BIM coordinator [Mentality&Cult] |
| | Training [Mentality&Cult] |
| | Employee education [Aspects] |
| | Resources [Aspects] |
| **Mobilization and management of technology** | Use of model server [Tools&Apps] |
| | Type and capacity of model server [Tools&Apps] |
| | Type of software package [Tools&Apps] |
| | Advanced BIM tools [Tools&Apps] |
| | Use of tools [Aspects] |
| **Generation and delivery of information** | Use and application of open standards [Aspects] |
| | Model view definitions [Tools&Apps] |
| | Internal and external information flow [InfoStruct&Flow] |
| | Internal information flow [Aspects] |
| | Use of modelling [InfoStruct&Flow] |
| **Assurance** | Quality assurance [Org&Mgmt] |
| **Organisational processes and management** | Financial resources [Org&Mgmt] |
| | Organization structure [Org&Mgmt] |
| | Organization [Aspects] |
| | Open ICT standards [InfoStruct&Flow] |
| **BIM processes** | Object libraries [InfoStruct&Flow] |
| | Supporting rules [Tools&Apps] |
| | Type of data exchange [InfoStruct&Flow] |
| | Type of data in each project phase [InfoStruct&Flow] |

## Appendix C.3 SFT's BIM Compass

### Information Extraction Card

| Name of Tool/method | BIM Compass | | | |
|---|---|---|---|---|
| **Author / owner** | Developed by Constructing Excellence, hosted by Scottish Futures Trust | | **Country/Origin** | Scotland, UK |
| **Link to tool** | https://bimportal.scottishfuturestrust.org.uk/page/bim-compass | | | |
| **Supporting document(s)** | Guidance on how the use the tool: http://www.scottishfuturestrust.org.uk/publications/how-to-use-the-bim-compass/ | | | |
| **Date of release, and version assessed** | Online version assessed 19/8/19. | | | |
| **Tool used to assess** | Organisation ☒ | Project ☒ | **More info**: "tool for suppliers and procurers to inform their current capability and identify areas for future training and upskilling" | |
| **Sector** | Building ☒ | Infrastructure ☒ | Other: | |
| **Applicability** | Generic ☒ | Market-specific ☒ | Discipline-specific ☒* | |
| | *Users select their discipline from a number of options ("we project manage, we design, We build, We supply/fabricate, we facility manage") but the questions remain the same. | | | |
| **Definition of maturity adopted** | None. | | | |
| **Implicit assumptions** | - Assumes that the standards (BS1192:2007; PAS1192-2:2014; etc.) themselves are the capabilities sets to assess organisations' capabilities.<br>- Assumes practical use of standards above (in terms of number of completed projects) is the only measure of capability/compliance (with "compliant" appear at levels 4 and 5 of the index used).<br>- Uses the same set of standards/capabilities for all disciplines<br>  | | | |
| **Intended use** | To assess "BIM capability" and compare against Industry benchmarks. | | | |
| **Intended users** | This is to support both suppliers and procurers to inform their current capability and identify areas for future training and upskilling. | | | |
| **Use setting** | Online questionnaire. | | | |
| **What maturity level/index is used? Number of levels?** | The assessment tool is set against UK Level 1 and Level 2 BIM standards as topics of assessment. Organisations are assessed against each standard using a five-level scale (levels are not labelled) ranging from readiness as first option (we are developing our <<standard name>> plan) to level of competency/maturity in all the following options (measured in terms of years of experience in using the standard in live projects). | | | |
| **Topics and items assessed, and number of measures?** | There are 8 capability areas as follows:<br>1. Collaborative Management: BS1192:2007<br>2. Design Management: BS7000-4:2013<br>3. Library Objects: BS8541<br>4. Information Management (CAPEX): PAS1192-2:2014<br>5. Information Management (OPEX): PAS1192-3:2014<br>6. Information Exchange: BS1192-4<br>7. Soft Landings: BS8536<br>8. Security: PAS1192-5 | | | |
| **Scoring model** | It is a three-step tool: | | | |

| | |
|---|---|
| | " **The Capability Assessment** – a series of evidence-based questions asking about the level of experience an organisation has, aligned to the 8 core BIM competencies as defined by the BIM Task Group;<br>**The Results** – the answers given generate capability charts to allow users to compare themselves against the industry average of BIM Levels 1 and 2 and provides average scores for all answers given for each core competency; and<br>**The Upskilling Action Plan** – an action plan is populated from the results showing which areas require improvement using red, amber, green coding for most attention, some attention and good progress respectively."<br>The core assessment is made by a matrix where users rate themselves on a five-level scale (levels are not labelled). The description of the five levels is:<br>• We are developing our <<standard name>> plan<br>• We have applied the << standard name >> on at least one project in the last 12 months<br>• We have applied the << standard name >> on at least 3 completed projects within the last 18 months<br>• We have been fully compliant with the << standard name >> on at least 50% of projects (where there is value in doing BIM) for the last 3 years<br>• We have been fully compliant with the << standard name >> on all projects (where there is value in doing BIM) for at least 5 years<br>Upon submission of the results, the system calculates the results and displays Spider charts to show comparison of the industry's average and the users score. A 3-point chart shows BIM Level 1 and an 8-point chart shows BIM Level 2.<br>In addition, a score for each competency is shown where the user score and industry average are displayed side by side.<br>In the next page, filtering of industry benchmarking standards can be made based on:<br>• Region<br>• Organisation size<br>• Project value<br>• Sector<br>The final page shows the Upskilling Action Plan which provides guidance on how to improve each competency.<br>  |
| **Level of Evidence** [Required/requested?] | None required. |
| **Assessor Requirements** | None. |
| **Quality of assessment offered by the tool in terms of good practice of performance management** | |

| | | | | | |
|---|---|---|---|---|---|
| - **Accuracy and applicability of metrics**<br>- **Attainability of benchmarks and logical progression towards benchmark targets**<br>- **Flexibility and consistency of assessment**<br>- **Neutrality of metrics**<br>- **Use of assessment outcomes to provide informative feedback for improvement** | | | | | |
| - This is a very simple assessment where users rate themselves against eight capabilities (Standards) across five unlabelled but progressive levels.<br>- The level to measure all items follows this rationale: Following the initial development of an organisational plan to implement a specific standard (which is a readiness measure), the capability of organisation is measured only in terms of number of projects on which an organisation has used a certain standard. "Compliance" on 50% or 100% of projects warrant 4 out 5 and 5 out 5 scores, respectively.<br>- The improvement feedback provided by the tool is very simplistic and not actionable by the assessed organisations (e.g. "If you are looking to begin your BIM journey you need to: develop your BS7000-4 plan"; "If you want to prove proficiency you need to: demonstrate the use of PAS1192-3 standards on at least three projects within the last 18 months".<br>- The assessment is quite rigid in what it is assessing, how it is assessed and the feedback given (e.g. specifying "three projects within the last 18 months". | | | | | |
| **Granularity of assessment** | Low ☒ | Moderate ☐ | High ☐ | Very High ☐ | |
| **Usability of tool/model** (1=low, 5=high) | 1 | 2 | 3 | 4 | 5 |
| Ease of use | ☐ | ☐ | ☐ | ☐ | ☒ |
| Quality/aesthetics of UI | ☐ | ☐ | ☐ | ☒ | ☐ |
| Help, dictionary, support | ☒* | ☐ | ☐ | ☐ | ☐ |
| | The link to the guidance document/page doesn't work. | | | | |
| **Completion effort/time** | This is a very quick assessment and can be done is around 15 minutes. More time can be taken over reviewing the results and comparing against industry benchmarking data. | | | | |
| **Case studies/research demonstrating application of the tool/model** | N/A | | | | |
| **License to use** | No | | | | |
| **Additional information** | | | | | |

## Categorisation of items

| **Tool** | **SFT's BIM Compass,** Scottish Futures Trust |
|---|---|
| **Handover** | Soft Landings: BS8536 |
| **Generation and delivery of information** | Library Objects: BS8541 |
| | Information Exchange: BS1192-4 |
| **Assurance** | Security: PAS1192-5 |
| **BIM processes** | Collaborative Management: BS1192:2007 |
| | Design Management: BS7000-4:2013 |
| | Information Management (CAPEX): PAS1192-2:2014 |
| | Information Management (OPEX): PAS1192-3:2014 |

## Appendix C.4 BIM Online Maturity Assessment

### Information Extraction Card

| Name of Tool/method | BIM Online Maturity Assessment | | | | | |
|---|---|---|---|---|---|---|
| **Author / owner** | National Federation of Builders (NFB) / CITB | | | **Country/Origin** | UK | |
| **Link to tool** | https://projectfive.checkboxonline.com/Digital-Construction.aspx | | | | | |
| **Supporting document(s)** | https://www.builders.org.uk/business-and-skills/building-information-modelling-bim/bim-online-maturity-assessment/ | | | | | |
| **Date of release, and version assessed** | No details on date of release. Current online version assessed 31 July 2019 which is branded with CITB and NFB. | | | | | |
| **Tool used to assess** | Organisation ☒ | Project ☐ | Other: | | | |
| **Sector** | Building ☐ | Infrastructure ☐ | Other: **Not specified** | | | |
| **Applicability** | Generic ☒ | Market-specific ☐ | Discipline-specific ☐ | | | |
| **Definition of maturity adopted** | None provided. | | | | | |
| **Implicit assumptions** | - The same set of questions/items are used to assess both the "BIM maturity and the collaborative working maturity".<br>- Both "BIM and collaborative maturity" can be expressed by one single score for the whole organisation. The overall score falls within one of the four wide intervals (denoting four categories of performance), each with a short narrative summarising the BIM and collaborative performance maturity of the assessed organisation. | | | | | |
| **Intended use** | "A CITB diagnostic to measure an organisation's maturity around collaborative working and BIM. It looks at your level of awareness of BIM, the competencies and knowledge of your people and your processes, systems and technology to support collaborative working using BIM".<br>"The responses help us to determine your current maturity in relation to BIM and collaborative working and supports our work to gather evidence of the industry's overall maturity. On completion of the diagnostic you will receive feedback on your maturity level and how you can go about developing your BIM and collaborative working capability."<br>"The tool provides an overview of where an organisation is in terms of BIM maturity and an action plan to help the organisation progress". | | | | | |
| **Intended users** | Organisations looking to improve their "BIM maturity". | | | | | |
| **Use setting** | Online multiple-choice **survey** | | | | | |
| **What maturity level/index is used? Number of levels?** | Topics are assessed using multiple choice questions (4 options are available to most questions) with options that are not organised using maturity levels (either explicitly or implicitly).<br>At the completion of the assessment, an overall score out total of 50 is given. The score meaning is:<br>0-13: You are still at the beginning of your journey towards adopting BIM and collaborative working. You would benefit from some support to raise awareness among your senior leaders and key staff and build some capability within your organisation. Consider some help to develop an understanding of what BIM means for your organisation and how you can apply it during project delivery. These initial steps will also help you to understand the basic principles of collaborative working.<br>14-26: Your organisation can demonstrate some basic awareness of BIM and the principles of collaborative working but there is a need to develop a more structured approach. Undertaking a review of your organisation's vision for BIM and collaborative working and evaluating your current processes against the standards that have been developed will provide a more structured approach. You will also benefit from providing your staff with focused training on BIM and collaborative working. Identify a BIM Champion to lead the day-to-day implementation of BIM.<br>27-39: You understand the importance of BIM and collaborative working and have taken some steps towards preparing your organisation. Your project experience is limited and the engagement with your supply chain on these issues is limited. However, applying some of your knowledge on projects with you supply chains will help to develop your maturity and identify some of the challenges to progressing further. A more in-depth review of processes, technology and systems will also help to identify what more you can do to improve your maturity. | | | | | |

| | |
|---|---|
| | 40+: Your organisation has made significant progress in developing its BIM and collaborative working maturity. You have well developed processes and systems. You have trained and supported your staff to enable them to apply the theory on projects. You have engaged your supply chain to deploy your processes and have developed some experience on projects. |
| **Topics and items assessed, and number of measures?** | Principles: are the building blocks in place to support BIM and collaborative working<br>• Vision and leadership<br>• Strategy<br>• Culture<br>• Implementation<br>Competence, knowledge and skills of your people<br>• People<br>• Training provision<br>Existing processes<br>• Information management processes<br>• Information management: Common Data Environment<br>• Model authoring/analysis software<br>• Delivering 4D, 5D and 6D outputs<br>Project experience<br>• Procurement for BIM and collaborative working<br>• Project delivery and the BIM Execution Plan<br>• Delivering asset information and COBie<br>• Government Soft Landings<br>Key principles |
| **Scoring model** | 21 multiple-choice questions are asked on the above areas. Upon completion of the survey, a score out of 50 is provided with narrative of what each category of scoring means (0-13; 14-26; 27-39; 40+).<br>It is not clear how the total score is calculated and how the individual questions are scored/weighted. |
| **Level of Evidence [Required/requested?]** | None required. |
| **Assessor Requirements** | No requirements, anyone can complete the diagnostic. |

**Quality of assessment offered by the tool in terms of good practice of performance management**

- **Accuracy and applicability of metrics**
- **Attainability of benchmarks and logical progression towards benchmark targets**
- **Flexibility and consistency of assessment**
- **Neutrality of metrics**
- **Use of assessment outcomes to provide informative feedback for improvement**

- This is basically a survey tool and therefore, does not perform well against most of the criteria above as explained here:
  - The multiple options (four in most cases) provided for each question do not 'explicitly' state or 'implicitly' embed levels of capability maturity that are established in a logical or progressive way.
  - The options (from which users can select one only) given for questions often include this conceptual issue: one option assessing the awareness/readiness (e.g. are you aware of ..), one option establishing the capability (e.g. do you have formal processes for information management), one option establishing both compliance and capability maturity level (e.g. having processes complying with BIM level 2 and applying them consistently in projects) – which is usually a Maturity level B (i.e. Defined). In some instances, within the same option two aspects (e.g. tool and process) are assessed, one assessed using capability (e.g. having a CDE) and another using maturity at a certain level (e.g. having structured information management processes to enable collaborative working – which is ad-hoc in this instance). As a result, it is difficult to determine the actual performance of an organisation when selecting one option from such a list.
  - The limitations above undermine the accuracy of measurement and the attainability of and progression towards benchmark. They also limit the usefulness of the feedback which is further undermined by the amalgamation of scores into an overall score for the whole organisation and all topics assessed. There are four pre-defined feedback comments that corresponds to four intervals (0-13; 14-26; 27-39; 40+).
- The metrics (or questions used) are generally neutral and applicable to most stakeholders across the project lifecycle although the tool tends to focus tend on the contractor/supply chain groups.
- The tool does not have the flexibility to be used at different scales and their subdivisions (e.g. organisation, organisational unit).

| **Granularity of assessment** | Low ☒ | Moderate ☐ | High ☐ | Very High ☐ |
|---|---|---|---|---|

| **Usability of tool/model** (1=low, 5=high) | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Ease of use | ☐ | ☐ | ☐ | ☒ | ☐ |

| | | | | | |
|---|---|---|---|---|---|
| Quality/aesthetics of UI | ☐ | ☒ | ☐ | ☐ | ☐ |
| Help, dictionary, support | ☒ | ☐ | ☐ | ☐ | ☐ |
| **Completion effort/time** | 30 minutes, possibly less provided the user has sufficient knowledge of the organisation. | | | | |
| **Case studies/research demonstrating application of the tool/model** | None available. | | | | |
| **License to use** | No. | | | | |
| **Additional information** | Tool is not up to date with ISO 19650. | | | | |

## Categorisation of items

| **Tool** | **BIM Online Maturity Assessment,** National Federation of Builders (NFB) / CITB |
|---|---|
| **Strategy** | Strategy [Principles] |
| | Culture [Principles] |
| **Mobilization and management of resources** | Training provision [Comp/know/skill of ppl] |
| | Vision and leadership [Principles] |
| | People [Comp/know/ skill of ppl] |
| **Mobilization and management of technology** | Model authoring/analysis software [existingProc] |
| | Information management: Common Data Environment [existingProc] |
| **Procurement** | Procurement for BIM and collaborative working [ProjExp] |
| **Handover** | Government Soft Landings [ProjExp] |
| **Generation and delivery of information** | Implementation [Principles] |
| | Project delivery and the BIM Execution Plan [ProjExp] |
| | Delivering asset information and COBie [ProjExp] |
| | Delivering 4D, 5D and 6D outputs [existingProc] |
| **BIM processes** | Information management processes [existingProc] |

## Appendix C.5 CPIx BIM Assessment Form

### Information Extraction Card

| Name of Tool/method | CPIx BIM Assessment Form | | | | | |
|---|---|---|---|---|---|---|
| **Author / owner** | Construction Project Information Committee | | | **Country/ Origin** | UK | |
| **Link to tool** | https://www.cpic.org.uk/cpix/cpix-bim-assessment-file/ | | | | | |
| **Date of release, and version assessed** | 2011, version assessed V1.0 | | | | | |
| **Tool used to assess** | Organisation ☒ | | Project ☐ | | Other: | |
| **Sector** | Building ☒ | | Infrastructure ☒ | | Other: | |
| **Applicability** | Generic ☒ | | Market-specific ☒ | | Discipline-specific ☐ | |
| **Definition of maturity adopted** | None provided | | | | | |
| **Implicit assumptions** | None | | | | | |
| **Intended use** | "The BIM Assessment Form provides a meaningful method of assessing a project member's BIM competence and maturity."<br>"The BIM Assessment Form should enable a Design Consultancy or Supply Chain Company to demonstrate Competence in and Understanding of BIM". | | | | | |
| **Intended users** | Company BIM representative | | | | | |
| **Use setting** | It appears the assessment should be done by interview, however, it seems as though self-assessment could be conducted using the form as it is an MS Word-based form. | | | | | |
| **What maturity level/index is used? Number of levels?** | N/A | | | | | |
| **Topics and items assessed, and number of measures?** | The form is structured to first ask "BIM Gateway Questions" that are focused on what the company does with regards BIM: training, qualifications, compliance with BS 1192 etc.<br>The next stage is on "12 Areas of BIM" below where respondents have to articulate their understanding of these models uses and possibly provide evidence:<br>• Design/construction intelligent 3D Modelling<br>• LCC and LCA Analysis<br>• Facilities Management<br>• Quantity take-off, costing<br>• Sales/Visualizations<br>• Safety Planning<br>• Clash Detection<br>• 4D-Scheduling<br>• Production BIM<br>• Procurement<br>• Supply Chain Management<br>• Simulations Energy, Fire etc.<br>The next section asks questions about BIM Project Experience requiring a minimum of 3 projects.<br>The final section asks 29 questions in what they call "BIM Capability questionnaire". It contains a range of open ended questions covering aspects of knowledge/competency (what does coordinated design mean to you?), and readiness/capability (does your organisation have BIM standards). | | | | | |
| **Scoring model** | This is a purely qualitative assessment that asks for written answers to the questions provided in the form. No scoring or levels are included. | | | | | |
| **Level of Evidence [Required/requested?]** | Evidence is required but no details of what form that should take. | | | | | |
| **Assessor Requirements** | No requirements given, therefore, assume anyone can conduct the assessment. | | | | | |
| **Quality of assessment offered by the tool in terms of good practice of performance management**<br>- **Accuracy and applicability of metrics**<br>- **Attainability of benchmarks and logical progression towards benchmark targets**<br>- **Flexibility and consistency of assessment**<br>- **Neutrality of metrics**<br>- **Use of assessment outcomes to provide informative feedback for improvement** | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| This is an open-ended qualitative assessment/questionnaire intended to understand the general readiness and capability of a supplier by the appointing party. It is difficult to see benefits for the assessed organisations. | | | | | | |
| **Granularity of assessment** | Low ☒ | | Moderate ☐ | High ☐ | | Very High ☐ |
| **Usability of tool/model** (1=low, 5=high) | N/A | 1 | 2 | 3 | 4 | 5 |
| Ease of use | ☐ | ☐ | ☒ | ☒ | ☐ | ☐ |
| | Open-ended questions about broad areas could be difficult to answer. | | | | | |
| Quality/aesthetics of UI | ☐ | ☒ | ☒ | ☒ | ☐ | ☐ |
| Help, dictionary, support | ☒ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Completion effort/time** | Given the format of the assessment (interviews), the nature of the questions and the amount of questions, it could be completed in half a day to one day but is likely to be longer if any depth is required and evidence needs to be provided. | | | | | |
| **Case studies/research demonstrating application of the tool/model** | None | | | | | |
| **License to use** | No. | | | | | |
| **Additional information** | Based on working documentation provided by Skanska | | | | | |

## Categorisation of items

| Tool | CPIx BIM Assessment Form, *Construction Project Information Committee* |
|---|---|
| **Procurement** | Procurement |
| **Generation and delivery of information** | Design/construction intelligent 3D Modelling |
| | LCC and LCA Analysis |
| | Clash Detection |
| | Simulations Energy, Fire etc. |
| | Safety Planning |
| | Facilities Management |
| | Quantity take-off, costing |
| | 4D-Scheduling |
| | Sales/Visualizations |
| | Production BIM |
| **Organisational processes and management** | Supply Chain Management |

## Appendix C.6 Maturity Matrix: Self-Assessment Questionnaire

### Information Extraction Card

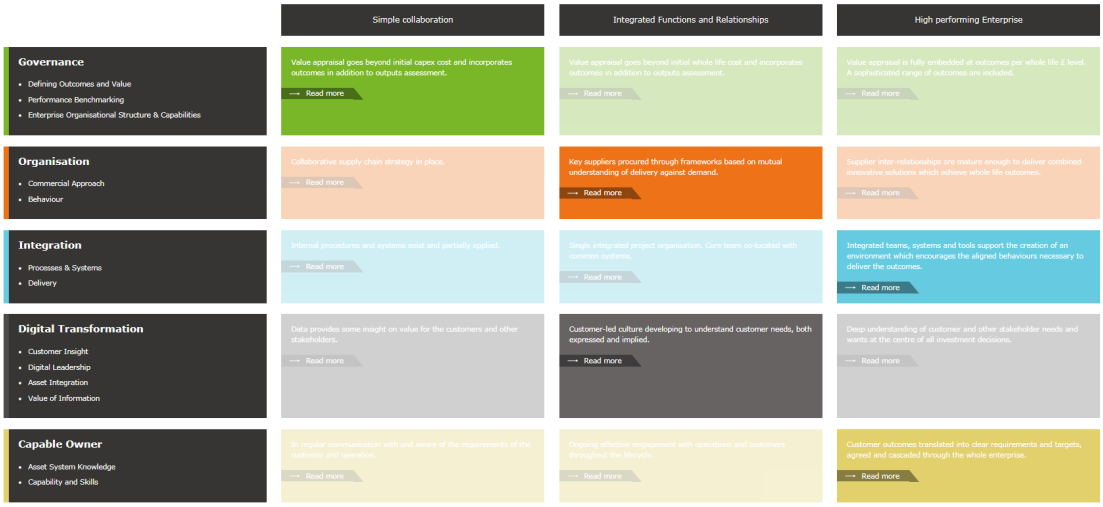
| Name of Tool/method | Maturity Matrix: Self-Assessment Questionnaire | | | | | |
|---|---|---|---|---|---|---|
| **Author / owner** | Project 13 – Institution of Civil Engineers | | | **Country/Origin** | UK | |
| **Link to tool** | http://www.p13.org.uk/tools-resources/self-assessment-tools-and-guidance/self-assessment-questionnaire/ | | | | | |
| **Date of release, and version assessed** | Website is copyright 2018. Online tool assessed 2 August 2019. | | | | | |
| **Tool used to assess** | Organisation ☒ | Project ☐ | Other: | | | |
| **Sector** | Building ☐ | Infrastructure ☒ | Other: | | | |
| **Applicability** | Generic ☒ | Market-specific ☐ | Discipline-specific ☒ Has a section (i.e. "Capable Owner") that is specific to owners | | | |
| **Definition of maturity adopted** | None offered. | | | | | |
| **Implicit assumptions** | Assumes five areas (Governance, Organisation, Integration, Digital Transformation, and Capable Owner) – called "Behaviours" – determine the "collaborative maturity" of an organisation through its relationship with project and programme partners. | | | | | |
| **Intended use** | The self-assessment enables infrastructure project and programme partners to understand their "collaborative maturity" as a single enterprise. It is not a BIM specific tool but one the topics assessed is "Digital Transformation". | | | | | |
| **Intended users** | Informed individuals from organisations involved in the "project and programme partners" | | | | | |
| **Use setting** | Online self-assessment questionnaire. | | | | | |
| **What maturity level/index is used? Number of levels?** | Five areas (Governance, Organisation, Integration, Digital Transformation, Capable Owner) are assessed using items/questions with three options from which users can select one. For each topic, the scores from items are aggregated in an overall score for the topic, which determines the organisation's "maturity" in that topic on a three-level index: Simple Collaboration; Integrated Functions and Relationships; and High Performing Enterprise. | | | | | |
| **Topics and items assessed, and number of measures?** | Assesses five core areas on the level of collaboration between partners in:<br>• Governance<br>  ○ Defining Outcomes and Value<br>  ○ Performance Benchmarking<br>  ○ Enterprise Organisational Structure and Capabilities<br>• Organisation<br>  ○ Commercial Approach<br>  ○ Behaviour<br>• Integration<br>  ○ Processes & Systems<br>  ○ Delivery<br>• Digital Transformation<br>  ○ Customer Insight<br>  ○ Digital Leadership<br>  ○ Asset Integration<br>  ○ Value of Information<br>• Capable Owner<br>  ○ Asset System Knowledge<br>  ○ Capability and Skills | | | | | |
| **Scoring model** | Multiple-choice questions. 4 questions for Governance, 3 questions for Organisation, 2 questions for Integration, 4 questions for Digital Transformation and 3 questions for Capable Owner.<br>The questions are presented in an ascending score order (option 1 carries 1 point, option 2 carries 2 points, etc.). At the end of each assessed topic, a total score is calculated by adding up the scores from each items and is reported as a ratio (e.g. 9/12) of score achieved (e.g. 9) to total points (e.g. 12) available for the topic. This score then determines the collaborative and digital construction "maturity" of the organisation/enterprise for each individual topic on a three-level index:<br>• Simple collaboration | | | | | |

| | |
|---|---|
| | • Integrated functions and relationships<br>• High performing enterprise<br>The results for each topic are summarised following completion of the assessment allowing users to see a description for each rating given (a 5 topics x 3 levels matrix). The feedback is directly related to the questions asked for each and provides a narrative of what the organisation is in its current state. |
| **Level of Evidence [Required/requested?]** | None |
| **Assessor Requirements** | None, can be completed by anyone. |

**Quality of assessment offered by the tool in terms of good practice of performance management**

- **Accuracy and applicability of metrics**
- **Attainability of benchmarks and logical progression towards benchmark targets**
- **Flexibility and consistency of assessment**
- **Neutrality of metrics**
- **Use of assessment outcomes to provide informative feedback for improvement**

One topic related to BIM (that is digital transformation) is assessed by the tool.
Looking at the "Digital Transformation" assessment, the options used to assess one sub-topic/item (e.g. use of data for customer insight in your organisation) combine in the assessment, in the following order:
(1) a capability maturity at a certain level (e.g. data provides some insight on value for the customers and other stakeholders), (2) an awareness/readiness (i.e. Customer-led culture developing to understand customer need ..), and (3) another capability maturity at a more advanced level of the first one (i.e. deep understanding of customer and other stakeholder needs and wants at the centre of all investment decisions). Given the aforementioned scoring model, this means that organisations with option 2 (awareness only) may score higher than organisations with option 1 (capability). This inconsistency may have been simply caused by a syntax issue but it is present in several questions, not only across the digital transformation topic but also in the other topics.
This affects the accuracy of assessment and means that the benchmarks are not reachable in a logical progression.
The metric (or questions in this case) are neutral and applicable to most stakeholders across the project lifecycle. However, one of the topics assessed is "Capable Owner" which is relevant to owners only.
The tool does not provide improvement plans but it does provide a narrative about the position of an organisation's Collaborative and Digital Transformation "maturity" within the matrix (5 topics x 3 levels) matrix (see Figure below).
Most of the questions/options given are neutral hence, does not prejudice proprietary, non-proprietary, free, open or commercial solutions.




| **Granularity of assessment** | Low ☒ | Moderate ☐ | High ☐ | Very High ☐ |
|---|---|---|---|---|

| **Usability of tool/model** (1=low, 5=high) | N/A | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Ease of use | ☐ | ☐ | ☐ | ☐ | ☐ | ☒ |
| Quality/aesthetics of UI | ☐ | ☐ | ☐ | ☐ | ☒ | ☐ |
| Help, dictionary, support | ☒ | ☐ | ☐ | ☐ | ☐ | ☐ |

| | |
|---|---|
| **Completion effort/time** | The questionnaire could be completed in 10-15 minutes. |
| **Case studies/research demonstrating application of the tool/model** | None available |

| | |
|---|---|
| **License to use** | No |
| **Additional information** | |

## Categorisation of items

| **Tool** | **Maturity Matrix: Self-Assessment Questionnaire,** Project 13 - Institute of Civil Engineers |
|---|---|
| **Strategy** | Customer Insight [DigTrans] |
| | Commercial Approach [Org] |
| **Mobilization and management of resources** | Capability and Skills [CapOwner] |
| | Behaviour [Org] |
| | Digital Leadership [DigTrans] |
| **Generation and delivery of information** | Delivery [Integration] |
| | Asset Integration [DigTrans] |
| | Value of Information [DigTrans] |
| **Organisational processes and management** | Enterprise Organisational Structure and Capabilities [Governance] |
| | Asset System Knowledge [CapOwner] |
| | Processes & Systems [Integration] |
| | Defining Outcomes and Value [Governance] |
| | Performance Benchmarking [Governance] |

## Appendix C.7 NBIMS Capability Maturity Model

### Information Extraction Card

| Name of Tool/method | NBIMS Capability Maturity Model | | | |
|---|---|---|---|---|
| **Author / owner** | National Institute of Building Sciences | | **Country/Origin** | USA |
| **Link to tool** | http://www.nationalbimstandard.org/nbims-us-v2/doc/Interactive_BIM_Capability_Maturity_Model_v_2_0_NBIMS.xls | | | |
| **Supporting document(s)** | National BIM Standard – United States ® Version 3, 2015 | | | |
| **Date of release, and version assessed** | Version 2012, assessed on 26/07/2019 | | | |
| **Tool used to assess** | Organisation ☒ | Project ☐ | **More info**: assesses models delivered by organisations against a "minimum BIM". | |
| **Sector** | Building ☒ | Infrastructure ☐ | Other: | |
| | From the point of view of traditional vertical construction (e.g. office buildings) | | | |
| **Applicability** | Generic ☒ | Market-specific ☐ | Discipline-specific ☐ | |
| | Capital facilities industry | | | |
| **Definition of maturity adopted** | No explicit definition of the term 'maturity' is included.<br>However, the tool defines a "minimum BIM", a threshold below which organisations and projects "should not call what they are doing BIM" (NBIMS V, p. 6). "minimum BIM" is defined in NBIMS V3 Figure 5.2-3 (p. 6). It amalgamates together varying minimum scores for the capability maturity across 11 areas assessed. | | | |
| **Implicit assumptions** | - Tool developer gives higher weights to topics that they assume they are more important than others (e.g. interoperability, information accuracy) to organisations.<br>- For each of the 11 assessed topics, tool developer assumes that pre-BIM topics (e.g. 2D non-intelligent design) can be merged with BIM topics (e.g. 3D intelligent model) on the same maturity index having 10 levels.<br>- Tool developer assumes there is a 'minimum BIM' made of varying thresholds/scores for the 11 assessed areas.<br>- The points required for Minimum BIM can be changed over time to allow for future education and BIM improvements industry-wide (i.e. industry-wide consensus). | | | |
| **Intended use** | Organisations assess their models against a 'minimum BIM' established as an industry average (i.e. benchmark).<br>"To enable project stakeholders (Architect, Engineer, Constructor, Operator, Owner, FM) to plot their current capability maturity while considering performance targets for their future operations". | | | |
| **Intended users** | Architect, Engineer, Constructor, operator, owner, FM community (NBIMS V3_5.2.4, p. 2). | | | |
| **Use setting** | Online (Interactive CMM) or offline (Tabular CMM)<br>Completion by individuals through self-evaluation of the [BIM] model or peer-review. | | | |
| **What maturity level/index is used? Number of levels?** | Maturity levels from 1 to 10 with 1 being the least "mature" and 10 being the most "mature". | | | |
| **Topics and items assessed, and number of measures?** | 11 areas of interest weighted based on importance as follows:<br>• Data Richness (84%)<br>• Life-cycle Views (84%)<br>• Change Management (90%)<br>• Roles or Disciplines (90%)<br>• Business Process (91%)<br>• Timeliness/ Response (91%)<br>• Delivery Method (92%)<br>• Graphical Information (93%)<br>• Spatial Capability (94%)<br>• Information Accuracy (95%)<br>• Interoperability/ IFC Support (96%) | | | |
| **Scoring model** | For each of the 11 areas of interest the achieved "maturity level" (called Credit) is calculated by multiplying the perceived maturity level (on the scale 1 to 10) by the area's corresponding weight. This result is compared against the required 'minimum BIM' score. | | | |
| **Level of Evidence [Required/requested?]** | No evidence required as assessment is based on (1) self-evaluation, and (2) perceived "maturity" levels. | | | |

| | |
|---|---|
| **Assessor Requirements** | Anyone can conduct the assessment, however, it is intended for use by those highlighted in the "Intended Use" question above. |

**Quality of assessment offered by the tool in terms of good practice of performance management**

- **Accuracy and applicability of metrics**
- **Attainability of benchmarks and logical progression towards benchmark targets**
- **Flexibility and consistency of assessment**
- **Neutrality of metrics**
- **Use of assessment outcomes to provide informative feedback for improvement**

The description of the levels of the maturity index for all topics assessed is not very elaborate/sufficient which undermines the accuracy of the scoring decisions. In addition, it requires a significant subjective judgement (for example, one options on the scale such "constr/supply & fabrication", "has limited Operation & Warranty", "Includes Operations & Warranty", denote maturity levels 5, 6 and 7 for the Lifecycle View topic). The expanded maturity indices with 10 levels whose differences are not easily detectable/distinguishable. All these characteristics limit the accuracy and consistency of assessment and the attainability - of benchmark through progressive accumulation of defined actions
"An accuracy evaluation test reported in NBIMS-US_V3 found yielded no more than a 5% difference in the various scores of the evaluators".
The metrics are applicable to all project stakeholders who are involved in in model & data production, management and delivery.

| **Granularity of assessment** | Low ☒ | Moderate ☐ | High ☐ | Very High ☐ |
|---|---|---|---|---|

| **Usability of tool/model** (1=low, 5=high) | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Ease of use | ☐ | ☒ | ☐ | ☐ | ☐ |
| Quality/aesthetics of UI | ☐ | ☒ | ☐ | ☐ | ☐ |
| Help, dictionary, support | ☐ | ☐ | ☒ | ☐ | ☐ |

| | |
|---|---|
| **Completion effort/time** | Completion effort is highly dependent on how quickly a user understands the different definitions in the tabular model and then transposes that as scores onto the interactive mode (for the I-CMM). Based on our estimation, assessment could be done in around an hour +/-. |
| **Case studies/research demonstrating application of the tool/model** | NA |
| **License to use** | No |
| **Additional information** | "Since the words are subjective and open to interpretation, it is possible that people will not always agree on all the possible divisions or descriptions of the varying levels of maturity, but they represent a simplified consensus-based approach. The CMM provides an evaluation tool in which a large number of items are structured in a format that people can use as a launching point for classifying themselves on a somewhat standardized continuum. Finally, it is understood that these descriptions will be updated as the community progresses and greater levels of BIM adoption dictate." (NBIMS V3_5.2.5.1, p. 3) |

## Categorisation of items

| **Tool** | **NBIMS Capability Maturity Model,** National Institute of Building Sciences |
|---|---|
| **Mobilization and management of resources** | Roles or Disciplines |
| **Generation and delivery of information** | Interoperability / IFC Support |
| | Data Richness |
| | Graphical Information |
| | Life-cycle Views |
| | Spatial Capability |
| | Delivery Method |
| **Assurance** | Change Management |
| | Information Accuracy |
| **Organisational processes and management** | Business Process |
| | Timeliness/ Response |

## Appendix C.8 Organizational BIM Assessment

### Information Extraction Card

| Name of Tool/method | Organizational BIM Assessment | | | | | |
|---|---|---|---|---|---|---|
| **Author / owner** | Pennsylvania State University | | | **Country/Origin** | USA | |
| **Link to tool** | https://lp.constantcontact.com/su/77NsQ0E/BIMforOwners | | | | | |
| **Supporting document(s)** | BIM Planning Guide for Facility Owners | | | | | |
| **Date of release, and version assessed** | | | | | | |
| **Tool used to assess** | Organisation | ☒ | Project | ☐ | Other: | |
| **Sector** | Building | ☒ | Infrastructure | ☒ | Other: | |
| **Applicability** | Generic | ☒ | Market-specific | ☐ | Discipline-specific ☐ | |
| **Definition of maturity adopted** | For some capability items, top maturity level (Level 5. Optimising) can be reached only by organisations whose practices are balloted for inclusion in industry standards. | | | | | |
| **Implicit assumptions** | | | | | | |
| **Intended use** | To assess the maturity of the organisations across six core "BIM planning elements" | | | | | |
| **Intended users** | Facility Owners | | | | | |
| **Use setting** | Offline MS Excel Workbook. | | | | | |
| **What maturity level/index is used? Number of levels?** | 6-level scale from 0-5:<br>0 – non-existent, 1 – initial, 2 – managed, 3 – defined, 4 – quantitatively managed, 5 – optimizing | | | | | |
| **Topics and items assessed, and number of measures?** | Six planning elements (topics) each with sub elements (items):<br>• Strategy – Organizational Mission and Goals; BIM Vision and Objectives; Management Support; BIM Champion; BIM Planning Committee<br>• BIM uses – Project Uses; Operational Uses<br>• Process – Project Processes; Organizational Processes<br>• Information – Model Element Breakdown (MEB); Level of Development (LOD); Facility Data<br>• Infrastructure – Software; Hardware; Physical Spaces<br>• Personnel – Roles and Responsibilities; Organizational Hierarchy; Education; Training; Change Readiness | | | | | |
| **Scoring model** | Users score each item on the 0-5 scale. Scores from the sub-elements are rolled into a score for their parent topic. The, the sum of scores of all topics represent the total maturity score for the organisation.<br>The same is done for the "target maturity" level which is can be established by the organisation undertaking the assessment. No different weighting is assigned to any element. | | | | | |
| **Level of Evidence [Required/requested?]** | None require or requested. | | | | | |
| **Assessor Requirements** | No requirements, anyone can conduct the assessment/analysis. | | | | | |
| **Quality of assessment offered by the tool in terms of good practice of performance management**<br>- **Accuracy and applicability of metrics**<br>- **Attainability of benchmarks and logical progression towards benchmark targets**<br>- **Flexibility and consistency of assessment**<br>- **Neutrality of metrics**<br>- **Use of assessment outcomes to provide informative feedback for improvement** | | | | | | |
| For most items, the description of the levels aims to establish the maturity of the items in a gradual manner. In a few instances the metrics' description is not clear/accurate and progressive. For example, the metric assessing the "software" item merges together: software functionalities/capabilities (at Level 1. Initial, and level 3 defined) with their availability to staff (at Level 4. Quantitatively managed), their management policy (at level 5. Optimised), and with data standardisation/definition (at level 2. Managed). In these few instances the metrics are not accurate and progressive.<br>The amount of detail adopted to describe the levels is generally fair and sufficient for an organisation to be able to select an accurate score for their maturity, and hence the tool offers consistency when it is used by different assessors.<br>Organisations can reach the Optimising (Level 5) maturity level across all items. However, for two items ("Model Element Breakdown, Level of Development"), Level 5 can be reached only by organisations whose practices are balloted for inclusion in industry standards. | | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| The scores of all topics is aggregated into overall score for both achieved maturity and target maturity. However, the tool developers note "while the organization could score high, there could be some key areas not implemented that could hinder the organizations BIM Implementation".<br>The tool can be used by organisations to benchmark their performance against themselves at different points in time. Metrics are neutral and can be used by all owners/FM organisations and do not prejudice proprietary, non-proprietary, free, open or commercial solution. | | | | | |
| **Granularity of assessment** | Low ☐ | Moderate ☒ | High ☐ | Very High ☐ | |
| **Usability of tool/model** (1=low, 5=high) | 1 | 2 | 3 | 4 | 5 |
| Ease of use | ☐ | ☐ | ☒ | ☐ | ☐ |
| Quality/aesthetics of UI | ☐ | ☐ | ☐ | ☒ | ☐ |
| Help, dictionary, support | ☒ | ☐ | ☐ | ☐ | ☐ |
| **Completion effort/time** | Requires the user to have sufficient knowledge of the organisation and their level of BIM engagement. When those are in place, the worksheet can be completed in 30-60 minutes. | | | | |
| **Case studies/research demonstrating application of the tool/model** | None available. | | | | |
| **License to use** | No. | | | | |
| **Additional information** | N/A | | | | |

## Categorisation of items

| **Tool** | **Organizational BIM Assessment,** Pennsylvania State University |
|---|---|
| **Strategy** | Organizational Mission and Goals: A mission is the fundamental purpose for existence of an organization. Goals are specific aims which the organization wishes to accomplish [Strategy] |
| | BIM Vision and Objectives: A vision is a picture of what an organization is striving to become. Objectives are specific tasks or steps that when accomplished move the organization toward their goals [Strategy] |
| | BIM Planning Committee: The BIM Planning Committee is responsible for developing the BIM strategy of the organization [Strategy] |
| **Mobilization and management of resources** | BIM Champion: A BIM Champion is a person who is technically skilled and motivated to guide an organization to improve their processes by pushing adoption, managing resistance to change and ensuring implementation of BIM [Strategy] |
| | Roles and Responsibilities: Roles are the primary function assumed by a person within the organization and Responsibilities are the tasks or obligations that one is required to do as part of that role [Personnel] |
| | Education: Education is to formally instruct about a subject [Personnel] |
| | Training: Train is to teach so as to make fit, qualified, or proficient in a specific task or process [Personnel] |
| **Mobilization and management of technology** | Software: the programs and other operating information used by a computer to implement BIM [Infrastructure] |
| | Hardware: physical interconnections and devices required to store and execute (or run) BIM software [Infrastructure] |
| **Generation and delivery of information** | Facility Data: Facility Data is non-graphical information that can be attached to objects within the Model that defines various characteristics of the object [Information] |
| | Model Element Breakdown (MEB): Model Element Breakdown Structure are identifiers assigned to each physical or functional element in the breakdown of the facility model [Information] |
| | Level of Development (LOD): The Level of Development (LOD) describes the level of completeness to which a Model Element developed [Information] |
| | Change Readiness: The willingness and state preparedness of an organization to integrate BIM [Personnel] |
| | Project Processes: The documentation of External Project BIM Processes [Process] |
| **Organisational processes and management** | Organizational Hierarchy: An arrangement of personnel and group into functional groups within the organization [Personnel] |
| | Management Support: To what level does management support the BIM Planning Process [Strategy] |

| | |
|---|---|
| | Physical Spaces: Functional areas within a facility used to properly implement BIM within the organization [Infrastructure] |
| | Organizational Processes: The documentation of Internal Organizational BIM Processes [Process] |
| **BIM Processes** | Project Uses: The specific methods of implementing BIM on projects [BIM Uses] |
| | Operational Uses: The specific methods of implementing BIM within the organization [BIM Uses] |

## Appendix C.9 Supply Chain BIM Capability Assessment

### Information Extraction Card

| Name of Tool/method | Supply Chain BIM Capability Assessment | | | | | |
|---|---|---|---|---|---|---|
| **Author / owner** | Wates | | | **Country/Origin** | UK | |
| **Link to tool** | https://watesbim.wufoo.com/forms/supply-chain-bim-capability-assessment-p02/ | | | | | |
| **Date of release, and version assessed** | Online version assessed 4 August 2019 | | | | | |
| **Tool used to assess** | Organisation ☒ | Project ☐ | **More info**: General Contractor assessing their supply chain | | | |
| **Sector** | Building ☒ | Infrastructure ☐ | Other: | | | |
| **Applicability** | Generic ☐ | Market-specific ☐ | Discipline-specific ☐ | | | |
| **Definition of maturity adopted** | None available. | | | | | |
| **Implicit assumptions** | N/A | | | | | |
| **Intended use** | An assessment Wates uses to assess organisations wanting to become a member of their supply chain for BIM projects. | | | | | |
| **Intended users** | Organisations within a main's contractor supply chain. | | | | | |
| **Use setting** | Online questionnaire. | | | | | |
| **What maturity level/index is used? Number of levels?** | Questions asked on:<br>• Organisation (general info about the respondent organisation)<br>• Standards (company certification, BIM policy; working experience with UK BIM Standards and Uniclass; willingness to share native models and working in IFC and CDE).<br>• Costs (questions asking whether performing 3D geometrical modelling, model coordination, adding data to model, and a final 'Construction Information Model' at handover, increase fee of suppliers).<br>• Software (maintenance agreement; software management strategy; training of staff; CDP/Qualification of staff; BIM roles within the organisation; software available for geometrical modelling, model analysis, and 3D coordination) assessed mainly as capability items.<br>• Model use (Internal vs external geometric modelling; LOD & LOI; drawings, schedule, specification preparation from models; use of BCF; COBie production; IFC export; model coordination, etc.) assessed mainly as capability items.<br>• References (two previous projects) | | | | | |
| **Topics and items assessed, and number of measures?** | Most questions asked are about capability require yes/no answers and no score is provided after submission. | | | | | |
| **Scoring model** | Certificates of BIM Level 2 certification<br>Organisation's BIM Policy | | | | | |
| **Level of Evidence [Required/requested?]** | None | | | | | |
| **Assessor Requirements** | N/A | | | | | |
| **Quality of assessment offered by the tool in terms of good practice of performance management**<br>- **Accuracy and applicability of metrics**<br>- **Attainability of benchmarks and logical progression towards benchmark targets**<br>- **Flexibility and consistency of assessment**<br>- **Neutrality of metrics**<br>- **Use of assessment outcomes to provide informative feedback for improvement** | | | | | | |
| This is mainly a questionnaire used by a main contractor to assess in most cases the capabilities (Yes / No questions) of their supply chain. A few questions assess the preparedness/readiness of suppliers for engaging in certain processes (e.g. engaging in a CDE) or producing certain deliverables (e.g. sharing of native models). | | | | | | |
| **Granularity of assessment** | Low ☒ | Moderate ☐ | High ☐ | Very High ☐ | | |
| **Usability of tool/model** (1=low, 5=high) | N/A | 1 | 2 | 3 | 4 | 5 |
| Ease of use | ☐ | ☐ | ☐ | ☐ | ☒ | ☐ |
| Quality/aesthetics of UI | ☐ | ☐ | ☒ | ☐ | ☐ | ☐ |
| Help, dictionary, support | ☒ | ☐ | ☐ | ☐ | ☐ | ☐ |

| | |
|---|---|
| **Completion effort/time** | Less than 30 minutes. |
| **Case studies/research demonstrating application of the tool/model** | N/A |
| **License to use** | No |
| **Additional information** | N/A |

## Categorisation of items

| **Tool** | **Supply Chain BIM Capability Assessment,** Wates |
|---|---|
| **Mobilization and management of resources** | BIM roles within the organisation [Software] |
| | Training of staff [Software] |
| | CDP/Qualification of staff [Software] |
| **Mobilization and management of technology** | Software management strategy [Software] |
| | Maintenance agreement [Software] |
| | Software available for geometrical modelling, model analysis, and 3D coordination [Software] |
| **Generation and delivery of information** | COBie production [ModelUse] |
| | IFC export [ModelUse] |
| | Internal vs external geometrical modelling [ModelUse] |
| | LOD & LOI [ModelUse] |
| | Drawings, schedule, specification preparation from models [ModelUse] |
| | Use of BCF [ModelUse] |
| | Model coordination [ModelUse] |
| | Performing 3D modelling, model coordination, adding data to model, final 'Construction Information Model' at handover [Costs] |
| | Willingness to share native models and working in IFC and CDE |
| **Organisational processes and management** | Company certification, BIM policy [Standards] |
| **BIM processes** | Working experience with UK BIM Standards and Uniclass [Standards] |

## Appendix C.10 Vico BIM Scorecard

### Information Extraction Card

| Name of Tool/method | Vico BIM Scorecard | | | |
|---|---|---|---|---|
| **Author / owner** | Vico Software (now part of Trimble) | | **Country/Origin** | USA |
| **Link to tool** | https://www.surveymonkey.com/r/9YCHVXC | | | |
| **Date of release, and version assessed** | Online version assessed 30 July 2019. Originally released 2011. | | | |
| **Tool used to assess** | Organisation ☒ | Project ☒ | **More info**: focus on general contractor with multiple offices/units. | |
| **Sector** | Building ☒ | Infrastructure ☒ | Other: | |
| **Applicability** | Generic ☐ | Market-specific ☐ | Discipline-specific ☒ (focuses on contractors) | |
| **Definition of maturity adopted** | None provided. | | | |
| **Implicit assumptions** | Assumes the organisation is large enough to have multiple offices as many questions are about standardised processes across different offices. | | | |
| **Intended use** | "The BIM Scorecard determines how many BIM capabilities you are using in your daily operations…and how well." | | | |
| **Intended users** | Organisations using BIM with a focus on general contractors | | | |
| **Use setting** | Online survey (via Survey Monkey). | | | |
| **What maturity level/index is used? Number of levels?** | The tool has multiple choice questions aiming to capture the capabilities used in organisations across a number of areas [see Capability maturity aspects assessed, and number of measures?]. | | | |
| **Topics and items assessed, and number of measures?** | BIM Capabilities<br>• Portfolio and Project Management<br>• Cost Planning<br>• Cost Control<br>• Schedule Planning<br>• Production Control<br>• Coordination<br>• Design Team Engagement | | | |
| **Scoring model** | A list of BIM capabilities are listed for the 7 topics above.<br>For each of the topics, there are several questions related to "Product," "Process," and "Integration" aspects, and result in an overall BIM Score which is sent at the completion of the survey by email. No details are available about the score calculation method. | | | |
| **Level of Evidence [Required/requested?]** | Not required. | | | |
| **Assessor Requirements** | Not required. | | | |

**Quality of assessment offered by the tool in terms of good practice of performance management**

- **Accuracy and applicability of metrics**
- **Attainability of benchmarks and logical progression towards benchmark targets**
- **Flexibility and consistency of assessment**
- **Neutrality of metrics**
- **Use of assessment outcomes to provide informative feedback for improvement**

The questionnaire-based tool is intended to identify the capabilities of organisations and organisations' unit across a number of topics. In all questions, the tool captures these capabilities as minimum abilities following by a certain maturity level (for example, in a question to "Do you have formatted data that people access and modify for each project?", typical option's syntax is: "Yes / No followed by the description of capability level". For example, "Yes, our company uses a central database with resource and material price information that is updated regularly". The rationale used in listing the options (A to D) is not clear. In some instances capabilities are listed from A to D in ascending order of capability level, while in other instances they are in descending order. The tool captures organisational priorities across the capability topics at the beginning of the survey. The feedback is expected to relate the score/outcomes back to these priorities when the results are sent by email, which were not emailed, in our simulated assessment.
The tool's measures are not all neutral as several proprietary applications are mentioned (as examples) in some of the options given.

| | | | | | |
|---|---|---|---|---|---|
| This tool is more suitable to assess compatibility between different units/offices of an organisation, a general contractor in this case. | | | | | |
| **Granularity of assessment** | Low ☒ | Moderate ☐ | High ☐ | Very High ☐ | |
| **Usability of tool/model** (1=low, 5=high) | 1 | 2 | 3 | 4 | 5 |
| Ease of use | ☐ | ☐ | ☐ | ☒ | ☐ |
| Quality/aesthetics of UI | ☐ | ☐ | ☒ | ☐ | ☐ |
| Help, dictionary, support | ☐ | ☒ | ☐ | ☐ | ☐ |
| **Completion effort/time** | A knowledgeable person from within the organisation could complete the survey in a short time (less than 30 minutes) with 21 multiple-choice questions in total. | | | | |
| **Case studies/research demonstrating application of the tool/model** | NA | | | | |
| **License to use** | No. | | | | |

## Categorisation of items

| **Tool** | **Vico BIM Scorecard,** Vico Software (now part of Trimble) |
|---|---|
| **Mobilization and management of resources** | Resource planning and cash flow analysis [PPM] |
| **Mobilization and management of technology** | Uses sharing technology to access planning materials for preconstruction process [DesignTeamEngag] |
| | Schedule planning software [SchedPlanning] |
| **Generation and delivery of information** | Standard formatted data for new projects [CostPlanning] |
| | Able to reuse preconstruction quantities/ estimates for production planning [SchedPlanning] |
| | Uses coordinated model to update quantities/ estimates & connect to total station for site layout [Coordination] |
| | 3D model connects to cost and time and can be propagated throughout a project stage [DesignTeamEngag] |
| | Cost estimating [CostPlanning] |
| | Bid estimate connected to quantities from drawing sets [CostPlanning] |
| | Tracking of actual cost to estimated and contracted values [CostControl] |
| | Cost estimate used as basis for project budgets/ work packages [CostControl] |
| | Use of scheduling software to track schedule progress [ProdControl] |
| | Can calculate overall impact on schedule based on each trade's progress [ProdControl] |
| | Using schedule to track production [ProdControl] |
| **Organisational processes and management** | How monthly/ weekly info reports provided [PPM] |
| **BIM processes** | Documented scheduling methodology [SchedPlanning] |
| | Standard process for drawing/ coordination throughout project [Coordination] |
| | Template to organise and connect model data, cost info and schedule [DesignTeamEngag] |
| | System for clash detection [Coordination] |
| | Standardised cost systems across offices/projects [CostControl] |
| | Project reporting standard [PPM] |

## Appendix D: Individual evaluations: project BIM maturity tools

## Appendix D.1 BIM Excellence Online Platform

(See Appendix C.1 for the Information Extraction Card for BIM Excellence Online Platform.)

**Comparison against ISO 19650**

| ISO 19650 Clauses | | Items (lowest level of granularity within the tool) |
|---|---|---|
| Assessment and Need [ISO 19650-2 Clause 5.1] | 5.1 | M01 General Management – Defining and communicating overall managerial goals from adopting new systems and workflows [Managerial] 5.1<br>M03 Strategic Planning - Identifying strategic objectives and developing implementation strategies [Managerial] |
| | 5.1.1 | No items map |
| | 5.1.2 | No items map |
| | 5.1.3 | No items map |
| | 5.1.4 | No items map |
| | 5.1.5 | No items map |
| | 5.1.6 | No items map |
| | 5.1.7 | No items map |
| | 5.1.8 | No items map |
| | | |
| Invitation to Tender [ISO 19650-2 Clause 5.2] | 5.2.1 | No items map |
| | 5.2.2 | No items map |
| | 5.2.3 | A06 Tendering and procurement - Developing the necessary specifications and documents to pre-qualify, recommend, or procure BIM products and services [Administration] |
| | 5.2.4 | No items map |
| | | |
| Tender Response [ISO 19650-2 Clause 5.3] | 5.3.1 | No items map |
| | 5.3.2 | No items map |
| | 5.3.3 | No items map |
| | 5.3.4 | No items map |
| | 5.3.5 | F02 Collaboration - Preparing the documentation necessary to enable Model-based Collaboration between Project Participants [Functional]<br>I03 Library Management - Developing or managing component libraries as required for the standardized delivery of BIM Projects [Implementation]<br>I04 Standardization and Templates - Generating standardized templates, item lists and workflows for initiating, checking or delivering BIM Projects [Implementation] |
| | 5.3.6 | No items map |
| | 5.3.7 | No items map |
| | | |
| Appointment [ISO 19650-2 Clause 5.4] | 5.4.1 | A04 Human Resource Management - Planning, developing, and managing human resources as to align staff competencies to (organisational) BIM goals [Administration] |
| | 5.4.2 | No items map |
| | 5.4.3 | No items map |
| | 5.4.4 | No items map |
| | 5.4.5 | No items map |
| | 5.4.6 | A07 Contract Management - Administering the contractual documentation underlying Collaborative BIM Projects and workflows [Administration] 5.4.6/5.4.7 |
| | 5.4.7 | A07 Contract Management - Administering the contractual documentation underlying Collaborative BIM Projects and workflows [Administration] 5.4.6/5.4.7 |
| | | |
| Mobilization [ISO 19650-2 Clause 5.5] | 5.5.1 | M06 Partnership and Alliancing - initiating partnerships and alliances with other organizations based on BIM Deliverables and workflows [Managerial]<br>I05 Technical Training - Developing a BIM Training Plan or maintaining a Skill Register to track staff training and their acquired skills [Implementation] |
| | 5.5.2 | F01 Functional Basics - Identifying the basic requirements and main deliverables expected from using BIM tools and workflows [Functional]<br>T01 General IT - Designing, installing, managing, maintaining, and ensuring the security of Information and Communication Technology (ICT) infrastructure including databases, servers, and networks [Technical] |

| | | |
|---|---|---|
| | | T02 Software Systems - Selecting, deploying, and maintaining software systems in a multi-user environment [Technical]<br>T03 Hardware and Equipment - Specifying, recommending, or procuring computer hardware and equipment [Technical] |
| | 5.5.3 | I06 System and Process Testing - Assessing the capability/compatibility of systems and the suitability of workflows and procedures [Implementation] |
| | | |
| Collaborative production of Information [ISO 19650-2 Clause 5.6] | 5.6.1 | No items map |
| | 5.6.2 | o01 General Modelling - Using software tools to model project requirements and generate Model-based Deliverables across industries, information systems and knowledge domains [Operation]<br>o02 Capturing and Representing - Using software tools and specialized equipment to capture and represent physical spaces and environments [Operation]<br>o03 Planning and Designing - Using software tools for conceptualization, planning and design [Operation]<br>o04 Simulating and Quantifying - Using software tools to conduct various types of model-based simulations and estimations [Operation]<br>o05 Constructing and Fabricating - Using BIModels for the specific purposes of construction and fabrication [Operation]<br>o06 Operating and Maintaining - Using models to operate, manage and maintain a Facility [Operation]<br>o07 Monitoring and Controlling - Using models to monitor Building Performance or control its spaces, systems and equipment [Operation]<br>o08 Linking and Extending - Linking BIModels and their components to other databases [Operation]<br>o09 Custom Modelling - Using software tools to deliver a custom combination of Model-based Deliverables reflecting a variety of Model Uses [Operation]<br>T04 Modelling - Generating BIModels based on pre-defined Modelling Standards and protocols [Technical]<br>T05 Documentation - Generating drawings and construction documents using standardized details and workflows [Technical]<br>T06 Presentation and Animation - Generating professional-quality renderings or 3D animations using Specialized Software Tools [Technical]<br>T07 Model Management - Managing and maintaining BIModels generated using standardized processes, protocols, and specifications [Technical]<br>T08 Document Management - Using Document Management Systems or similar to store, manage and share files and BIModels [Technical]<br>T09 Data Management - Managing data flows – speed, volume, quality, and security – across project, asset, and information lifecycles [Technical]<br>S02 Data and Network Support - Managing and maintaining the storage of data, documents, 2D Drawings and BIModels [Supportive] |
| | 5.6.3 | A08 Risk Management - Managing the risks associated with using BIM tools and collaborative workflows [Administration]<br>F04 Project Management – Managing projects where BIM Workflows are used, and BIM Deliverables are specified[Functional]<br>F04 Team and Workflow Management – Managing teams involved in the delivery of BIM Projects [Functional]<br>A09 Quality Management - Establishing, managing and controlling the quality of models, documentation and other Project Deliverables [Administration] |
| | 5.6.4 | No items map |
| | 5.6.5 | No items map |
| | | |
| Information model delivery [ISO 19650-2 Clause 5.7] | 5.7.1 | No items map |
| | 5.7.2 | No items map |
| | 5.7.3 | No items map |
| | 5.7.4 | No items map |
| | | |
| Project close-out | 5.8.1 | No items map |
| | 5.8.2 | R04 Knowledge Management and Engineering - Developing a Knowledge Management Strategy and capturing/representing the BIM-specific knowledge of staff [Research & Development] |

| | | |
|---|---|---|
| [ISO 19650-2 Clause 5.8] | | |
| | | |
| Items that do not map to ISO 19650 | | M02 Leadership - Leading and guiding others throughout the process of implementing new systems and workflows [Managerial]<br>M04 Organizational Management - Identifying the organizational changes necessary for instigating, monitoring, and improving BIM Adoption [Managerial]<br>M05 Business Development and Client Management - Maximising the value achieved by the organization and its clients from BIM tools and workflows [Managerial]<br>A01 Administration, Policies and Procedures - Developing managerial initiatives into policies and procedures to facilitate the adoption of BIM tools and workflows [Administration]<br>A02 Finance, Accounting and Budgeting - Planning, allocating and monitoring the costs associated with BIM Adoption [Administration]<br>A03 Performance Management - Assessing organizational BIM capability/maturity, Individual Competency and project performance using standardized metrics [Administration]<br>A05 Marketing - Promoting an organization's BIM Capability to its clients and business partners [Administration]<br>F03 Facilitation - Facilitating the process of BIM collaboration between Project Participants [Functional]<br>I01 Implementation Fundamentals - Identifying and managing issues associated with BIM implementation [Implementation]<br>I02 Component Development - Implementing a structured approach for developing or customizing Model Components using documented Modelling Standards [Implementation]<br>I07 Guides and Manuals - Developing guides, manuals or educational material covering Model-based Workflows [Implementation]<br>S01 General IT Support - Troubleshooting software issues and supporting staff in resolving technical problems [Supportive]<br>S03 Equipment Support - Developing specifications for BIM Hardware and BIM Hardware Deployment Programmes [Supportive]<br>S04 Software Support - Addressing issues related to BIM Software Tools, fulfilling relevant Support Tasks and managing the relationship with software vendors/resellers [Supportive]<br>S05 Software and Web Development - Developing extensions for BIM Software Tools, productivity software or web portals to improve BIM Deliverables [Supportive]<br>R01 General Research and Development - Conducting general or BIM-specific research and development activities [Research & Development]<br>R02 Strategy Development and Planning - Developing a BIM Implementation Strategy or a BIM Implementation Plan to guide BIM Adoption [Research & Development]<br>R03 Teaching and Coaching - Developing BIM training material to educate staff and facilitate the BIM Adoption process [Research & Development]<br>R05 Change Management - Developing a Change Management strategy that accompanies/supports the BIM Implementation process [Research & Development]<br>R06 Research and Analysis - Participating in and/or publishing academic research focused on BIM innovation or collaboration [Research & Development]<br>R07 Industry Engagement and Knowledge Sharing - Sharing BIM knowledge and experience with the wider industry through formal/informal workshops, seminars, and presentations [Research & Development] |

## Appendix D.2 BIM Maturity Assessment Tool (BMAT), University of Cambridge

### Information Extraction Card

| Name of Tool/method | BIM Maturity Assessment Tool (BMAT) | | | |
|---|---|---|---|---|
| **Author / owner** | University of Cambridge | | **Country/Origin** | UK |
| **Link to tool** | http://bimmaturitytool.herokuapp.com/login | | | |
| **Supporting document(s)** | https://www.ifm.eng.cam.ac.uk/research/asset-management/research-projects/bim-maturity-assessment/ | | | |
| **Date of release, and version assessed** | Current online version dated 2018, assessed 31/7/19. | | | |
| **Tool used to assess** | Organisation ☐ | Project ☒ | **More info**: Parties involved (Employer, Designer, Contractor, and joint venture) | |
| **Sector** | Building ☐ | Infrastructure ☐ | **Other**: Not specified | |
| **Applicability** | Generic ☐ | Market-specific ☒ | Discipline-specific ☐ | |
| **Definition of maturity adopted** | None provided. | | | |
| **Implicit assumptions** | - There appears to be weighting to the different questions. However, the weighting system is not exposed.<br>- The tool assumes the need to perform the assessment across all stages of a project (called "BIM development maturity", and "supporting processes" using topics that are relevant to each stage and user group). | | | |
| **Intended use** | Not specified. From our evaluation, the tool measures the "BIM development maturity" (Part I) and the "supporting processes" (part II). "The tool provides separate assessment of the different stakeholders (contractor, designer and employer), and is designed to be used as a continuous performance measurement tool that can be used to track the evolution of BIM maturity throughout the construction phase through to handover". | | | |
| **Intended users** | Different user groups including employer, contractor, designer, joint venture – which suggests that a member from each user group within the project should complete their respective parts of the assessment. | | | |
| **Use setting** | Online | | | |
| **What maturity level/index is used? Number of levels?** | There is a combination of questions with responses on a four, five or six level scale. However, the majority of items are measured using four levels ('a' to 'd' options). These levels are not labelled using e.g. defined, managed, etc. | | | |
| **Topics and items assessed, and number of measures?** | The assessment is made up for two parts:<br>**Part I – Information Delivery Stages**<br>• Assessment and need (employer)<br>  ○ Asset information model<br>  ○ Information manager<br>  ○ EIR document<br>  ○ EIR contents<br>• Procurement (employer)<br>  ○ Procurement strategy<br>  ○ Pre-qualifications questionnaire<br>  ○ Pre-contract BEP<br>  ○ Employer information requirements<br>• Post contract award (select role: employer, contractor, designer, joint venture. Different working for employer.)<br>  ○ Information manager<br>  ○ Management<br>  ○ Planning and documentation<br>  ○ Methods and procedures<br>  ○ Soft landings & Handbook<br>• AIM maintenance<br>Employer questions:<br>  ○ Current model<br>  ○ Information verification<br>  ○ Handback<br>  ○ Operations, maintenance and post occupancy<br>Contractor, Designer & Joint Venture questions:<br>  ○ Current model<br>  ○ Operations, maintenance and post occupancy<br>**Part II – Supporting Processes**<br>• Performance management (Joint Venture)<br>  ○ Reviewing performance<br>  ○ Communicating performance<br>  ○ Value creation: Improving performance<br>• Information security (Joint Venture) | | | |

| | |
|---|---|
| | ○ IT solutions<br>• Mobilisation (select role: contractor, designer, joint venture)<br>○ Communication<br>○ Infrastructure<br>○ Training and education<br>• Production (select role: employer, contractor, designer, joint venture. Different wording for employer)<br>Employer questions:<br>○ Information verification and validation<br>○ Soft landings & Handbook<br>Contractor, Designer & Joint Venture questions:<br>○ Management<br>○ Planning and documentation<br>○ Methods and procedures<br>○ IT solutions<br>○ 3D BIM<br>○ 4D BIM (Scheduling)<br>○ 5D BIM (Cost)<br>○ Information verification and validation<br>○ Roles and responsibilities<br>○ Awareness and communication<br>○ Built Asset Security Strategy<br>○ Built Asset Management Plan<br>○ Security Breach/Incident Management Plan<br>• Information quality (Joint Venture)<br>○ Roles and responsibilities<br>○ Information exchange<br>○ Information quality monitoring<br>○ Value creation: Improving performance<br>• Collaborative working (Joint Venture)<br>○ Joint Relationship Management Plan<br>○ Joint communications strategy<br>○ Joint knowledge management strategy<br>○ Joint risk management process<br>○ Value creation: CDE<br>○ Value creation: Clash detection<br>○ Value creation: Soft landings |
| **Scoring model** | It was not possible to detect how the scoring works given the weighting involved and how the scores from different questions and for/from different user groups are aggregated into an overall score for each topic at different stages. |
| **Level of Evidence [Required/requested?]** | None requested. |
| **Assessor Requirements** | None provided, therefore, assume anyone can complete the assessment. |
| **Quality of assessment offered by the tool in terms of good practice of performance management**<br>- **Accuracy and applicability of metrics**<br>- **Attainability of benchmarks and logical progression towards benchmark targets**<br>- **Flexibility and consistency of assessment**<br>- **Neutrality of metrics**<br>- **Use of assessment outcomes to provide informative feedback for improvement** | |
| Part I of the tool (i.e. the "BIM development maturity") mainly measures the compliance of Employer, Contractor, Designer, and the project (joint venture) against key concepts/requirements of BIM Level 2. For all questions in this part, this is generally done using 4 options (a, b, c, and d) that follow different patterns:<br>One pattern is:<br>- 'a' signifying no compliance (for example, PIP non-existent),<br>- 'b' signifying compliance achieved but the maturity in the implementation of the corresponding requirement is either non-existent (for example, PIP existing but not reviewed to inform post contract BEP) or ad-hoc (for example, Limited indication of management activities)<br>- 'c' and 'd' signifying a certain level of maturity in implementing the compliance requirements that is higher than ad-hoc (either defined or integrated)<br>Part II assesses the project and disciplines involved across 4 topics (Performance Management; Information Security; Information Quality; Collaborative Working) using items assessed on either 4 (a to d), 5 (a to e), or 6 (a to f) levels. These follow a similar pattern as the above although in part II not all items measured are compliance items/requirements.<br>The accuracy of the tool in measuring the compliance of project and the involved disciplines at different stages of the project is expected to be good but not without challenges: 1. the subjectivity challenges when rating some items (e.g. "all tolerances and conventions agreed with suppliers" vs. "some tolerances and conventions agreed with suppliers"); | |

| | | | | | |
|---|---|---|---|---|---|
| 2. The interdependencies between stages and its effect on compliance (for example, some options used in the assessment looks to upstream stages and others looks to downstream stages).<br>The way the assessment of "BIM development maturity" and the "supporting processes" is established, suggests the tool is intended for the purpose of benchmarking between projects. However, with the current version of the tool, the assessment outcomes are not benchmarked against those of other projects or targets established by the project being assessed.<br>It is not clear how the tool uses the assessment outcomes to devise an action plan for the project. They may be used as a general review of the project and disciplines involved by identifying certain gap in competencies and performance.<br>The options are progressive but not necessarily equally weighted across the scale: often the first two options allude to no or limited capability, and the subsequent two options allude to high capability with a small difference. On a four-point scale, this affects the cumulative nature of benchmarks. | | | | | |
| **Granularity of assessment** | Low ☐ | Moderate ☒ | High ☐ | Very High ☐ | |
| **Usability of tool/model** (1=low, 5=high) | 1 | 2 | 3 | 4 | 5 |
| Ease of use | ☐ | ☐ | ☐ | ☐ | ☒ |
| Quality/aesthetics of UI | ☐ | ☐ | ☐ | ☐ | ☒ |
| Help, dictionary, support | ☒ | ☐ | ☐ | ☐ | ☐ |
| **Completion effort/time** | Requires the joint input from different user groups to complete the assessment, which affect the completion effort/time. | | | | |
| **Case studies/research demonstrating application of the tool/model** | None available. | | | | |
| **License to use** | No. | | | | |
| **Additional information** | Uses the pre ISO 19650 terminology. | | | | |

## Comparison against ISO 19650

| ISO 19650 Clauses | | Items (lowest level of granularity within the tool) |
|---|---|---|
| Assessment and Need [ISO 19650-2 Clause 5.1] | 5.1.1 | – Information manager appointment [Assmt&Need] 5.1.1 |
| | 5.1.2 | – Asset information model: Employer to capture early information in AIM [Assmt&Need] 5.1.2<br>– Information quality monitoring: a quality monitoring process outlines a systematic approach to identify data errors including measurement methods [InfoQuality] 5.1.2/5.1.4/5.1.5 |
| | 5.1.3 | No items map |
| | 5.1.4 | – Information quality monitoring: a quality monitoring process outlines a systematic approach to identify data errors including measurement methods [InfoQuality] 5.1.2/5.1.4/5.1.5 |
| | 5.1.5 | – Information quality monitoring: a quality monitoring process outlines a systematic approach to identify data errors including measurement methods [InfoQuality] 5.1.2/5.1.4/5.1.5 |
| | 5.1.6 | No items map |
| | 5.1.7 | No items map |
| | 5.1.8 | – Built Asset Security Strategy: a BASS must be developed and maintained detailing the approach to risk assessment and risk mitigation [InfoSecurity] 5.1.8<br>– Built Asset Management Plan: a BASMP must outline the responsibilities, policies, rules and procedures for security management [InfoSecurity] 5.1.8<br>– Security Breach/Incident Management Plan: a SB/IMP should record the assessment of potential risks, subsequent risk mitigation measures and review process [InfoSecurity] 5.1.8 |
| | | |
| Invitation to Tender [ISO 19650-2 Clause 5.2] | 5.2.1 | – Issue EIRs document [Assmt&Need] 5.2.1<br>– Establish EIR contents [Assmt&Need] 5.2.1 |
| | 5.2.2 | – Procurement strategy: Completeness of tender documents / CDE ownership [Procurement] 5.2.2 |
| | 5.2.3 | – Pre-qualifications questionnaire: in place to ensure competence in BIM and collaborative information exchange [Procurement] 5.2.3 |
| | 5.2.4 | – Employer information requirements: included in tender pack. Completeness should be reviewed as BEPs received [Procurement] 5.2.4 |

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|---|---|---|
| Tender Response [ISO 19650-2 Clause 5.3] | 5.3.1 | No items map |
| | 5.3.2 | – Pre-contract BEP in place to assess supplier's proposed approach and capability to meet EIR [Procurement] 5.3.2 |
| | 5.3.3 | No items map |
| | 5.3.4 | No items map |
| | 5.3.5 | – Planning and documentation: setting up requirements and responsibilities [PostContractAward] 5.3.5<br>– Methods and procedures for origin, tolerances, naming and drawing conventions agreed [PostContractAward] 5.3.5 |
| | 5.3.6 | No items map |
| | 5.3.7 | No items map |
| | | |
| Appointment [ISO 19650-2 Clause 5.4] | 5.4.1 | – IT solutions outlined in BEP [PostContractAward] 5.4.1 |
| | 5.4.2 | – Management: BEP assigns responsibilities and authorities; milestones aligned with project programme [PostContractAward] 5.4.2 |
| | 5.4.3 | No items map |
| | 5.4.4 | No items map |
| | 5.4.5 | No items map |
| | 5.4.6 | No items map |
| | 5.4.7 | No items map |
| | | |
| Mobilization [ISO 19650-2 Clause 5.5] | – | – Supplier appoints information manager [PostContractAward] 5.5.1<br>– Training and education: appropriate action should be taken to address the training needs of the delivery team [Mobilisation] 5.5.1<br>– Roles and responsibilities: a Built Asset Security Manager should be appointed by the employer when appropriate [InfoSecurity] 5.5.1<br>– Awareness and communication: everyone working on the project must be aware of the information security policy and system [InfoSecurity] 5.5.1<br>– Roles and responsibilities: responsibility for data quality management must be assigned [InfoQuality] 5.5.1<br>– Information exchange: data exchange process must be agreed, implemented and tested and include a method of recording each exchange [InfoQuality] 5.5.1<br>– Value creation: Improving performance: an improvement plan should be developed to eliminate root causes and improve error detection [InfoQuality] 5.5.1<br>– Joint Relationship Management Plan: incorporate the agreed governance structure, operational structure, and contracting arrangements [CollaborativeWorking]<br>– Joint communications strategy: outlines what, when and how communications will take place between all collaborative parties [CollaborativeWorking] 5.5.1<br>– Joint knowledge management strategy: defines processes to capture and manage knowledge creation (e.g. sharing best practice and protecting knowledge) [CollaborativeWorking] 5.5.1<br>– Joint risk management process: roles and responsibilities must be outlined and a joint risk register must be established and maintained [CollaborativeWorking] 5.5.1<br>– Value creation: a CDE should be used to facilitate collaborative working and sharing of information [CollaborativeWorking]5.5.1 |
| | 5.5.2 | – Infrastructure: IT systems and infrastructure must be procured, implemented and tested [Mobilisation] 5.5.2 |
| | 5.5.3 | – Communication: agreed BEP, and subsequent changes, must be shared with whole delivery team [Mobilisation] 5.5.3<br>– Value creation: iterative collaborative clash detection and mitigation processes should be developed and adhered to [CollaborativeWorking] 5.5.3<br>– Value creation: Soft landings: collaboration between designer, constructor and operator will ensure efficient handover and operation [CollaborativeWorking] 5.5.3 |
| | | |
| Collaborative production of Information [ISO 19650-2 Clause 5.6] | 5.6.1 | – IT solutions: production must use software, exchange formats and IT outlined in the BEP [Production] 5.6.1 |
| | 5.6.2 | – 3D BIM: a 3D model, linked across disciplines, should be used to inform coordination [Production] 5.6.2<br>– 4D BIM (Scheduling): model-based construction planning, and visual sequencing and scheduling [Production] 5.6.2<br>– 5D BIM: model-based costing and quantity take off (Cost) [Production] 5.6.2 |

| | | |
|---|---|---|
| | | – Soft landings & Handbook: operational performance must inform all design and construction decisions [Production] 5.6.2<br>– Management: production must be managed (roles, responsibilities, authorities) as outlined in the BEP [Production] 5.6.2<br>– Planning and documentation: production must be planned and documented (MPDT, MIDP, PIP) as outlined in BEP [Production] 5.6.2<br>– Methods and procedures: production must follow the methods and procedures outlined in the BEP [Production] 5.6.2 |
| | 5.6.3 | No items map |
| | 5.6.4 | – Information verification and validation: review meetings [Production] 5.6.4 |
| | 5.6.5 | No items map |
| | | |
| Information model delivery [ISO 19650-2 Clause 5.7] | 5.7.1 | – Handback: handover includes all models and relevant supporting documentation [AIM Maintenance] 5.7.1 |
| | 5.7.2 | – Operations, maintenance and post occupancy: there should be a clear plan for commissioning, training, handover and operation leading to post-occupancy [AIM Maintenance] 5.7.2<br>– Current model should reflect the current design intent or as-built condition [AIM Maintenance] 5.7.2 |
| | 5.7.3 | No items map |
| | 5.7.4 | – Information verification: employer should verify (complete) information on receipt into AIM [AIM Maintenance] 5.7.4 |
| | | |
| Project close-out [ISO 19650-2 Clause 5.8] | 5.8.1 | No items map |
| | 5.8.2 | No items map |
| | | |
| Items that do not map to ISO 19650 | | – Reviewing performance: A plan should outline procedures for performance management and set targets for performance [PerformMgmt]<br>– Communicating performance: A plan should outline procedures for performance management and set targets for performance [PerformMgmt]<br>– Value creation: Improving performance: A plan should outline procedures for performance management and set targets for performance [PerformMgmt] |

## Appendix D.3 BIM Maturity Measure

### Information Extraction Card

| Name of Tool/method | BIM Maturity Measure | | | | |
|---|---|---|---|---|---|
| **Author / owner** | Arup | | **Country/Origin** | UK | |
| **Link to tool** | http://www.ice.org.uk/ICEDevelopmentWebPortal/media/Disciplines-Resources/Best Practice/123456_BIM_Maturity_Measure_Ver_200.xlsm | | | | |
| **Date of release, and version assessed** | Tool released in December 2014 at Autodesk University. Version 2 (2015) assessed. | | | | |
| **Tool used to assess** | Organisation ☐ | Project ☒ | **More info**: assesses also disciplines involved in the project. | | |
| **Sector** | Building ☒ | Infrastructure ☒ | Other: | | |
| **Applicability** | Generic ☒ | Market-specific ☐ | Discipline-specific ☐ | | |
| **Definition of maturity adopted** | None provided | | | | |
| **Implicit assumptions** | • Assumes weightings for different items assessed, however, no description of the way they are weighted is given nor are they changeable by the user. However, the weightings are changeable by Arup who set the tool up to change the weighting as the environment changes and as the AEC industry evolves and changes. ARUP maintains the integrity to track back.<br>• For project assessment, it is assumed that the "project maturity" can be assessed across 11 broad topics (EIR, open standards, contracts, among others).<br>• For disciplines (up to 31 disciplines divided into primary and secondary disciplines) "maturity assessment", the topics assessed are mostly the same therefore, assumes that each discipline is involved in the same capabilities on a BIM project. There is the opportunity to add additional discipline-specific metrics (there is a placeholder for these) for each discipline but not the opportunity to remove all the common metrics. | | | | |
| **Intended use** | • To assess the "project BIM maturity" and the "BIM maturity" of the different disciplines involved in the project.<br>• "To highlight successes (good practice by analysing data from the tool applications across many projects) and areas for improvement".<br>• It is a high-level assessment intended to be applied to a high number of projects not just a few.<br>• The tool is not intent to be used for a certification and not an audit; rather it is used to assess a wide range of projects that gives confidence to people using the tool to assess their projects. | | | | |
| **Intended users** | Individuals from projects and disciplines involved in the project. Attributes of users from both project and disciplines are not specified. | | | | |
| **Use setting** | Offline protected, electronic MS Excel workbook. Organisations can unprotect the tool and adapt it. Internally in Arup, it is an online assessment where projects are uploaded to the tool and individuals can use it online. | | | | |
| **What maturity level/index is used? Number of levels?** | 6-level scale from 0-5: 0 – non-existent, 1 – initial, 2 – managed, 3 – defined, 4 – measured, 5 – optimizing | | | | |
| **Topics and items assessed, and number of measures?** | For the ***Project assessment***, there are 11 topics (referred to as questions) to be assessed:<br>• Client specifies BIM requirements e.g. through an employer's information requirement (EIR);<br>• BIM design data review;<br>• BIM Execution Plan (BEP);<br>• Project procurement route;<br>• Common data environment (CDE);<br>• Document/model referencing, version control and status;<br>• Marketing strategy; | | For ***Discipline assessment***, there are 11 topics (referred to as questions) applicable to all disciplines and discipline specific elements that can be added to: 3D coordination;<br>• Drawings;<br>• Level of information/detail;<br>• Discipline model reviews;<br>• Embedded data, schedules and specifications (discipline specific measure but no description of the maturity index is provided);<br>• Visualisation;<br>• 4D (construction sequencing);<br>• 5D (quality and cost); | | |

| | |
|---|---|
| | • Virtual design reviews (VDR);<br>• Open standard deliverables;<br>• BIM contractual obligations;<br>• BIM champion.<br>• Links to design analysis tools;<br>• Handover to contractor;<br>• Use in operations and FM. |
| | Note, internally to Arup, some of the disciplines' criteria have been completely personalised and with different sets of criteria. |
| **Scoring model** | For ***Project assessment***, the achieved maturity level (on 0 to 5 scale) for a topic (out of the 11 topics above) is multiplied by its assumed weight to calculate an 'adjusted score' for the selected area. Then, all 'adjusted scores' for the assessed topics are converted, using the weighted average, into a project maturity score.<br>For ***Discipline assessment***, the same scoring method above is used with the difference that it is applied for the 11 discipline's topics above. |
| **Level of Evidence [Required/requested?]** | None required or requested. |
| **Assessor Requirements** | None specified. |

**Quality of assessment offered by the tool in terms of good practice of performance management**

- **Accuracy and applicability of metrics**
- **Attainability of benchmarks and logical progression towards benchmark targets**
- **Flexibility and consistency of assessment**
- **Neutrality of metrics**
- **Use of assessment outcomes to provide informative feedback for improvement**

Descriptions are generally high level (e.g. "discussion with a contractor of implementation of an industry BIM Standard" and several items lack the description for some "maturity" levels.

The description of levels for 'most' topics/items is not aimed to measure maturity but the adoption of certain capabilities (e.g. use of open standard) on projects. The description of levels confuses the concept of "extend of a capability" (maturity) with the evidence required. For example, for the "open standard deliverables" level 5 (optimising) is attained with "successful client handover of IFC/COBie as deliverables" which is a level denoting evidence instead of a target that can be reached following the index in logical progression.

One good example/topic that assesses maturity is "BIM Champion" in the project assessment. Most of the other topics are assessed in terms of the availability of a certain requirements/activity/practice and its diffusion ("the extent of …") across the project team (for example, see the CDE topic in Project assessment) or within the discipline/organisation involved. Measuring the extent of practicing certain abilities/activities is a partial interpretation of maturity assessment that still preclude the assessment of the quality, repeatability and degree of excellence across the topics assessed. Moreover, inspecting the description of the 6 level of several topics, some of the issues include: some capabilities (for example, "internal company using CDE" are scored as high as "level 3 maturity" (Defined). Some compliance requirements (for example, "working to an agreed BEP becomes a contractual requirements …") is assigned the highest level of maturity (i.e. optimised). Some ad-hoc capabilities (for example, "ad-hoc 3D coordination" are assigned a maturity score of 2 (Managed). All these aspects limit both the accuracy of the "maturity" assessment obtained and its true reflection of maturity assessment. The tool can be used to measure the diffusion/extent of certain capabilities across a project and the disciplines involved.

Consistency of assessment may be challenged by the short/broad description provided for the 6 levels.

The description of the maturity index allows logical progression towards future benchmarks in terms of diffusion of certain capabilities (e.g. expand use of LOD requirements from internal use, to some project parties, to all project parties).

It is not possible to tailor the assessment (e.g. weighted average is always done based on 11 areas without allowing users to remove topics that may not be relevant to the project or the discipline). However, it can be tailored in the way the data are analysed and communicated.

The established weights for certain topics – without the possibility of altering them – serve the benchmark purpose of this tool.

The tool does not provide feedback for improvement for projects and disciplines that complete the assessment. However, internally, the team shares reports and feedback with all groups and skills networks. In several groups and regions, best practices are identified and events are organised to present these case studies more broadly. The only output is their score against the industry average.

The metrics used for the assessment are neutral and do not prejudice proprietary, non-proprietary, free, open or commercial solution.

| **Granularity of assessment** | Low ☒ | Moderate ☐ | High ☐ | Very High ☐ |
|---|---|---|---|---|

| **Usability of tool/model** (1=low, 5=high) | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Ease of use | ☐ | ☐ | ☒ | ☐ | ☐ |
| Quality/aesthetics of UI | ☐ | ☐ | ☒ | ☐ | ☐ |

| | | | | | |
|---|---|---|---|---|---|
| Help, dictionary, support | ☐ | ☒ | ☐ | ☐ | ☐ |
| **Completion effort/time** | Depends on how many disciplines are being assessed and how well the user knows the project being assessed. We estimate no more than 30 minutes per discipline for a user who is familiar with the project/discipline. | | | | |
| **Case studies/research demonstrating application of the tool/model** | There are no case studies available publicly, however, there are case studies internally, and Arup would happy and keen to publish some.<br>Azzouz, A., and Hill, P. (2017) 'How BIM is Assessed Using ARUP's BIM Maturity Measure?' In: Chan, P W and Neilson, C J (Eds) *Proceeding of the 33rd Annual ARCOM Conference*, 4-6 September, Cambridge, UK, pp. 35-44.<br>Links to other publications:<br>• https://www.researchgate.net/publication/325576044_Digital_innovation_in_Europe_Regional_differences_across_one_international_firm<br>• https://www.researchgate.net/publication/317579642_Hunting_for_perfection_How_Arup_measures_BIM_maturity_on_projects_worldwide<br>• https://www.researchgate.net/publication/305115558_Using_the_Arup_BIM_Maturity_Measure_to_Demonstrate_BIM_Implementation_in_Practice<br>• https://www.architectsjournal.co.uk/buildings/why-measure-bim-and-what-should-you-measure/10024528.article<br>• http://www.bimplus.co.uk/people/which-country-most-bim-mature-europe/ | | | | |
| **License to use** | No. | | | | |
| **Additional information** | This model appears on the ICE website too. The version assessed was the tool available from ICE website as it appeared to be a later version (i.e. the filename was Ver_200 whereas the version from Arup's website had Ver_100). There are minor differences in the two documents but they will yield the same results. | | | | |

## Comparison against ISO 19650

| ISO 19650 Clauses | | Items (lowest level of granularity within the tool) |
|---|---|---|
| Assessment and Need [ISO 19650-2 Clause 5.1] | 5.1.1 | No items map |
| | 5.1.2 | No items map |
| | 5.1.3 | No items map |
| | 5.1.4 | No items map |
| | 5.1.5 | No items map |
| | 5.1.6 | No items map |
| | 5.1.7 | Common Data Environment (CDE) – measures the extent of which a Common Data Environment (CD) is used to facilitate sharing of information models [Project] 5.1.7/5.3.5 |
| | 5.1.8 | |
| | | |
| Invitation to Tender [ISO 19650-2 Clause 5.2] | 5.2.1 | Client specifies BIM requirements e.g. through an Employer's Information Requirement (EIR) – measures the extent of which the client requirements for BIM have been defined and implemented [Project] 5.2.1 |
| | 5.2.2 | No items map |
| | 5.2.3 | No items map |
| | 5.2.4 | No items map |
| | | |
| Tender Response [ISO 19650-2 Clause 5.3] | 5.3.1 | No items map |
| | 5.3.2 | BIM Execution Plan (BEP) – measures the extent of which the Project uses a BIM Execution Plan (BEP) to formalise how information will be managed and delivered in accordance with client requirements [Project] 5.3.2/5.4.1 |
| | 5.3.3 | Project Procurement Route – measures the extent consideration of BIM during procurement discussions with Contractors [Project] 5.3/5.4/5.5 |
| | 5.3.4 | No items map |
| | 5.3.5 | Common Data Environment (CDE) – measures the extent of which a Common Data Environment (CD) is used to facilitate sharing of information models [Project] 5.1.7/5.3.5 |
| | 5.3.6 | No items map |
| | 5.3.7 | No items map |
| | | |

| | | |
|---|---|---|
| Appointment [ISO 19650-2 Clause 5.4] | 5.4 | Project Procurement Route – measures the extent consideration of BIM during procurement discussions with Contractors [Project] 5.3/5.4/5.5 |
| | 5.4.1 | BIM Execution Plan (BEP) – measures the extent of which the Project uses a BIM Execution Plan (BEP) to formalise how information will be managed and delivered in accordance with client requirements [Project] 5.3.2/5.4.1 |
| | 5.4.2 | No items map |
| | 5.4.3 | No items map |
| | 5.4.4 | No items map |
| | 5.4.5 | No items map |
| | 5.4.6 | BIM Contractual Obligations – to what extent as the Project Team agreed & signed up to Contractual Obligations, in regards to BIM [Project] 5.4.6 |
| | 5.4.7 | |
| | | |
| Mobilization [ISO 19650-2 Clause 5.5] | 5.5 | Project Procurement Route – measures the extent consideration of BIM during procurement discussions with Contractors [Project] 5.3/5.4/5.5 |
| | 5.5.1 | No items map |
| | 5.5.2 | No items map |
| | 5.5.3 | No items map |
| | | |
| Collaborative production of Information [ISO 19650-2 Clause 5.6] | 5.6 | Document/Model Referencing, Version Control and Status – measures the extent of which model standard method and procedure has been carried out [Project] 5.6 |
| | 5.6.1 | No items map |
| | 5.6.2 | No items map |
| | 5.6.3 | Virtual Design Reviews (VDR) – measures the extent of which Virtual Design Reviews are conducted prior to issuing Model, for both Coordination and QA verification of deliverables [Project] 5.6.3/4<br>Open Standard deliverables – measures the extent of which Deliverables verified by open standard specifications, eg IFC, COBie [Project] 5.6.3/4<br>3D Coordination – measures the extent of which the Model is used as part of design coordination during Design and Construction phases [Discipline] 5.6.3/4<br>Drawings – measures the extent of which documentation, including drawings are derived directly from the model [Discipline] 5.6.3/4<br>Level of Information/Detail – measures the extent of which design outputs are controlled to only deliver the relevant information to a defined level of detail for each project stage [Discipline] 5.6.3/4<br>Discipline Model Reviews - measures the extent of which appropriate checking and validation has been applied as part of the information exchange process [Discipline] 5.6.3/4<br>Embedded Data, Schedules and Specifications – The 'I' in BIM, the ability to embed all relevant data into the model, to extract and use for all design and documentation aspects [Discipline] 5.6.3/4<br>Visualisation – measures the extent of which model visualisation is used as a design communication tool [Discipline] 5.6.3/4<br>4D (Construction Sequencing) – extent of which the model is used to facilitate construction sequencing [Discipline] 5.6.3/4<br>5D (Quantity and Cost) – to measure the extent of which the model is used to extract cost and quantity information [Discipline] 5.6.3/4<br>Links to Design Analysis Tools – measures the extent to which the model is used as art of the design analysis process [Discipline] 5.6.3/4<br>Handover to Contractor – measures the extent of which the model is developed to integrate with the project construction phase [Discipline] 5.6.3/4 |
| | 5.6.4 | Use in Operations and FM – measures the extent of which the model is developed to support the Operations and FM phase [Discipline] 5.6.4<br>Virtual Design Reviews (VDR) – measures the extent of which Virtual Design Reviews are conducted prior to issuing Model, for both Coordination and QA verification of deliverables [Project] 5.6.3/4<br>Open Standard deliverables – measures the extent of which Deliverables verified by open standard specifications, eg IFC, COBie [Project] 5.6.3/4<br>3D Coordination – measures the extent of which the Model is used as part of design coordination during Design and Construction phases [Discipline] 5.6.3/4<br>Drawings – measures the extent of which documentation, including drawings are derived directly from the model [Discipline] 5.6.3/4 |

| | | |
|---|---|---|
| | | Level of Information/Detail – measures the extent of which design outputs are controlled to only deliver the relevant information to a defined level of detail for each project stage [Discipline] 5.6.3/4<br>Discipline Model Reviews - measures the extent of which appropriate checking and validation has been applied as part of the information exchange process [Discipline] 5.6.3/4<br>Embedded Data, Schedules and Specifications – The 'I' in BIM, the ability to embed all relevant data into the model, to extract and use for all design and documentation aspects [Discipline] 5.6.3/4<br>Visualisation – measures the extent of which model visualisation is used as a design communication tool [Discipline] 5.6.3/4<br>4D (Construction Sequencing) – extent of which the model is used to facilitate construction sequencing [Discipline] 5.6.3/4<br>5D (Quantity and Cost) – to measure the extent of which the model is used to extract cost and quantity information [Discipline] 5.6.3/4<br>Links to Design Analysis Tools – measures the extent to which the model is used as art of the design analysis process [Discipline] 5.6.3/4<br>Handover to Contractor – measures the extent of which the model is developed to integrate with the project construction phase [Discipline] 5.6.3/4 |
| | 5.6.5 | BIM Design Data Review – Measures the extent of which Pre-Bid and Post-Award reviews are undertaken to ensures client requirements are being met [Project] 5.6.5 |
| | | |
| Information model delivery [ISO 19650-2 Clause 5.7] | 5.7 | Document/Model Referencing, Version Control and Status – measures the extent of which model standard method and procedure has been carried out [Project] 5.6/5.7 |
| | 5.7.1 | No items map |
| | 5.7.2 | No items map |
| | 5.7.3 | No items map |
| | 5.7.4 | No items map |
| | | |
| Project close-out [ISO 19650-2 Clause 5.8] | 5.8.1 | No items map |
| | 5.8.2 | No items map |
| | | |
| Items that do not map to ISO 19650 | | Marketing Strategy – measures the extent of which BIM-specific Case Studies are prepared to showcase and share the key points [Project]<br>BIM Champion – measures the extent of maturity from the change team (BIM Champion and BIM Implementation Team) supporting the adoption across the organisation |

## Appendix D.4 BIM Working Group BMAT

### Information Extraction Card

| Name of Tool/method | BIM Working Group BMAT | | | | |
|---|---|---|---|---|---|
| **Author / owner** | Public Sector BIM Working Group | | **Country/Origin** | UK | |
| **Link to tool** | This tool is not available publicly. | | | | |
| **Date of release, and version assessed** | No date on the Excel workbook but the filename includes 180409 which suggests it could be from 2018. | | | | |
| **Tool used to assess** | Organisation ☐ | Project ☒ | Other: "Client BIM delivery" and "Supplier BIM delivery". | | |
| **Sector** | Building ☒ | Infrastructure ☒ | Other: | | |
| **Applicability** | Generic ☒ | Market-specific ☐ | Discipline-specific ☐ | | |
| | Used by public sector organisations. | | | | |
| **Definition of maturity adopted** | None offered. | | | | |
| **Implicit assumptions** | | | | | |
| **Intended use** | This is a 'non-badged' tool produced by the public sector BIM working group that is used by Government departments developing their own 'badged' versions. | | | | |
| **Intended users** | Project team answering the questions as collectively. | | | | |
| **Use setting** | Workshop/roundtable completing an editable Excel Workbook. | | | | |
| **What maturity level/index is used? Number of levels?** | Maturity is scored on a percentage basis. There are no definitions or categorisation of ranges. | | | | |
| **Topics and items assessed, and number of measures?** | • BIM Procurement / Employer Engagement (7 questions)<br>• BIM Delivery (12 questions)<br>• Data, Verification and Validation (5 questions)<br>• Collaborative Working (5 questions)<br>• Visualisation / Stakeholder Engagement (4 questions)<br>• Discipline based model authoring (5 questions)<br>• Construction (5 questions)<br>• Model based estimating and change management (4 questions) | | | | |
| **Scoring model** | 1. The questions should be answered in full by the end of each project stage, looking back over that stage.<br>2. The questions should be answered collectively by the project team, with the Employer Project Manager having the final say if there is disagreement.<br>3. The questions are the same for each project stage and therefore at the early stages of a project many of the answers will be 'No' - the intention is to show maturity growing throughout the project stages.<br>4. If at a given project stage the question is 'not applicable' then the answer given should be 'No'.<br>5. It would only be possible to score 100% at the end of Stage 6.<br>6. Where a team member does not agree with the answer given, the table at the bottom of each project stage gives them the opportunity to state their concerns.<br>7. Other team members do not have to agree with the written statements given, as long as the party making the statement is prepared to put their name to it.<br>All topics (See 'Capability maturity areas/topics' below) are assessed using Yes/No questions for all items. The score for each topic is then calculated as the % of questions answered with "yes". The average of all topics gives the project "maturity" score.<br>Separate scores are also calculated for the "Client BIM delivery" and "the Supplier BIM delivery" using the scoring method explained earlier. All topics except "BIM procurement/Employer Engagement" contributes to the "Supplier BIM delivery" score, and the following topics makes up the "client BIM delivery" score: BIM Procurement / Employer Engagement; Data, Verification and Validation; collaborative working; and visualisation and stakeholder engagement.<br>The score are displayed on a radar diagram for each project stage and a trend graph for stages is plotted. | | | | |

| | |
|---|---|
| **Level of Evidence [Required/requested?]** | None. Judgement is made by the project team. |
| **Assessor Requirements** | Members of the project team from the project being assessed. |

**Quality of assessment offered by the tool in terms of good practice of performance management**

- **Accuracy and applicability of metrics**
- **Attainability of benchmarks and logical progression towards benchmark targets**
- **Flexibility and consistency of assessment**
- **Neutrality of metrics**
- **Use of assessment outcomes to provide informative feedback for improvement**

The tool mainly assesses the compliance of the project's activities/deliverables with BIM level 2 standards and guidelines and provides scores for: "BIM Maturity Project", "Client BIM Delivery", and "Supplier BIM delivery". The items, assessed under each topic with Yes/No, are in checklists. There are no maturity levels to measure the extent of abilities and quality of deliverables. The checklists remain fixed for all stages while not all options are relevant to all stages.
The tools establishes target scores (called "level of maturity that might/should be expected at each project stage) for each topic across all project stages. For example, for the "BIM Procurement/Employer Engagement" topic, this is set as 56% at Stage 1, 86% at Stage 2, and 100% at Stage 3. Progression across these levels is achieved simply by answering "yes" to some/all of the 7 questions asked for this topic.
Consistency of scores is possible as the assessment is completed and agreed upon within a collaborative team effort. Where members do not agree, the Employer's Project Manager makes the deciding vote. However, the accuracy of compliance levels may be affected by some double counting; completion/perfection of compliance checklists; scoring approach (i.e. in Data, verification and validation, there are items specific to the supplier that are still counted in the client's score); and the syntax of certain items (e.g. Health & Safety information has been or is planned to be supplied as described in the BEP).
The feedback for improvement is limited as the options given to assess each topic are in the form of checklists.

| | | | | | |
|---|---|---|---|---|---|
| **Granularity of assessment** | Low ☒ | | Moderate ☐ | High ☐ | Very High ☐ |
| **Usability of tool/model** (1=low, 5=high) | 1 | 2 | 3 | 4 | 5 |
| Ease of use | ☐ | ☐ | ☒ | ☐ | ☐ |
| Quality/aesthetics of UI | ☐ | ☐ | ☒ | ☐ | ☐ |
| Help, dictionary, support | ☐ | ☐ | ☐ | ☒ | ☐ |
| **Completion effort/time** | Given the setting for completion of this assessment, it is likely to take a minimum of one hour, however, it could take significantly longer if there are disagreements within the team and evidence are asked to corroborate the answers. It also depends on the stage of the project. | | | | |
| **Case studies/research demonstrating application of the tool/model** | None available. | | | | |
| **License to use** | No. | | | | |
| **Additional information** | | | | | |

## Comparison against ISO 19650

| ISO 19650 Clauses | | Items (lowest level of granularity within the tool) |
|---|---|---|
| Assessment and Need [ISO 19650-2 Clause 5.1] | 5.1.1 | – 1f The Employer has a nominated Information Manager for the project? [BIM Procurement / Employer Engagement] 5.1.1 |
| | 5.1.2 | No items map |
| | 5.1.3 | No items map |
| | 5.1.4 | No items map |
| | 5.1.5 | No items map |
| | 5.1.6 | No items map |
| | 5.1.7 | – 4a The Employer CDE has been used throughout the appropriate stages of project by the supplier to PAS1192-3 [Collaborative working] 5.1.7 |
| | 5.1.8 | No items map |
| | | |
| Invitation to Tender [ISO 19650-2 Clause 5.2] | 5.2.1 | – 1a The Employers Information Requirements (EIR) document has been issued for the project [BIM Procurement / Employer Engagement] 5.2.1<br>– 1e Where specific BIM surveys are required by the Employer, the purpose, format and extent of the surveys has been made clear in the EIR (for example point cloud surveys) [BIM Procurement / Employer Engagement] 5.2.1 |

| | | |
|---|---|---|
| | 5.2.2 | No items map |
| | 5.2.3 | No items map |
| | 5.2.4 | No items map |
| | | |
| Tender Response [ISO 19650-2 Clause 5.3] | 5.3.1 | No items map |
| | 5.3.2 | No items map |
| | 5.3.3 | No items map |
| | 5.3.4 | No items map |
| | 5.3.5 | No items map |
| | 5.3.6 | No items map |
| | 5.3.7 | No items map |
| | | |
| Appointment [ISO 19650-2 Clause 5.4] | 5.4 | – 1b The Information Delivery Plan (IDP) is comprehensive providing sufficient general & specific employer information requirements for the plan of work stage for the supplier to deliver to [BIM Procurement / Employer Engagement] 5.4<br>– 1c The IDP has been adequately defined in the context of the project, detailing the deliverables, formats, Level of Definition (both Level of Detail and Level of Information) for the work stage to be contractually adopted [BIM Procurement / Employer Engagement] 5.4<br>– 1d Project specific Government Soft Landings (GSL) requirements have been provided, including defined outcome measurement, for a defined post operational evaluation process [BIM Procurement / Employer Engagement] 5.4 |
| | 5.4.1 | – 2b The BIM Execution Plan (BEP) is comprehensive, providing sufficient information about how the EIR and IDP are to be delivered at all project stages [BIM Delivery] 5.4.1 |
| | 5.4.2 | No items map |
| | 5.4.3 | No items map |
| | 5.4.4 | No items map |
| | 5.4.5 | – 2c A comprehensive Master Information Delivery Plan (MIDP) has been provided, that confirms delivery in response to the entire IDP [BIM Delivery] 5.4.5 |
| | 5.4.6 | No items map |
| | 5.4.7 | No items map |
| | | |
| Mobilization [ISO 19650-2 Clause 5.5] | 5.5.1 | – 1g If required (see PAS1192-5), the Employer has a nominated Security Manager for the project? [BIM Procurement / Employer Engagement] 5.5.1<br>– 2d The supplier has a nominated Information Manager for the project [BIM Delivery] 5.5.1 |
| | 5.5.2 | No items map |
| | 5.5.3 | No items map |
| | | |
| Collaborative production of Information [ISO 19650-2 Clause 5.6] | 5.6.1 | – 4b A Supplier CDE has been used throughout the appropriate stages of the project by the supplier to PAS1192-2 [Collaborative working] 5.6.1<br>– 6d All drawings and documents are also managed and accessible via the supplier and employer CDE [Discipline based model authoring] 5.6.1 |
| | 5.6.2 | – 3c Published information: files and data has been verified (complete) & validated (correct) by the supplier prior to receipt into the Employer's Common Data Environment (CDE) [Data, Verification and Validation] 5.6.2<br>– 4e The resolved coordinated BIM is being comprehensively referenced for site construction information [Collaborative working] 5.6.2<br>– 5b Use of federated model/data to present visualisation has taken place with stakeholders and benefits have been identified [Visualisation / Stakeholder Engagement] 5.6.2<br>– 5c The federated model/data is being used as part of GSL processes by the supplier [Visualisation / Stakeholder Engagement] 5.6.2<br>– 5d The federated model/data is being used as part of GSL processes by the employer/FM provider [Visualisation / Stakeholder Engagement] 5.6.2<br>– 6e Lower tier suppliers play an appropriate part in model authoring / content [Discipline based model authoring] 5.6.2<br>– 7a Modelling based planning / efficient construction process is has been undertaken [Construction] 5.6.2<br>– 7b Visual scheduling / sequencing has been carried out [Construction] 5.6.2<br>– 7c Model use for safety planning in pre-construction and construction [Construction] 5.6.2<br>– 7d Model use for testing and commissioning [Construction] 5.6.2<br>– 8a Model use for cost estimating [Model based estimating and change management] 5.6.2 |

| | | |
|---|---|---|
| | | – 8b Model use for quantity take off [Model based estimating and change management] 5.6.2<br>– 8c Model use change management / value engineering, including proposed design enhancements and what-if scenario cost impacts/assessments [Model based estimating and change management] 5.6.2<br>– 8d Model use detailed estimating, focusing detail on the parts that have a high risk [Model based estimating and change management] 5.6.2 |
| | 5.6.3 | – 2e The information security requirements are being adhered to and aligned to the general project security requirements [BIM Delivery] 5.6.3<br>– 3a Information and Data security policy is detailed in the Post BEP in line with the EIR and it is being applied [Data, Verification and Validation] 5.6.3<br>– 4c Iterative clash detection and mitigation processes are clearly set out and are being adhered to [Collaborative working] 5.6.3<br>– 5a Regular team reviews are taking place, including with the client team, clearly using an interactive federated model/data [Visualisation / Stakeholder Engagement] 5.6.3 |
| | 5.6.4 | – 4d Risks are being identified and mitigated by using BIM processes, including, but not limited to, stakeholder engagement and clash detection [Collaborative working] 5.6.4 |
| | 5.6.5 | No items map |
| | | |
| Information model delivery [ISO 19650-2 Clause 5.7] | 5.7.1 | |
| | 5.7.2 | – 3b Data is being provided in COBie to BS1192-4 [Data, Verification and Validation] 5.7.2<br>– 6a Federated discipline based models have been provided with a stage appropriate data sets [Discipline based model authoring] 5.7.2<br>– 6b The current model reflects the current design intent or as-built condition, as appropriate [Discipline based model authoring] 5.7.2<br>– 6c Buildability reviews have been carried out using the federated/discipline models [Discipline based model authoring] 5.7.2<br>– 7e O&M Manual referenced to the model as a minimum & included in the MIDP [Construction] 5.7.2 |
| | 5.7.3 | |
| | 5.7.4 | – 2a The supplier has delivered BIM processes as described in the BIM Execution Plan (BEP) [BIM Delivery] 5.7.4<br>– 2f Surveys have been carried out in the format and to the extent described in the EIR/IDP [BIM Delivery] 5.7.4<br>– 2g Design management coordination and optimisation is being carried out as described in the BEP [BIM Delivery] 5.7.4<br>– 2h Commissioning has been or is planned to be supplied as described in the BEP [BIM Delivery] 5.7.4<br>– 2i O&M information has been or is planned to be supplied as described in the BEP [BIM Delivery] 5.7.4<br>– 2j Health & Safety information has been or is planned to be supplied as described in the BEP [BIM Delivery] 5.7.4<br>– 2k The supplier has provided information exchanges as required by the EIR/IDP and as detailed in the suppliers BEP/MIDP [BIM Delivery] 5.7.4<br>– 2l The supplier has provided published stage information exchanges complete with COBie data as defined in the EIR [BIM Delivery] 5.7.4<br>– 3d Published information: files and data received is being validated (complete) by the employer on receipt into the Employer's CDE [Data, Verification and Validation] 5.7.4<br>– 3e Employer information verification issues are being reported back to the supplier [Data, Verification and Validation] 5.7.4 |
| | | |
| Project close-out [ISO 19650-2 Clause 5.8] | 5.8.1 | No items map |
| | 5.8.2 | No items map |
| | | |
| Items that do not map to ISO 19650 | | No items map |

## Appendix D.5 Dstl BIM Maturity Measurement Tool

### Information Extraction Card

| Name of Tool/Model | Dstl BIM Maturity Measurement Tool | | | |
|---|---|---|---|---|
| **Supporting document(s)** | https://www.dropbox.com/s/l8xvet5melp2gqg/Dstl%20BIM%20Maturity%20Measurement%20Tool.xlsx?dl=0 | | | |
| **Author / owner** | Dstl | | **Country/Origin** | UK |
| **Date of release, and version assessed** | 2016 as indicated by CDBB. No date appears on the version of the tool assessed. Version assessed was acquired by CDBB. | | | |
| **Tool used to assess** | Organisation ☐ | Project ☒ | Other: ☒ "Project BIM Maturity", "Client BIM delivery" and "Supplier BIM delivery". | |
| **Sector** | Building ☒ | Infrastructure ☒ | Other: | |
| **Applicability** | Generic ☒ | Market-Specific ☐ | Discipline-Specific ☐ | |
| **Definition of maturity adopted** | None provided. | | | |
| **Implicit assumptions** | It is assumed that this tool follows the same method of assessment as that of the Government BMAT. | | | |
| **Intended use** | For use on Dstl projects, amended from the Government BIM Working Group (BMAT) tool. | | | |
| **Intended users** | Project teams as a collective. | | | |
| **Use setting** | Workshop/roundtable completing the editable Excel workbook. | | | |
| **Workshop Scoring Method** | Considering the method for the Government BMAT on which this tool is based, the project team completes the questionnaire (yes/no responses) based on the questions covering the eight areas below. This automatically populates the stage summaries with percentage scores. | | | |
| **What maturity level/index is used? Number of levels?** | Maturity is given as a percentage score for each area of measurement. No description of ranges across percentage scores. | | | |
| **What are the capability maturity areas/topics (process, outcomes) assessed, and number of measures?** | 8 areas assessed, 46 'primary questions'. Measures have been summarised to be more concise.<br>1. BIM Procurement/Employer Engagement<br>a. Project-bespoke EIR<br>b. EIR is comprehensive for stage<br>c. EIR contains comprehensive IPD<br>d. EIR contains GSL requirements<br>e. EIR contains BIM Survey requirements<br>f. Employer-nominated Information Manager<br>g. Employer-nominated Security Manager<br>2. BIM Delivery<br>a. BIM processes delivered as in BEP<br>b. BEP is comprehensive<br>c. Post BEP includes Master IDP corresponding to IDP<br>d. Supplier-dedicated Information Manager<br>e. General BIM security requirements adhered to in line with project security requirements<br>f. Surveys conducted as per EIR<br>g. Design management coordination and optimisation conducted as in BEP<br>h. Commissioning planned to be supplied as per BEP<br>i. O&M information planned to be supplied as per BEP<br>j. Health & Safety information planned to be supplied as per BEP<br>k. Supplier has provided information exchanges (data drops) as per EIR Suppliers BEP<br>l. Supplier provided information exchanges in the correct format as per EIR<br>3. Data, verification and validation<br>a. Data security policy detailed & applied as in Post BEP & EIR<br>b. Data provided in COBie to BS1192-4.<br>c. Data received & verified by supplier as complete into AIM CDE<br>d. Data received & validated by supplier as accurate into AIM CDE<br>e. Information verification issues reported back to supplier | | | |

| | |
|---|---|
| | 4. Collaborative working<br>a. Employer CDE used throughout project by supplier, to PAS1192-3<br>b. Supplier team used a CDE to PAS1192-2<br>c. Iterative clash detection and mitigation processes clearly set out and adhered to<br>d. Proven that risks are being identified and mitigated by use of BIM processes, including e.g. stakeholder engagement and clash detection<br>e. Resolved coordinated BIM is being comprehensively referenced for site construction information<br>5. Visualisation / Stakeholder Engagement<br>a. Regular team reviews taken place, inc. client team, using federated model/data<br>b. Federated model/data used to present visualisation took place with stakeholders and benefits identified<br>c. Federated model/data being used as part of GSL processes by supplier<br>d. Federated model/data being used as part of GSL processes by employer/FM provider<br>6. Discipline based model authoring<br>a. Federated discipline based models provided with stage appropriate data sets<br>b. Current model reflects current design intent / as-built<br>c. Buildability reviews carried out using federated/discipline models<br>d. All drawings and docs accessible via the CDE<br>e. Lower tier suppliers play appropriate part in model authoring / content<br>7. Construction<br>a. Modelling based planning and efficient construction process identification undertaken.<br>b. Visual scheduling / sequencing carried out<br>c. Model use for safety planning in pre-construction and construction<br>d. Model use for testing and commissioning<br>e. O&M Manual referenced to the model as a minimum<br>8. Model based estimating and change management<br>a. Model used for cost estimating<br>b. Model used for quantity take off<br>c. Change management / value engineering, inc. proposed design enhancements and what-if scenario cost impacts, assessed using modelling<br>d. Appropriate use of model for detailed estimating, focusing detail on parts with high risk |
| **Scoring model** | Each question requires a yes or no response. The score for each topic is then calculated as the % of questions answered with "yes". The average of all topics gives the project "maturity" score.<br>Separate scores are also calculated for the "Client BIM delivery" and "the Supplier BIM delivery" using the weighting calculations below with a 60/40 client/supplier ratio.<br>The score are displayed on a radar diagram for each project stage and a trend graph for stages is plotted.<br>**Weighting calculations:**<br>Client questions - 1 7 70%<br>Client questions - 3 1 10%<br>Client questions - 4 1 10%<br>Client questions - 5 1 10%<br>10 100%<br><br>Supplier questions - 2 12 32%<br>Supplier questions - 3 4 11%<br>Supplier questions - 4 4 11%<br>Supplier questions - 5 3 8%<br>Supplier questions - 6 5 14%<br>Supplier questions - 7 5 14%<br>Supplier questions - 8 4 11%<br>37 100% |

| | |
|---|---|
| | Overall score for client weighted according to proportion of positive responses to client questions; overall score for supplier weighted according to proportion of positive responses to supplier questions ; overall score for project weighted according to a 60% 40% ratio client:supplier. |
| **Level of Evidence [Required/requested?]** | None requested. Judgement is made by the project team. |
| **Assessor Requirements** | Members of the project team from the project being assessed. |

**Quality of assessment offered by the tool in terms of good practice of performance management:**

- **Accuracy and applicability of metrics**
- **Attainability of benchmarks and logical progression towards benchmark targets**
- **Flexibility and consistency of assessment**
- **Neutrality of metrics**
- **Use of assessment outcomes to provide informative feedback for improvement**

The tool mainly assesses the compliance of the project's activities/deliverables with BIM level 2 standards and guidelines and provides scores for: "BIM Maturity Project", "Client BIM Delivery", and "Supplier BIM delivery". The items, assessed under each topic with Yes/No, are in checklists. There are no maturity levels to measure the extent of abilities and quality of deliverables. Unlike the Government BMAT, there are no separate tabs for different stages on the version assessed.
Maturity is measured throughout the project against changes from no to yes as the same assessment is made at the end of each stage where 100% can only achieved at the end of the final stage.
Consistency of scores is possible as the assessment is completed and agreed upon within a collaborative team effort. Where members do not agree, the Employer's Project Manager makes the deciding vote. However, the accuracy of compliance levels may be affected by some double counting; completion/perfection of compliance checklists; scoring approach (i.e. in Data, verification and validation, there are items specific to the supplier that are still counted in the client's score); and the syntax of certain items (e.g. Health & Safety information has been or is planned to be supplied as described in the BEP).
The feedback for improvement is limited as the options given to assess each topic are in the form of checklists.

| **Granularity of assessment** | Low ☒ | Moderate ☐ | High ☐ | Very high ☐ | | |
|---|---|---|---|---|---|---|
| **Usability of tool/model** (1=low, 5=high) | NA[26] | 1 | 2 | 3 | 4 | 5 |
| Ease of use | ☐ | ☐ | ☒ | ☐ | ☐ | ☐ |
| Quality/aesthetics of UI | ☐ | ☐ | ☒ | ☐ | ☐ | ☐ |
| Help, dictionary, support documentations. | ☐ | ☐ | ☒ | ☐ | ☐ | ☐ |
| Completion effort/time | Given the setting for completion of this assessment, it is likely to take a minimum of one hour, however, it could take significantly longer if there are disagreements within the team and evidence are asked to corroborate the answers. It also depends on the stage of the project. | | | | | |
| **Case studies demonstrating application of the tool/model** | None available. | | | | | |
| **Published research based on the tool** | None available. | | | | | |
| **License to use** | No. | | | | | |
| **Additional information** | | | | | | |

## Comparison against ISO 19650

| ISO 19650 Clauses | | Items (lowest level of granularity within the tool) |
|---|---|---|
| Assessment and Need [ISO 19650-2 Clause 5.1] | 5.1.1 | 1f. Does the Employer have a nominated Information Manager for the project? [BIM Procurement / Employer Engagement] 5.1.1 |
| | 5.1.2 | No items map |
| | 5.1.3 | No items map |
| | 5.1.4 | No items map |
| | 5.1.5 | No items map |
| | 5.1.6 | No items map |

[26] E.g. for methodologies providing approaches/metrics for maturity assessment but are not operationalised into tools.

| | | |
|---|---|---|
| | 5.1.7 | 4a. Employer Common Data Environment has been used throughout the project by the supplier, to PAS1192-3 [Collaborative working] 5.1.7 |
| | 5.1.8 | No items map |
| | | |
| Invitation to Tender [ISO 19650-2 Clause 5.2] | 5.2.1 | 1a. Employers Information Requirements (EIR) template has been made bespoke to the project [BIM Procurement / Employer Engagement] 5.2.1<br>1b. The EIR is comprehensive enough for the stage, providing sufficient information about not only what the client requires, but also the formats it is required in [BIM Procurement / Employer Engagement] 5.2.1<br>1c. The EIR contains a clear and comprehensive Information Delivery Plan (IDP), detailing the work stages when information is required [BIM Procurement / Employer Engagement] 5.2.1<br>1d. The EIR includes project specific Government Soft Landings (GSL) requirements [BIM Procurement / Employer Engagement] 5.2.1<br>1e. If specific BIM surveys are required by the Employer, the purpose, format and extent of the surveys has been made clear in the EIR (for example point cloud surveys) [BIM Procurement / Employer Engagement] 5.2.1 |
| | 5.2.2 | No items map |
| | 5.2.3 | No items map |
| | 5.2.4 | No items map |
| | | |
| Tender Response [ISO 19650-2 Clause 5.3] | 5.3.1 | No items map |
| | 5.3.2 | No items map |
| | 5.3.3 | No items map |
| | 5.3.4 | No items map |
| | 5.3.5 | No items map |
| | 5.3.6 | No items map |
| | 5.3.7 | No items map |
| | | |
| Appointment [ISO 19650-2 Clause 5.4] | 5.4.1 | 2b. The BIM Execution Plan (BEP) is comprehensive, providing sufficient information about how what the client requires is to be delivered in future project stages, including confirmation of formats [BIM Delivery] 5.4.1 |
| | 5.4.2 | No items map |
| | 5.4.3 | No items map |
| | 5.4.4 | No items map |
| | 5.4.5 | 2c. In addition to the answer to 2a, the Post BEP includes a comprehensive Master Information Delivery Plan (MIDP) that corresponds to the IDP [BIM Delivery] 5.4.5 |
| | 5.4.6 | No items map |
| | 5.4.7 | No items map |
| | | |
| Mobilization [ISO 19650-2 Clause 5.5] | 5.5.1 | 1g. If required (see PAS1192-5), does the Employer have a nominated Security Manager for the project? [BIM Procurement / Employer Engagement] 5.5.1<br>2d. The supplier has a dedicated Information Manager for the project [BIM Delivery] 5.5.1 |
| | 5.5.2 | No items map |
| | 5.5.3 | No items map |
| | | |
| Collaborative production of Information [ISO 19650-2 Clause 5.6] | 5.6.1 | 4b. Supplier team has used a Common Data Environment to PAS1192-2 [Collaborative working] 5.6.1<br>6d. All drawings and documents are also accessible via the CDE [Discipline based model authoring] 5.6.1 |
| | 5.6.2 | 3a. Data security policy is detailed in the Post BEP in line with the EIR and it is being applied [Data, Verification and Validation] 5.6.2<br>4e. The resolved coordinated BIM is being comprehensively referenced for site construction information [Collaborative working] 5.6.2<br>5b. Use of federated model/data to present visualisation took place with stakeholders and benefits have been identified [Visualisation / Stakeholder Engagement] 5.6.2<br>5c. The federated model/data is being used as part of GSL processes by the supplier [Visualisation / Stakeholder Engagement] 5.6.2<br>5d. The federated model/data is being used as part of GSL processes by the employer/FM provider [Visualisation / Stakeholder Engagement] 5.6.2<br>6e. Lower tier suppliers play an appropriate part in model authoring / content [Discipline based model authoring] 5.6.2 |

| | | |
|---|---|---|
| | | 7a. Modelling based planning and efficient construction process identification is being / has been undertaken [Construction] 5.6.2<br>7b. Visual scheduling / sequencing has been carried out [Construction] 5.6.2<br>7c. Model use for safety planning in pre-construction and construction [Construction] 5.6.2<br>7d. Model use for testing and commissioning [Construction] 5.6.2<br>8a. Model used for cost estimating [Model based estimating and change management] 5.6.2<br>8b. Model used for quantity take off [Model based estimating and change management] 5.6.2<br>8c. Change management / value engineering, including proposed design enhancements and what-if scenario cost impacts, assessed using modelling [Model based estimating and change management] 5.6.2<br>8d. Appropriate use of model for detailed estimating, focusing detail on the parts that have a high risk [Model based estimating and change management] 5.6.2 |
| | 5.6.3 | 4c. Iterative clash detection and mitigation processes are clearly set out and are being adhered to [Collaborative working] 5.6.3<br>5a. Regular team reviews have taken place, including the client team, using federated model/data [Visualisation / Stakeholder Engagement] 5.6.3 |
| | 5.6.4 | 3c. Data received has been verified, by the supplier, as being complete - on receipt into the AIM CDE [Data, Verification and Validation] 5.6.4<br>3d. Data received has been validated, by the supplier, as being accurate - on receipt into the AIM CDE [Data, Verification and Validation] 5.6.4<br>3e. Any information verification issues have been reported back to the supplier [Data, Verification and Validation] 5.6.4<br>4d. It can be proven that risks are being identified and are being mitigated by the use of BIM processes, including, but not limited to, stakeholder engagement and clash detection [Collaborative working] 5.6.4 |
| | 5.6.5 | No items map |
| | | |
| Information model delivery [ISO 19650-2 Clause 5.7] | 5.7.1 | No items map |
| | 5.7.2 | 3b. Data is being provided in COBie to BS1192-4 [Data, Verification and Validation] 5.7.2<br>6a. Federated discipline based models have been provided with a stage appropriate data sets [Discipline based model authoring] 5.7.2<br>6b. Does the current model reflect current design intent / as-built [Discipline based model authoring] 5.7.2<br>6c. Buildability reviews have been carried out using the federated/discipline models [Discipline based model authoring] 5.7.2<br>7e. O&M Manual referenced to the model as a minimum [Construction] 5.7.2 |
| | 5.7.3 | No items map |
| | 5.7.4 | 2a. The supplier has delivered BIM processes via the constituent parts described in the BIM Execution Plan (BEP) [BIM Delivery] 5.7.4<br>2e. The general BIM security requirements are being adhered to in line with the security requirements for the project [BIM Delivery] 5.7.4<br>2f. Surveys have been carried out in the format and to the extent described in the EIR [BIM Delivery] 5.7.4<br>2g. Design management coordination and optimisation is being carried out as described in the BEP [BIM Delivery] 5.7.4<br>2h. Commissioning has been or is planned to be supplied as described in the BEP [BIM Delivery] 5.7.4<br>2i. O&M information has been or is planned to be supplied as described in the BEP [BIM Delivery] 5.7.4<br>2j. Health & Safety information has been or is planned to be supplied as described in the BEP [BIM Delivery] 5.7.4<br>2k. The supplier has provided information exchanges (data drops) as required by the EIR and as detailed in the suppliers BEP [BIM Delivery] 5.7.4<br>2l. The supplier has provided the information exchanges in the correct format, as outlined in the EIR [BIM Delivery] 5.7.4 |
| | | |
| Project close-out [ISO 19650-2 Clause 5.8] | 5.8.1 | No items map |
| | 5.8.2 | No items map |
| | | |

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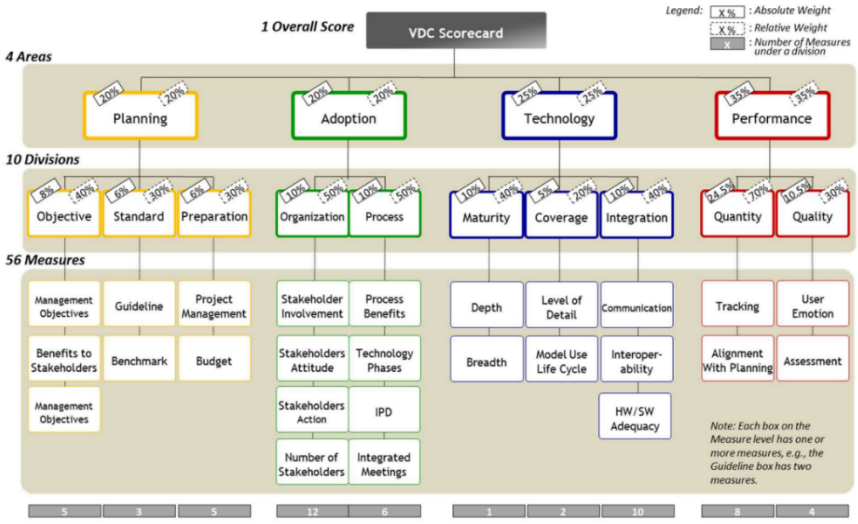
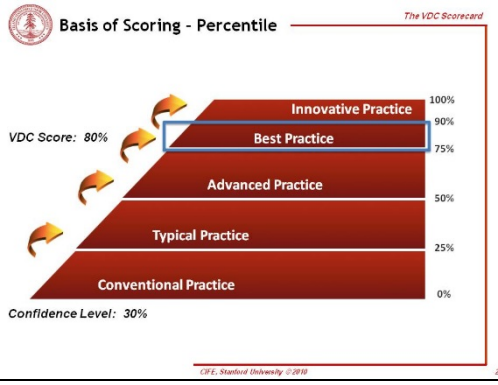
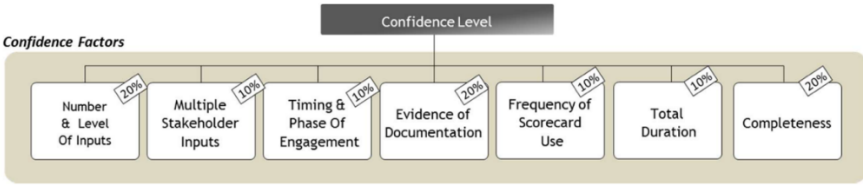
|---|---|
| Items that do not map to ISO 19650 | No items map |

## Appendix D.6 VDC Scorecard

### Information Extraction Card

| Name of Tool/method | VDC Scorecard | | | | | |
|---|---|---|---|---|---|---|
| **Author / owner** | Centre for Integrated Facility Engineers (CIFE), Stanford University | | **Country/Origin** | | USA | |
| **Link to tool** | https://vdcscorecard.stanford.edu/vdc-scorecard | | | | | |
| **Supporting document(s)** | Kam, C., Senaratna, D., McKinney, B., Xiao, Y. and Song, M. (2014) ' The VDC Scorecard: Formulation and Validation', CIFE, Stanford, UK. | | | | | |
| **Date of release, and version assessed** | Initial release 2009. Version assessed was dated 2012, available online. | | | | | |
| **Tool used to assess** | Organisation | ☐ | Project | ☒ | Other: | |
| **Sector** | Building | ☒ | Infrastructure | ☐ | Other: | |
| **Applicability** | Generic | ☒ | Market-specific | ☐ | Discipline-specific ☐ | |
| **Definition of maturity adopted** | None offered. | | | | | |
| **Implicit assumptions** | - Assumes five tiers of practice: conventional practice ranging from 0% to 25%, typical practice ranging from 25% to 50%, advanced practice ranging from 50% to 75%, best practice ranging from 75% to 90%, and best practice ranging from 90% to 100% percentile. This percentile system represents the industry norm against which projects are assessed. These levels were drawn based on experts' opinion.<br>- Uses an adaptive scoring system based on evolving industry norms instead of prefixed norms valid for a short period. Such a system is justified by the need to keep up with the rapid change of technologies. | | | | | |
| **Intended use** | "The VDC Scorecard evaluates the maturity of Virtual Design & Construction (VDC) in practice based on an industry performance rating framework, and measures the degree of VDC innovation in planning, adoption, technology, and performance." | | | | | |
| **Intended users** | AEC professionals can use the evaluation framework to track and assess VDC performances of their projects. | | | | | |
| **Use setting** | Interview | | | | | |
| **What maturity level/index is used? Number of levels?** | No details from the information available. However, the this document, available publicly [Link: PDF ], provides a list of the topics assessed and some of the metrics used. Questions asked and response options vary. | | | | | |
| **Topics and items assessed, and number of measures?** | The VDC Scorecard covers 4 areas of VDC (BIM) performance: **Planning, Adoption, Technology and Performance** including a total of **56 measures that are evaluated quantitatively or qualitatively**.<br>**Planning**: This area aligns defined quantitative and qualitative project objectives with desired business outcomes, and identifies standards, technologies, and resources that will be relevant to the project. It assesses<br>○ **Objective** sub-topics: communication improvement (meeting effectiveness, field-generated RFI, etc.), cost performance improvement (cost conformance, change order, etc.), schedule performance (schedule conformance, response latency, volume rework, etc.), facility performance (lifetime energy use, energy efficiency, post occupancy evaluation, etc.), safety performance (accident reduction, hazard identification using 3D), project quality (drawing coordination consistency, more and better design iteration), and other VDC management objectives.<br>○ **'Standard'** sub-topics such as the used VDC guidelines or BEP and their coverage (timing of deliverables, file naming structure, coordination plan, etc.)<br>○ **Preparation sub-topics:** the means used to communicate in projects for both personal interactions (face-to-face, video conference, etc.) and model exchange/management.<br>**Technology**: This area evaluates the models and analyses employed by assessing the maturity of the model uses, the level of detail of models across project phases, and the success of integration across technologies. It covers: | | | | | |

| | |
|---|---|
| | ○ **Integration sub-topics**: capturing most common format of model exchanges, most successful exchanges between model uses, challenges of bi-directional exchanges, and information loss.<br>○ **Coverage sub-topics**: it assesses the coverage of using "3D" across the building elements/systems (e.g. foundations, basement, etc.).<br>○ **Maturity sub-topics**: it capture the model uses (visualisation, model based analysis, integrated analysis, etc) over the project lifecycle<br>**Adoption**: This area assesses the organizations and processes involved in VDC by evaluating the success in aligning stakeholders' talents, motivations, incentives, and business structures to create integrated teams and processes that support the project objectives across all phases of the project. It assesses qualitatively and quantitatively:<br>○ **Process sub-topics:** assess broad project benefits (e.g. more alternative evaluated earlier, shorted total duration), efficiency of project meetings, and response to RFI (days).<br>○ **Organisation sub-topics:** assess aspects such as availability of VDC training, coverage of the training, % of time spent using VDC applications, availability of BIM champions, stakeholder attitude, diffusion of BIM, etc.<br>**Performance**: This area assesses the attainment of project objectives quantitatively (e.g. tracking, and alignment with project planning) and qualitatively (user emotion). |
| **Scoring model** |  <br><br>Figure 1. DC Scorecard Evaluation Framework (Kam et al., 2014)<br>- The 10 Scorecard Division scores are created using the 56 Scorecard Measures, in turn the 4 Scorecard Area scores are created using the 10 Scorecard Division scores and finally the total VDC score is created using a weighted sum of the 4 Scorecard Area scores.<br>- The Division scores are 10 measures created using a weighted average of Division-related metrics or measurements.<br>- No information is provided as to how to assess/estimate the 56 measures (although the units of measurements for many of them is known) and how their scores is rolled up into a division score.<br>- The score of the project will be benchmarked against the percentile system in the figure below.<br>  <br> |

| | |
|---|---|
| | - A confidence level is defined and is based on seven factors:<br>  |
| **Level of Evidence [Required/requested?]** | Can require extensive evidence (e.g. Evidence of Documentation with independent audit) if a high confidence level is required. |
| **Assessor Requirements** | VDC interviewer from CIFE |

**Quality of assessment offered by the tool in terms of good practice of performance management**

- **Accuracy and applicability of metrics**
- **Attainability of benchmarks and logical progression towards benchmark targets**
- **Flexibility and consistency of assessment**
- **Neutrality of metrics**
- **Use of assessment outcomes to provide informative feedback for improvement**

The tool is clearly conceived as a benchmark tool against industry-wide benchmarks that are movable targets over time. Measures covers a very wide range of topics but the levels or options available to the questions often are not exposed/explained in details. Most of the questions are capabilities (minimum abilities) types of questions (e.g. availability of BEP, means of interactions, etc.). There is a "maturity division" in which the tool captures the different model uses for different purposes such as: visualisation and communication; documentation; model based analysis; integrated analysis; and automation and optimisation, but it is likely (from looking at the PDF file) that these are assessed as capabilities (yes / no) – minimum abilities. There are several questions about benefits of VDC (e.g. improve communication, improve cost performance, improve schedule performance, reduce change order rates, identifying hazard, reducing incidents, drawing coordination consistency) that users are required to answer quantitatively in terms of actual performance, target performance (established by the organisation to form a baseline for the benefit assessment), and frequency of measurements. These questions are generally very difficult to answer and estimate accurately. The targets in these questions are specific to each individual organisation which may cast some doubt about the usefulness of the tool for benchmark purposes.

It is difficult to comment whether it is possible to attain a benchmark in a progressive manner given the large amount of both quantitative and qualitative measures involved and the concealed indices/measures. The same can be said for the consistency of assessment. However, according to the tool's developers "The Confidence Level also suffered in many of the projects" (Kam et al., 2014, p. 22).

The topics/items assessed are neutral and can be used in any project.

| **Granularity of assessment** | Low ☐ | Moderate ☐ | High ☒ | Very High ☐ |
|---|---|---|---|---|

| **Usability of tool/model** (1=low, 5=high) | N/A | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| Ease of use | ☒ | ☐ | ☐ | ☐ | ☐ | ☐ |
| | It is intended for use by a VDC researcher conducting an interview. The actual documents available appear to be PDFs of excel workbooks that are edited/completed by the interviewer and, therefore, makes the forms difficult to understand fully as not all options are visible in the PDF. | | | | | |
| Quality/aesthetics of UI | ☐ | ☒ | ☐ | ☐ | ☐ | ☐ |
| | As the form available is PDF, makes it difficult to see how it is used in practice and therefore is not user friendly nor visually appealing. | | | | | |
| Help, dictionary, support | ☒ | ☐ | ☐ | ☐ | ☐ | ☐ |

| | |
|---|---|
| **Completion effort/time** | "The average interviewing time taken for the Express Version was 4 hours. On average 51% of the measures were filled with certainty. In over 70% of the projects scored, at least both the Architect and the General Contractor were interviewed." |
| **Case studies/research demonstrating application of the tool/model** | See Kam et al. (2014) above. |
| **License to use** | No - but there is not sufficient information to successfully conduct a "self-assessment" based on the documents and information available here. |

## Comparison against ISO 19650

| ISO 19650 Clauses | | Items (lowest level of granularity within the tool) |
|---|---|---|
| Assessment and Need [ISO 19650-2 Clause 5.1] | 5.1.1 | No items map |
| | 5.1.2 | No items map |
| | 5.1.3 | No items map |
| | 5.1.4 | No items map |
| | 5.1.5 | No items map |
| | 5.1.6 | No items map |
| | 5.1.7 | No items map |
| | 5.1.8 | No items map |
| | | |
| Invitation to Tender [ISO 19650-2 Clause 5.2] | 5.2.1 | No items map |
| | 5.2.2 | No items map |
| | 5.2.3 | No items map |
| | 5.2.4 | No items map |
| | | |
| Tender Response [ISO 19650-2 Clause 5.3] | 5.3.1 | No items map |
| | 5.3.2 | – A1>D2>M1.0 Established VDC guidelines or BEP for: phase-, project-, programme-, enterprise-specific guideline or BEP [Planning - Standard] 5.3.2<br>– A1>D2>M2.0 Contents covered by VDC guidelines/BEP: project objectives; model leads/manager; training; responsibilities; coordination plan; conflict resolution; timing of BIM model; submission plan; Level of Detail; BIM/VDC uses; software used; interoperability; file naming structure; file sharing mgmt.; others/innovative [Planning - Standard] 5.3.2 |
| | 5.3.3 | No items map |
| | 5.3.4 | No items map |
| | 5.3.5 | No items map |
| | 5.3.6 | No items map |
| | 5.3.7 | No items map |
| | | |
| Appointment [ISO 19650-2 Clause 5.4] | 5.4 | No items map |
| | 5.4.1 | No items map |
| | 5.4.2 | No items map |
| | 5.4.3 | No items map |
| | 5.4.4 | No items map |
| | 5.4.5 | No items map |
| | 5.4.6 | No items map |
| | 5.4.7 | No items map |
| | | |
| Mobilization [ISO 19650-2 Clause 5.5] | 5.5.1 | – A2>D1>M9.0 Designated BIM Champion/Specialist [Adoption - Organization] 5.5.1 |
| | 5.5.2 | – A1>D3>M1.0 Means of interaction: tele-conference, face-to-face, video/web-conference, iRoom/Big Room, Others/Innovative [Planning - Preparation] 5.5.2<br>– A1>D3>M4.0 Available VDC software [Planning - Preparation] 5.5.2<br>– A1>D3>M5.0 Data sharing method [Planning - Preparation] 5.5.2 |
| | 5.5.3 | – A1>D3>M2.0+ Uses project or model management system: design fabrication; model/drawing documentation; RFI; transmittal; submittal; change order; schedule; progress report – includes labour, equipment, material; daily/weekly/monthly reports; quality control report; punchlist; cost report; others/innovative [Planning - Preparation] 5.5.3 |
| | | |
| Collaborative production of Information [ISO 19650-2 Clause 5.6] | 5.6.1 | No items map |
| | 5.6.2 | – A2>D2>M2.0 Model uses: visualization and communication; documentation; model-based analysis; integrated analysis; automation & optimization; other model uses [Adoption - Process] 5.6.2<br>– A3>D1>M1.0 Model uses: visualization and communication; documentation; model-based analysis; integrated analysis; automation & optimization; other model uses [Technology - Maturity] 5.6.2<br>– A3>D2>M1.0 Coverage of product - product elements modeled in 3D: foundations, basement, superstructure, enclosure, roofing, interior, stairs, conveying, plumbing, HVAC, fire protection, electrical, equipment, furnishings, site improvement, site mechanical utilities, site electrical utilities [Technology - Coverage] 5.6.2 |

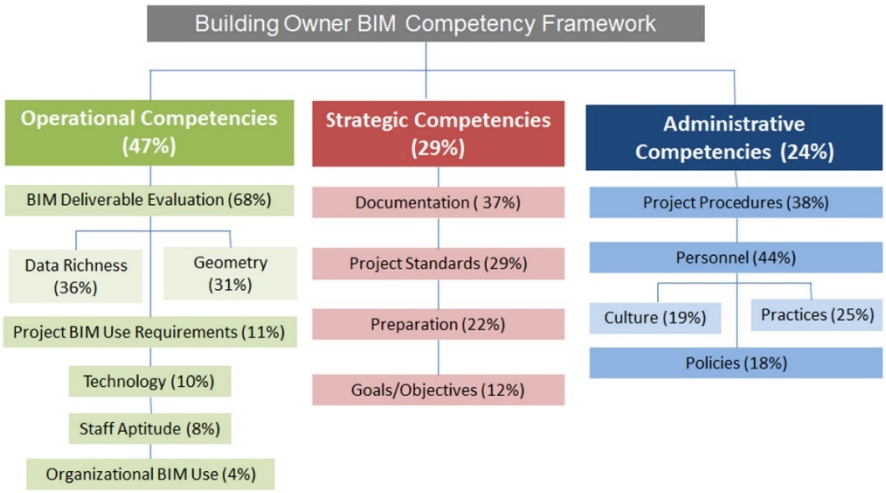
| | | |
|---|---|---|
| | | – A3>D3>M10.0 Model used for communications w/ customers/jurisdiction [Technology - Integration] 5.6.2 |
| | 5.6.3 | No items map |
| | 5.6.4 | No items map |
| | 5.6.5 | No items map |
| | | |
| Information model delivery [ISO 19650-2 Clause 5.7] | 5.7.1 | No items map |
| | 5.7.2 | A3>D3>M1.0 Format of model exchanges [Technology - Integration] 5.7.2 |
| | 5.7.3 | No items map |
| | 5.7.4 | No items map |
| | | |
| Project close-out [ISO 19650-2 Clause 5.8] | 5.8.1 | No items map |
| | 5.8.2 | No items map |
| | | |
| Items that do not map to ISO 19650 | | – A1>D1>M1.0+ Level of Formalization of VDC among stakeholders [Planning - Objective]<br>– A1>D1>M2.0a Established VDC objectives to improve: communication; cost performance; schedule performance; facility performance; safety; project quality; other objectives [Planning - Objective]<br>– A1>D1>M2.0b No. of quantitative objectives established [Planning - Objective]<br>– A1>D1>M2.0c Most important VDC objective [Planning - Objective]<br>– A1>D1>M3.0 Stakeholder benefits from objectives [Planning - Objective]<br>– A1>D2>M3.0 Contribution to future projects: phase-, project-, programme-, enterprise-specific guideline or BEP [Planning - Standard]<br>– A1>D3>M3.0 Established budget for VDC in project [Planning - Preparation]<br>– A2>D1>M1.0 Stakeholder motivated to leverage VDC to improve performance w/designated members w/explicit VDC responsibilities or involved in decision making [Adoption - Organization]<br>– A2>D1>M2.0 Good/better VDC skill of project team than proposed team [Adoption - Organization]<br>– A2>D1>M3.0 How often VDC training is offered [Adoption - Organization]<br>– A2>D1>M4.0 Enterprise level or project level training [Adoption - Organization]<br>– A2>D1>M5.0 % of time staff works with VDC applications [Adoption - Organization]<br>– A2>D1>M6.0 % FTE using VDC during peak phase [Adoption - Organization]<br>– A2>D1>M7.0 Starting/ending phase of stakeholder [Adoption - Organization]<br>– A2>D1>M8.0 Previous VDC experience of organization [Adoption - Organization]<br>– A2>D1>M10.0 Stakeholder's attitude toward VDC [Adoption - Organization]<br>– A2>D1>M11.0 Stakeholder's actions toward VDC [Adoption - Organization]<br>– A2>D1>M12.0 Organizational diffusion of BIM [Adoption - Organization]<br>– A2>D2>M1.0 Process benefits of using VDC: More alternatives evaluated earlier; Shorter total duration; Tight synchronization between design & fabrication; Last responsible moment benefit from VDC; Minimal waste in the process [Adoption - Process]<br>– A2>D2>M3.0 Project delivery method [Adoption - Process]<br>– A2>D2>M4.0+ Efficiency of VDC/BIM integrated project-wide meeting [Adoption - Process]<br>– A2>D2>M5.0 Response time to RFI [Adoption - Process]<br>– A2>D2>M6.0 Frequency of review of VDC/BIM processes and benefits thereof [Adoption - Process]<br>– A3>D2>M1.0 LoD for project phases: conceptual, approximate geometry, precise geometry; fabrication; as-built [Technology - Coverage]<br>– A3>D3>M2.0 Average information loss after model exchange [Technology - Integration]<br>– A3>D3>M3.0 Highest LoD for all model uses: visualization and communication; documentation; model-based analysis; integrated analysis; automation & optimization; other model uses [Technology - Integration]<br>– A3>D3>M4.0 LoD adequate for purpose: visualization and communication; documentation; model-based analysis; integrated analysis; automation & optimization; other model uses [Technology - Integration]<br>– A3>D3>M5.0 VDC software adequate for purpose: visualization and communication; documentation; model-based analysis; integrated analysis; automation & optimization; other model uses [Technology - Integration] |

| | |
|---|---|
| | – A3>D3>M6.0 VDC hardware adequate for purpose: visualization and communication; documentation; model-based analysis; integrated analysis; automation & optimization; other model uses [Technology - Integration]<br>– A3>D3>M7.0 Business impact of information loss: visualization and communication; documentation; model-based analysis; integrated analysis; automation & optimization; other model uses [Technology - Integration]<br>– A3>D3>M8.0 No. stakeholders using model: visualization and communication; documentation; model-based analysis; integrated analysis; automation & optimization; other model uses [Technology - Integration]<br>– A4>D1>M1.0 Frequency of measuring against VDC objectives [Performance - Quantity]<br>– A4>D1>M1.1 Frequency of measuring VDC objectives to improve: communication; cost performance; schedule performance; facility performance; safety; project quality; other objectives [Performance - Quantity]<br>– A4>D1>M2.0 Assessment of actual performance against VDC objectives to improve: communication; cost performance; schedule performance; facility performance; safety; project quality; other objectives [Performance - Quantity]<br>– A4>D1>M3.0 Primary contribution to: visualization; documentation; model-based analyses; integrated analyses; automation & optimization; other model uses[Performance - Quantity]<br>– A4>D1>M4.0 % of RFIs on time[Performance - Quantity]<br>– A4>D1>M5.0 Unforeseen change order rate [Performance - Quantity]<br>– A4>D1>M6.0 Field initiated change order rate [Performance - Quantity]<br>– A4>D1>M7.0 Percentage of target to improve & Maturity of target to improve: communication; cost performance; schedule performance; facility performance; safety; project quality; other objectives Performance - [Quantity]<br>– A4>D2>M1.0 Actual performance against VDC objectives [Performance - Quality]<br>– A4>D2>M2.0 Assessment of: visualization; documentation; model-based analyses; integrated analyses; automation & optimization; other model uses [Performance - Quality]<br>– A4>D2>M3.0 Satisfaction of stakeholders of VDC/BIM at coordination meetings & Importance of VDC/BIM coordination meetings to stakeholders [Performance - Quality]<br>– A4>D2>M4.0 Level of user emotion (satisfaction) [Performance - Quality] |

## Appendix E: Individual evaluations: BIM maturity methods

## Appendix E.1 Owner's BIMCAT (Competency Assessment Tool)

### Information Extraction Card

| Methodology | Owner's BIMCAT (competency assessment tool) | | |
|---|---|---|---|
| **Supporting document(s)** | Giel, B. and Issa, R. (2014) 'Framework for Evaluating the BIM Competencies of Building Owners', *2014 International Conference on Computing in Civil and Building Engineering*, June 23-25, Orlando, Florida, United States, pp. 552-559. DOI: https://doi.org/10.1061/9780784413616.069. | | |
| **Author / owner** | Giel and Issa (2013) | **Country/Origin** | USA |
| **Date of release, and version assessed** | 2013 | | |
| **Tool used to assess** | Organisation ☒ | Project ☐ | Other: |
| **Sector** | Building ☒ | Infrastructure ☐ | Other: |
| **Applicability** | Generic ☐ | Market-Specific ☐ | Discipline-Specific ☒ Building Owners |
| **Definition of maturity adopted** | None offered. | | |
| **Implicit assumptions** | The initial list of factors was derived from literature (other models in existence at the time – NBIMS CMM, BIM maturity matrix, BIM Quickscan, BIM proficiency matrix, VDC Scorecard, and owners' maturity matrix) making the assumption that those offered provided suitable representation.<br>The methods assumes there is a need to provide different weightings for the different competency areas and their factors. The final weighting below for the three competency areas was calculated following the application of weightings to each of the individual BIM competency factors, received from the final Delphi with 21 prequalified BIM experts.<br>• Operational competencies 49%<br>• Strategic competencies 29%<br>• Administrative competencies 24%<br>Weighting for the competence factors (items) is show in the figure below. | | |
| **Intended use** | To assess the BIM competency of building owners in the AECO industry. | | |
| **Intended users** | Building owners in the AECO industry. | | |
| **Use setting** | Self-assessment scorecard. | | |
| **What maturity level/index is used? Number of levels?** | **BIM competency level**<br>Level 0<br>Level 1<br>Level 2<br>Level 3<br>Level 4<br>Level 5 | **Name**<br>Non-existent<br>Initialized<br>Managed<br>Defined<br>Quantitatively managed<br>Optimizing | **Score range**<br>0–200<br>200–400<br>400–600<br>600–800<br>800–1,000<br>1,000–1,200 |
| **What are the capability maturity areas/topics (process, outcomes) assessed, and number of measures?** | There are 66 factors across three competency areas:<br>  | | |

<table>
<tr><td></td><td>Strategic Competencies<br>– Requirement for Project Process Maps<br>– Technology Improvement Plan<br>– R&D Efforts<br>– BIM Job Duties<br>– Organizational Charts with Roles and…<br>– Internal Benchmarking Strategies<br>– BIM standards and protocols<br>– BIM Planning Team<br>– Renovation BEP<br>– Organizational Business Process Maps<br>– BIM Implementation Guide<br>– Mission Statement<br>– Allocation of budget toward BIM<br>– BIM Execution Plan (BEP) Standard<br>– BIM Vision<br>– BIM Champion<br>– Required Project BIM Meetings<br>– QC Plan for checking BIM Deliverables</td><td>Administrative Competencies<br>– Evaluation Strategies for assigning BIM…<br>– Risk Management<br>– Project Benchmarking strategies<br>– Reliance on BIM for real-time information<br>– BIM Hiring Practices for new staff<br>– Organizational Change Readiness<br>– BIM Procurement Procedures<br>– Support Staff Buy-in<br>– Knowledge Management<br>– Life Cycle Views<br>– Change Management<br>– Delivery Methods which address BIM<br>– BIM Education Practices<br>– BIM Training Practices<br>– Contracts which address BIM<br>– Upper Management Buy-in</td><td>Operational Competencies<br>– Hardware Standards<br>– Dedicated space configured with technology<br>– Understanding of Relational Databases<br>– Construction Cost Data Req<br>– Disaster Mgmt Data Req<br>– Staff BIM Experience<br>– Networking Services<br>– Energy and Environmental Sustainability Data Req<br>– Software Standards<br>– Planning Phase Uses<br>– Design/Programming Data Req<br>– Systems Control and Monitoring Data Req<br>– Model Progression Specification<br>– Design Model Geometry<br>– BIM Capability<br>– Spatial Capability<br>– Existing Environment Integration<br>– Asset Model Geometry<br>– Maintenance Mgmt Data Req<br>– Model Element Classification<br>– O&M Phase Uses<br>– Space Mgmt Data Req<br>– Asset Mgmt Data Req<br>– Design for Maintenance Geometry<br>– Construction Model Geometry<br>– As-Built Model Geometry<br>– Design Collision Detection<br>– Construction Clash Detection<br>– LOD<br>– Design Phase Uses<br>– Construction Phase Uses<br>– FMS Data Transfer Req</td></tr>
<tr><td>Scoring model</td><td colspan="3">The tool/method consists of 124 total questions, for a maximum total score of 1,200 points.<br>BIM competency level | Name | Score range<br>Level 0 | Non-existent | 0–200<br>Level 1 | Initialized | 200–400<br>Level 2 | Managed | 400–600<br>Level 3 | Defined | 600–800<br>Level 4 | Quantitatively managed | 800–1,000<br>Level 5 | Optimizing | 1,000–1,200<br>No information is available about the question asked at item level and their corresponding score.</td></tr>
<tr><td>Assessor Requirements</td><td colspan="3">Any person in a management position within an owner organisation having relevant knowledge about the organisation’s BIM execution efforts.</td></tr>
<tr><td>Granularity of assessment</td><td>Low ☒</td><td>Moderate ☐</td><td>High ☐</td><td>Very high ☐</td></tr>
<tr><td>Case studies demonstrating application of the methodology</td><td colspan="3">N/A</td></tr>
<tr><td>Published research based on the methodology</td><td colspan="3">N/A</td></tr>
</table>

| | |
|---|---|
| **Additional information** | The paper reviewed discusses an assessment tool but this has not been found in the desktop research. |

## Appendix E.2 BIM Maturity Assessment Tool (Department for Transport)

### Information Extraction Card

| Method | BIM Maturity Assessment Tool | | | | |
|---|---|---|---|---|---|
| **Supporting document(s)** | BIM Guidance for Infrastructure Bodies | | | | |
| **Author / owner** | Department for Transport | | **Country/Origin** | UK | |
| **Date of release, and version assessed** | Document not dated. | | | | |
| **Tool used to assess** | Organisation ☒ | Project ☐ | Other: | | |
| **Sector** | Building ☐ | Infrastructure ☒ | Other: **infrastructure and transport** | | |
| **Applicability** | Generic ☒ | Market-Specific ☐ | Discipline-Specific ☐ | | |
| **Definition of maturity adopted** | | | | | |
| **Implicit assumptions** | | | | | |
| **Intended use** | To assess the maturity of the organisation against the UK BIM levels and supporting Standards | | | | |
| **Intended users** | The guide has been developed for asset owners but it is recommended to be shared with advisors and suppliers prior to implementation of BIM. | | | | |
| **What maturity level/index is used? Number of levels?** | – See next field. | | | | |
| **Maturity areas/topics (process, outcomes) assessed, and number of measures?** | There are two tools offered, a simplified maturity assessment tool and an extensive maturity assessment tool.<br>The **simplified maturity assessment tool** contains a series of items that are ordered across BIM Level 0 (5 items), Level 1 (6 items) and Level 2 (7 items). The items are generally capability and compliance items (for example, "Have documented Information Standards complying with BS 1192:2007 and BS 7000-4:2013"). Users ticks a box to show that they comply with a given item or not. The, they select either "Best practice within the organisations" or "general capability" as an indication of the diffusion of the capability within the organisation.<br>The **extensive maturity assessment tool** is offered to assess the maturity of the organisation against the BIM Standards. It's categories are:<br>**Organisational Information Requirements**<br>Define the data and information relating to asset management activities (aligned with PAS 55-2), capable of enabling the organisation. (13 items)<br>**Asset Information Requirements**<br>Capture information relating to assets in accordance with BS 8587 and PAS 55-2<br>Legal Information (4 items)<br>Commercial information (9 items)<br>Financial information (6 items)<br>Technical information (4 items)<br>Managerial information (14 items)<br>**Built Asset Security Information Requirements (where appropriate)**<br>Detail the requirements with regard to the arrangement for, and overseeing of, the secure capture, handling, dissemination, storage and access and use of all data and information pertaining to sensitive assets and systems for: (followed by 9 criteria).<br>**Employers Information Requirements**<br>Capture information relating to compliance with PAS 1192 Part 2.<br>Technical (3 items)<br>Data Exchange Format (1 item)<br>Co-ordinates (1 item)<br>Level of Detail (Level of Model Detail and Level of Information) (2 items)<br>Training (2 items)<br>Management Standards (15 items)<br>Security (6 items)<br>Collaboration Process (1 items)<br>Health and Safety and Construction Design Management (2 items)<br>Systems Performance (1 item) | | | | |

| | | | | |
|---|---|---|---|---|
| | Compliance Plan (1 item)<br>Delivery Strategy for Asset Information (1 item)<br>Commercial (0 item)<br>Data Drops and Project Deliverables (2 items)<br>Strategic Purpose (1 items)<br>Defined BIM/Project Deliverables (2 items)<br>User responds simply by selecting Yes/No for each capabilities. Responses are collated from across different departments. | | | |
| **Scoring model** | For the simplified maturity assessment tool, there are two columns for scoring – best practice within the organisation and general capability. Where an organisation complies with the criteria, they put a tick.<br>For the extensive maturity assessment tool, there are four columns for Department 1-4 which suggest that this is a tool to assess conformance across the organisation's departments. | | | |
| **Granularity of assessment** | Low ☒ | Moderate ☐ | High ☐ | Very high ☐ |
| **Case studies demonstrating application of the methodology** | None | | | |
| **Published research based on the methodology** | None | | | |
| **Additional information** | | | | |

## Appendix E.3 Building Information Modeling Cloud Score (BIMCS)

### Information Extraction Card

| Method | Building Information Modeling Cloud Score (BIMCS) | | | | | |
|---|---|---|---|---|---|---|
| **Supporting document(s)** | Du, J., Liu, R. and Issa, R.R. (2014) 'BIM cloud score: benchmarking BIM performance', *Journal of Construction Engineering and Management*, 140(11), p.04014054. | | | | | |
| **Author / owner** | Du et al., 2014 | | | **Country/Origin** | USA | |
| **Date of release, and version assessed** | 2014 | | | | | |
| **Tool used to assess** | Organisation ☒ | | Project ☐ | | Other: | |
| **Sector** | Building ☒ | | Infrastructure ☒ | | Other: Not specified | |
| **Applicability** | Generic ☒ | | Market-Specific ☐ | | Discipline-Specific ☐ | |
| **Definition of maturity adopted** | None | | | | | |
| **Assumptions** | | | | | | |
| **Intended use** | To benchmark one organisation's BIM performance against another. It is also intended to support individual organisations improve their performance of BIM use in relation to their competitors. | | | | | |
| **Intended users** | Organisations using BIM. | | | | | |
| **Use setting** | Software as a service (SaaS) model enabling the collection, aggregation, and presentation of benchmarking data in an autonomous and interactive way. | | | | | |
| **Maturity level/index is used? Number of levels?** | The tool is a fully intended for benchmarking purpose. Scores are given as a percentage. | | | | | |
| **What are the capability maturity areas/topics (process, outcomes) assessed, and number of measures?** | The proposed metrics aim to capture the technical aspects of the development process and final products of BIM. 20 metrics across six aspects: | | | | | |
| | **Productivity**<br>Number of objects created per week<br>Number of absolute object number changes per week<br>Model LOD per number of coordination meetings<br>Project data changes per week<br>**Effectiveness**<br>Variance of QTO<br>Number of steps per object<br>Average changes per object<br>**Quality**<br>Number of warnings per object<br>Criticality of warnings<br>Consistency of 3D model and 2D references<br>Models' analytical reporting quality | | | **Accuracy**<br>QTO accuracy<br>Discrepancies between each discipline's models<br>Average number of generic objects per assembly<br>Constructability (Clash detection)<br>**Usefulness**<br>How often the model gets accessed<br>Ease of construction documentation creation<br>Reliability of model data for end users during operations and maintenance<br>**Economy**<br>File size per SF (at certain LOD)<br>Number of objects created per SF | | |
| | 1-2 quantify production (BIM modelling) and 3-6 quantify product (BIM model) | | | | | |
| **Scoring model** | Scores are given as a percentage for each category and then collated to provide an overall BIM Cloud Score. Then benchmarking aspect provides a percentile score against other organisations. | | | | | |

**BIM Cloud Score Ribbon**

| Categories | Productivity | Effectiveness | Quality | Accuracy | Usefulness | Economy | BIM Cloud Score (%) |
|---|---|---|---|---|---|---|---|
| Sample project | 70% | 20% | 65% | 85% | 82% | 65% | 60.6% |

- The overall BIM performance score for this project is 60.6%.

| | | | | |
|---|---|---|---|---|
| | The initial BIMCS was developed based on perceptions of the domain experts but once sufficient data is obtained, data mining is conducted to generate a weighting system for the metrics. Factor analysis will be conducted to devise a new list of metrics which are linear combinations of the original list.<br>"The BIMCS can be installed as an add-in to Revit (Autodesk 2014). After installing it, a link is created under the external tools tab of Revit (Fig. 7 in supporting document t). There are three main functions: (1) start/ terminate monitoring, (2) start/terminate uploading information, and (3) view benchmarking results. The first function controls the start or end of the monitoring actions. The second function allows users to upload their BIM performance information to the server, and the third function displays the benchmarking result.<br>"After starting the monitoring function, the BIMCS will screen and monitor the BIM database continuously and meter the scores of each performance metric on the back end. The user's BIM modelling activities will not be affected. If the start/terminate uploading information is turned on, performance information will be uploaded to the benchmarking server automatically on a regular basis. The uploaded information is classified, processed, and aggregated in the remote server.<br>"Then, the user can view the results using the add-in. By clicking view benchmarking result, a window will pop out and show the results as a probability distribution curve and tabular results" (pp. 9-10)<br>Users can redistribute weighting which is then sent to the add-in for other users in other organisations the option of accepting the new weighting. This purpose of this is to reflect the latest trend of BIM performance.<br>Validation for new metrics is done with the users via the add-in. | | | |
| **Granularity of assessment** | Low ☒ | Moderate ☐ | High ☐ | Very high ☐ |
| **Case studies demonstrating application of the methodology** | N/A | | | |
| **Published research based on the methodology** | N/A | | | |
| **Additional information** | | | | |

## Appendix E.4 Organizational BIM Assessment Profile

### Information Extraction Card

| **Method** | **Organizational BIM Assessment Profile**<br>(This matrix is used in the first step of a three step approach (Assessment, Alignment, and advancement) in a guide for Strategic planning for BIM implementation in client organisations.) | | |
|---|---|---|---|
| **Supporting document(s)** | BIM Planning Guide for Facility Owners<br>https://www.academia.edu/5464858/BIM_Planning_Guide_for_Facility_Owners-Version_2_0 | | |
| **Author / owner** | Pennsylvania State University | **Country/Origin** | USA |
| **Date of release, and version assessed** | Document is dated 2013. | | |
| **Tool used to assess** | Organisation ☒ | Project ☐ | Other: |
| **Sector** | Building ☒ | Infrastructure ☐ | Other: |
| **Applicability** | Generic ☒ | Market-Specific ☐ | Discipline-Specific ☒ owners assessing project teams |
| **Definition of maturity adopted** | | | |
| **Implicit assumptions** | | | |
| **Intended use** | Determining the BIM experience of potential project team members. Using the tool should determine:<br>• Competence of the firm and its personnel with BIM based, on minimum BIM requirements;<br>• Ability of the firm's specific project personnel to meet minimum BIM requirements;<br>• Experience and means of sharing information with other design and construction firms;<br>• Experience in BIM Project Execution Planning and implementation;<br>• Standard BIM Uses and software platforms implemented on typical projects; and<br>• Technical Capabilities when implementing BIM, e.g.; can the organization self-perform the necessary requirements, or do they have to rely on a third party? | | |
| **Intended users** | Building owners to assess the competence of project teams in the use of BIM for a collaboration project. | | |
| **Use setting** | No details provided. | | |
| **What maturity level/index is used? Number of levels?** | 6 level scale from 0-5.<br>0 – Non-existent; 1-Initiatl; 2-Managed; 3-Defined; 4. Quantitatively managed; 5. Optimising. | | |
| **Capability maturity areas/topics assessed, and number of measures?** | Four planning elements are offered and additional questions. The four elements:<br>**BIM Project Execution Planning Experience** – the prior experience the team has with planning for BIM projects<br>**Collaboration Experience** – how willing is the team to collaborate with others and what is their experience in doing so<br>**BIM Tools** – is the team competent in implementing various BIM tools<br>**BIM Champion** – technical capabilities<br>Owners can solicit evidence to accompany the assessment through additional questions such as:<br>1. Please describe a recent challenge in implementing BIM that you / your firm has overcome to be able to improve project outcomes?<br>2. Please explain the BIM training the project team has undergone.<br>3. Please describe any specific resources (personnel or other) that you expect to leverage for this project, and how you will enable success in the BIM Execution and overall project goals.<br>4. Please identify BIM uses you may be able to implement on this project that you have found as valuable and complementary to the other BIM uses we have requested.<br>5. Provide an example of a project(s) in which you previously implemented (BIM use). Provide the following information for each project:<br>A. Project Name<br>B. Building Type | | |

<table>
<tr><td></td><td>
C. Brief Project Description<br>
D. Project size and value<br>
E. Location<br>
F. Completion Date<br>
G. Description of value added through BIM implementation<br>
6. Provide a completed BIM Project Execution Plan for a project mentioned in item 5. If no BIM plan was used, provide a detailed description of how BIM was used in project. Be sure to include roles and responsibilities, BIM Uses implemented, collaboration between project participants, and deliverables.<br>
Note: Requiring a BIM plan within the qualifications/proposal submission greatly increases the size of the submission, but provides the owner with important evidence as to the true qualifications of the project team.<br>
7. Please explain the lessons you have learned from a recent project regarding model sharing or collaboration using BIM, preferably related to the BIM requirements we have requested.
</td></tr>
<tr><td>Scoring model</td><td>
For the planning elements, a maturity matrix is used with a description of most levels. An extract is shown below:
<table>
<tr><th>Planning Element</th><th>Description</th><th colspan="6">Level of Maturity</th><th>Score</th></tr>
<tr><th>Category</th><th>Category Description</th><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>0</th></tr>
<tr><td>BIM Project Execution Planning Experience</td><td>The prior experience the team has with planning for BIM on projects</td><td>Team has no experience with BIM planning on a project</td><td>Team has completed discrete BIM Uses but has not composed a BIM plan</td><td>Team has assisted in BIM Planning with other teams</td><td>Team has led BIM planning on projects</td><td>Team has integrated BIM planning into standard operating procedures</td><td>Team has developed a standard BIM Execution Plan to use on projects</td><td>0</td></tr>
<tr><td>Collaboration Experience</td><td>How willing is the team to collaborate with others and what is their experience in doing so</td><td>Team has not collaborated with other teams and does not encourage collaboration</td><td>Team has collaborated on previous projects, but is not willing to share model/information fluidly</td><td>Team has experience and is willing to share information with other team members</td><td>Team leads collaboration efforts and encourages information sharing among parties</td><td>Team is willing to co-locate for a project</td><td>Team encourages co-location on all projects</td><td>0</td></tr>
<tr><td>BIM Tools</td><td>Is the project team competent in implementing various BIM tools</td><td>Team has not implemented BIM and is not willing to do so</td><td>Team has not implemented BIM, but is willing to</td><td>Team has implemented BIM to a limited extent</td><td>Team has implemented BIM on many projects if required by the owner</td><td>Team implements BIM tools on all projects</td><td>Team encourages all parties to implement BIM tools on all project</td><td>0</td></tr>
<tr><td>BIM Champion</td><td>Technical Capabilities</td><td>Team does not implement BIM or any other electronic technology</td><td>Team does not implement BIM but utilizes limited electronic communication tools</td><td>Team does not implement BIM but extensively uses electronic communication tools for items such as RFI, Submittals, etc</td><td>Team Uses BiM to a limited extent and electronic communication tools</td><td>Team implements cutting edge technologies on projects</td><td>Team is innovative in developing new technologies and BIM uses</td><td>0</td></tr>
</table>
Table 4-1: BIM Qualifications Scoring Matrix
</td></tr>
<tr><td>Level of Evidence [Required/requested?]</td><td>Required as per the questions posed.</td></tr>
<tr><td>Granularity of assessment</td><td>Low ☒ | Moderate ☐ | High ☐ | Very high ☐</td></tr>
<tr><td>Case studies demonstrating application of the methodology</td><td>None</td></tr>
<tr><td>Published research based on the methodology</td><td>None</td></tr>
<tr><td>Additional information</td><td></td></tr>
</table>

# Appendix F: Individual evaluations: BIM benefits tools

## Appendix F.1 BIM Return on Investment Tool

### Information Extraction Card

| Benefits Tool/Model | BIM Return on Investment Tool | | | |
|---|---|---|---|---|
| **Supporting docs/links** | https://bimportal.scottishfuturestrust.org.uk/page/roi-calculator | | | |
| **Author / owner** | Scottish Futures Trust | **Country/Origin** | Scotland, UK | |
| **Date of release, and version assessed** | Online version assessed on 1/08/19. | | | |
| **Benefits measured in** | Projects ☒ | Organisations ☐ | | |
| **Benefits are measured for** | Planning ☒ | Design ☒ | Construction ☒ | Operation ☒ |
| **Applicability** | Generic ☐ | Market-Specific ☒ | Discipline-Specific ☐ | |
| **Sector** | Building ☒ | Infrastructure ☒ | Other: | |
| **Intended use** | General[27] ☒ | | Specialised[28] ☐ | |
| **Intended users** | Procuring authorities / public bodies. | | | |
| **Benefits management[29] approach** | The benefits has a list of benefit measures that can be evaluated: qualitatively by asking users to rate them on a Likert scale; or quantitatively by asking users to provide estimates of the benefits (for example, assumed efficiency saving per annum at operation stage) and the likelihood of the benefit realisation (e.g. low, medium, high). Investment/cost of implementing BIM (for example for CDE, OIR, BIM training, maintenance of AIM, facilities management systems) is estimated and deducted from the benefits.<br>The qualitative assessment uses the seven-stage project model: Brief, Concept, Definition, Design, Build & Commission, Handover & Closeout; and Operation & in-use. The quantitative assessment uses a three-stage project model: Brief & Design, Procure & Construct, and Operation. | | | |
| **Assumptions made** | • To support the user, quantitative questions are supported by "base position assumptions" from projects not using BIM to be compared with "Benefit of adopting BIM Level 2". These base assumptions consider that the organisation completing the assessment has not implemented any level of BIM and that current/traditional practices are inefficient compared to those of BIM level 2. This may result in forecast benefits that are over estimated compared to actual benefits.<br>• The tool assumes that development of EIR, AIR, OIR, etc. entails a new/additional cost (for any of these elements, it ranges between £10k and £25k) to projects hence, there is also an assumption that BIM is not business as usual. | | | |
| **Baseline used** | Many "base position assumptions" referring to "Current approach within construction projects through non BIM approach". | | | |
| **Definition of benefit** | None provided. | | | |
| **Benefits/key Performance Indicators measured by the tool/model? and how each is measured?** | Areas assessed are as follows:<br>**Step 1- project details data input** (basic data includes Construction start date, construction value, and operation period)<br>**Step 2- <u>Qualitative</u> Assessment:** Scoring is done on a five-point Likert scale from 0 (strongly disagree) to 4 (strongly agree) expressing the level of agreement of users about **50 benefit statements** across:<br>Brief<br>Concept<br>Definition<br>Design<br>Build & Commission | | | |

[27] To assess general BIM benefits to the adopting organisation and/or on projects.

28 To assess specialised BIM benefits from specific technologies (e.g. mobile/site BIM technologies) for specific purpose (e.g. snagging)

29 Benefits management is "the identification and structuring/definition of benefits, the planning of benefits realisation, the realisation and tracking of benefits, and the evaluation (review and optimisation) of benefits"

| | |
|---|---|
| | Handover & Closeout<br>Operation & In Use<br>All statements start with "BIM Level 2 will offer and support ..." followed by a description of the benefit (for example, "Improved security in the management of an assets digital data").<br>**Step 3: <u>Quantitative</u> Assessment:** users to estimate the benefits and investment using **14 quantitative benefit** questions and **7 investment questions**:<br>Brief & Design: Reduce internal management costs<br>Brief & Design: Reduced printing costs<br>Procure & Construct: Reduce prelim costs on site<br>Procure & Construct: Reduce time and inflation costs<br>Procure & Construct: Improved tender prices<br>Procure & Construct: Reduce construction risk<br>Procure & Construct: Reduce client held risk<br>Procure & Construct: Reduce costs for CBWIC<br>Procure & Construct: Reduce cost to manage change<br>Operation: Robust data transfer at completion<br>Operation: Efficient data management<br>Operation: Improved energy performance<br>Operation: Efficient maintenance events<br>Operation: Bundling of maintenance events<br>Operation: Additional quantitative events<br>**Step 4: Investment Details**<br>CDE Investment<br>Information Manage Role<br>BIM Training<br>EIR Development<br>OIR & AIR Development<br>Investment in Facilities Management System<br>Maintenance of AIM during Operations<br>Additional Investment Costs<br>Following completion, a project dashboard shows both the qualitative and quantitative benefit of the projects. |
| **Quality of measurement offered by the benefit tool/model** | |
| Accuracy | This is dependent on the knowledge of the user inputting the data. Together (1) the several "base position assumptions" from projects not using BIM to be compared with "Benefit of adopting BIM Level 2", and (2) the assumption that the organisation completing the assessment has not implemented any element/level of BIM may produce forecast benefits that are much higher than the actual benefits.<br>The measurement also relies on the user inputting specific quantitative figures that indicate the cost of implementing BIM-related activities that do not currently exist in the organisation at the time of completing the assessment. The tool seems to yield the largest benefits in the Operation stage and, this is simply the result of using the lifetime (30-50 years) as a multiplier of the yearly operational benefit inputted by the user.<br>The qualitative questions are based on subjective opinions of the users and what they think the impact of doing BIM Level 2 on a project will be in comparison to "current non-BIM approach". The subjectivity in this category of questions reduces the reliability of the assessment.<br>The quality of the measurement offered by the tool is only as good as the veracity of the data being input by the user. It requires completion by a user who is very knowledgeable of current working practices, BIM Level 2 and project costs.<br>It would be still challenging for such a knowledgeable user to quantify the benefits using broad measures such as: "Assumed efficiency saving per annum from Saving time and resources in the location of asset management drawings and data during operational stage"; "Assumed efficiency saving per annum to energy costs from improve energy performance through advanced modelling and design development", etc. despite the tool offers some brief guidelines and estimates for the user to quantify such benefits (e.g. "assume on average saving 3 hours per maintenance event; assume £50/hr for labour and plan hire; Calculation: 3hours x £50/hr x 30 number of maintenance event = £5,400/year x 40 years = £180,000)". |

<table>
<tr><td>Informative</td><td>The questions and comparisons of current to future state (from the quantitative questions) generally provide useful insights into the general benefits of adopting BIM Level 2. The output of the qualitative assessment offer limited feedback such as “Significant Benefit when assessed against a variety of qualitative benefits. This assessment is based on the self-assessment and data provided against defined criteria.” These have an educational value for clients who are still contemplating whether they should adopt BIM in their project.<br>The quantitative assessment of BIM benefits does not seem to provide informative outputs or offer any advantage over the qualitative assessment given the way it operates (e.g. asks users to quantify benefits using broad measures – e.g. Assumed efficiency saving per annum to Life Cycle Costs– and produces outputs that simply reiterates data entered by users). The dashboard output at the end of the assessment simply reiterates the data entered and provides three figures of estimated ROI following adoption of BIM – low, mean and upper estimates. There is no narrative supporting the user in how to achieve the benefits though they could be somewhat inferred by the questions that offer a comparison between no-BIM with post BIM Level 2.<br>The tool addresses the steps of benefits identification/definition and evaluation, but it does not offer insights for tracking, realisation and optimisation of benefits.</td></tr>
<tr><td>Neutral</td><td>Yes but the context used is BIM Level 2.</td></tr>
<tr><td>Effort involved</td><td>In less than one hour provided the user has sufficient knowledge to be able to complete all elements of the assessment.</td></tr>
<tr><td>Monetisation of benefit measures/KPI</td><td>Yes. This is a key part of the assessment that looks at investment required to adopt BIM and savings made as a result of its implementation on a project.</td></tr>
<tr><td rowspan="2">Means of assessment / data collection</td><td>Offline questionnaire ☐<br>Online questionnaire ☒<br>On site ☐<br>Automated collection ☐</td></tr>
<tr><td>Other:</td></tr>
<tr><td>Usability of tool/model (1=poor, 5=excellent)</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Ease of use</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>☒</td></tr>
<tr><td>Quality/aesthetics of UI</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>☒</td></tr>
<tr><td rowspan="2">Help, dictionary, documentation etc.</td><td>☐</td><td>☒</td><td>☐</td><td>☐</td><td>☐</td></tr>
<tr><td colspan="5">While there are instructions within the tool itself, they are very brief – one sentence per section assessed.</td></tr>
<tr><td>Details of any case studies demonstrating application of the tool/model</td><td colspan="5">Case studies are provided as downloads within the tool:<br>https://www.theb1m.com/video/delivering-healthcare-with-bim<br>https://bimroi.scottishfuturestrust.org.uk/storage/uploads/roisurveyanalysisjun17.pdf<br>https://www.theb1m.com/video/does-bim-take-more-time</td></tr>
<tr><td>Additional information</td><td colspan="5"></td></tr>
</table>

## Appendix F.2 BIM Value

### Information Extraction Card

| Benefits Tool/Model | BIM Value | | | |
|---|---|---|---|---|
| **Supporting docs/links** | https://bimvaluetool.natspec.org/ | | | |
| **Author / owner** | NATSPEC and SBEnrc | **Country/Origin** | Australia | |
| **Date of release, and version assessed** | Current online version assessed 2nd August 2019. Website is Copyright 2015. | | | |
| **Benefits measured in** | Projects ☒ | | Organisations ☒ | |
| **Benefits are measured for** | Planning ☒ | Design ☒ | Construction ☒ | Operation ☒ |
| | Whole-of-Life; Planning; Construction; Operations; Decommissioning; Design | | | |
| **Applicability** | Generic ☒ | Market-Specific ☐ | Discipline-Specific ☐ | |
| **Sector** | Building ☒ | Infrastructure ☒ | Other: | |
| **Intended use** | General[30] ☒ | | Specialised[31] ☐ | |
| **Intended users** | • Client/Owner<br>• Designer<br>• Contractor<br>• Sub-contractor<br>• Fabricator/Manufacturer | | • Surveyor<br>• Asset Manager<br>• Supplier<br>• Student<br>• Other | |
| **Benefit management[32] approach/strategy** | The tool includes a benefit realisation strategy addressing the steps of identification and definition of benefit, the first two steps in a benefit management strategy. | | | |
| **Assumptions made** | None | | | |
| **Baseline used** | The baseline is not specified or clear for many of the metrics [see "Benefits/KPI measured by the tool" field]. For some metrics, the tool refers to benchmarks with either projects delivered without BIM or issues that would have been undetected if BIM was not used. In other instances, the tool refers to the level of benefits (called success criteria) found in research papers (for example, for the Quality metric, the tool cites "a potential success criteria could be achieving ≥ 95% of all field material deliveries within <24 from scheduled use (Kunz & Fischer, 2012)". | | | |
| **Definition of benefit** | None provided. But there is a dictionary of benefit metrics ( https://bimvaluetool.natspec.org/dictionaries/#wrap-metrics ) | | | |
| **Benefits/KPI measured by the tool/model? And how each is measured?** | This tool does not measure the benefits but provide guidance about the type of benefits and metrics that are relevant to different stakeholders. It is a decision-support tool designed to help users develop a value realisation strategy.<br>The tool allows the user to link together a specific benefit (for example, improved coordination) at a specific asset lifecycle stage (for example, Construction and Operations) with an enabler (for example, design reviews), and the corresponding metrics (for example, variations and change orders).<br>Measures proposed for the metrics are based on peer reviewed literature and some industry guidelines (for example, for the "variation and change order", the tools suggests the "number of changes or variation/change orders as a percentage of number of changes in similar non-BIM projects" as a measure).<br>The summary provided at the end of the questions offers a description of each metric, a supporting example and a reference.<br>The tool's workflows end at this point and recommends "these metrics can help you monitor your progress towards achieving those benefits from BIM" to users. The options for each question change depending on the type and the life cycle stage selected.<br>The metrics are as follows: | | | |

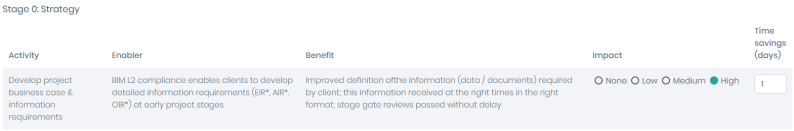
[30] To assess general BIM benefits to the adopting organisation and/or on projects.
[31] To assess specialised BIM benefits from specific technologies (e.g. mobile/site BIM technologies) for specific purpose (e.g. snagging)
[32] Benefits management is "the identification and structuring/definition of benefits, the planning of benefits realisation, the realisation and tracking of benefits, and the evaluation (review and optimisation) of benefits"

| | | |
|---|---|---|
| | • Cost of change<br>• Variations and change orders<br>• Time for change<br>• Request for information<br>• Conflict<br>• Latency<br>• Labour intensity<br>• Cost predictability<br>• Sustainability and environmental performance scores<br>• Resource use and management<br>• Carbon footprint<br>• Quality<br>• Knowledge management metrics<br>• Stakeholder involvement<br>• Accuracy and number of errors/omissions | • Cost savings/avoidance Speed of production<br>• Volume of rework<br>• Clashes<br>• Off-site manufacturing<br>• Model (or drawing) coordination consistency<br>• Time per unit<br>• Meeting effectiveness<br>• Meeting efficiency<br>• Satisfaction<br>• Cost per defects-warranty<br>• Fire safety<br>• Overall time<br>• Overall cost<br>• Profit<br>• Asset/equipment useful life |

| **Quality of measurement offered by the benefit tool/model** | | | | | |
|---|---|---|---|---|---|
| Accuracy | Difficult to verify as the tool suggests and defines a list of benefits and the corresponding measures that are either qualitative or semi-quantitative (for example, meeting efficiency). It is always challenging to compares with baselines of projects non-using BIM and the dependence of such baselines on organisation and project contextual factors. | | | | |
| Informative | The feedback and information generated is high level without details. The tool may be useful for early adopters of BIM as an educational tool about the benefits of BIM. | | | | |
| Neutral | Yes. | | | | |
| Monetisation of benefit measures/KPI | Few metrics are expressed in monetary terms. Others that are not in monetary terms are generally difficult to monetise and the tool does not include or require an approach for their monetisation. | | | | |
| **Means of assessment / data collection** | Offline questionnaire ☐ | Online questionnaire ☒ | On site ☐ | Automated collection ☐ | |
| | Other: | | | | |
| **Usability of tool/model** (1= poor/low, 5= excellent/high) | 1 | 2 | 3 | 4 | 5 |
| Ease of use | ☐ | ☐ | ☐ | ☐ | ☒ |
| Quality/aesthetics of UI | ☐ | ☐ | ☐ | ☒ | ☐ |
| Help, dictionary, documentation etc. | ☐ | ☐ | ☐ | ☒ | ☐ |
| | Clear instructions for a simple tool. https://bimvaluetool.natspec.org/about/ | | | | |
| Average time(s) (min) for measuring different benefits/KPIs? | Less than 30 minutes | | | | |
| **Details of any case studies demonstrating application of the tool/model** | None available. | | | | |
| **Additional information** | "The content is based on academic and industry research and has been developed in close consultation with industry, government and research organisations across Australia and internationally. This ensures that it is relevant to a range of stakeholders. This tool is detailed in the book *Delivering Value with BIM - A Whole-of-life Approach* by Adriana Sanchez, Keith Hampson and Simon Vaux published by Routledge." | | | | |

## Appendix F.3 BIM Benefits

### Information Extraction Card

| Benefits Tool/Model | BIM Benefits | | | |
|---|---|---|---|---|
| **Supporting docs/links** | | | | |
| **Author / owner** | University of Cambridge | **Country/Origin** | UK | |
| **Date of release, and version assessed** | © 2018 BIM Benefits. Online version assessed 2 August 2019. | | | |
| **Benefits measured in** | Projects ☒ | | Organisations ☐ | |
| **Benefits are measured for** | Planning ☒ | Design ☐ | Construction ☒ | Operation ☒ |
| | Follows RIBA Plan of Work stages from 0 to 7. | | | |
| **Applicability** | Generic ☒ | Market-Specific ☐ | Discipline-Specific ☐ | |
| **Sector** | Building ☒ | Infrastructure ☒ | Other: | |
| **Intended use** | General[33] ☒ | | Specialised[34] ☐ | |
| **Intended users** | As the tool covers the benefits of BIM from Stage 0 (Strategy) to Stage 7 (Operation & end of use), the intended users (not explicitly stated in the tool) are expected to be key benefit holders from across all these stages. | | | |
| **Benefit management[35] approach** | The tool aims to quantify the benefits from adopting BIM Level 2 on projects.<br>The tools uses the following rationale: the measure used for most benefits is Time (saved days) which is then converted into monetary values based on daily wages/rates. Days saved are the result of performing some of the proposed activities at certain project stages (for example, "develop detailed information requirements (EIR*, AIR*. OIR*) at early project stages" at "Stage 0 - Strategy") but it is not clear when (or at what stage) the benefit (days saved) being estimated is occurring. Users estimate the impact of performing a certain activity on Likert scale and add a forecast of the expected saving in terms of number of days. In this process, there is a description of the Activity, the Enabler and the Benefit (See screenshot below).<br>  <br>Stage 0: Strategy<br>Activity: Develop project business case & information requirements<br>Enabler: BIM L2 compliance enables clients to develop detailed information requirements (EIR*, AIR*. OIR*) at early project stages<br>Benefit: Improved definition ofthe information (data / documents) required by client; this information received at the right times in the right format; stage gate reviews passed without delay<br>Impact: None Low Medium High<br>Time savings (days): 1<br>The same benefit (days saved) is also calculated for the whole schedule/duration of the project (See screenshot below) which may indicate an overlap / double counting in the estimation of the benefits.<br>  <br>Quantification of savings from a reduction in the duration of project schedule<br>Reduction in project schedule (days): 2<br>Average daily preliminary cost (£): 1000<br>Total<br>It is not easy to follow the questions – especially for early adopters or users intending to adopt BIM – as there are only general statements without instructions for use and/or support guidance.<br>The tool does not capture contextual information such as size and the duration of the project.<br>The benefits in terms of types and scale vary for the different project parties and the tool is not explicit about who is the targeted party when assessing benefits across the project stages (e.g. a benefit for one party could be a disbenefit for another). Similarly, | | | |

[33] To assess general BIM benefits to the adopting organisation.
[34] To assess specialised BIM benefits from specific technologies (e.g. mobile/site BIM technologies) for specific purpose (e.g. snagging)
[35] Benefits management is "the identification and structuring/definition of benefits, the planning of benefits realisation, the realisation and tracking of benefits, and the evaluation (review and optimisation) of benefits"

| | |
|---|---|
| | the procurement method used in project – not captured by the tool – may trigger different dynamics in the distribution/unlocking of benefits.<br>The tool addresses the first two stages of a benefit management strategy, by helping users to define and identify the benefits. The tool does not address the stages of tracking, realisation and optimisation of benefits.<br>The tool resembles more to a questionnaire aiming at understanding the implications of BIM Level 2 for construction projects in general instead of a benefit tool for estimating BIM benefits in specific projects. |
| **Assumptions made** | The adoption of elements of BIM Level 2 [e.g. Supply chain submits Master Information Delivery Plan (MIDP) and pre-contract BEP to the client; BIM L2 compliance enables clients to develop detailed information requirements (EIR*, AIR*, OIR*) at early project stages] is likely to have a positive impact on construction projects. |
| **Baseline used** | Baselines and base assumptions are not stated.<br>The method seems to have an implicit that the benefits are measured from baselines of projects and organisations that are not currently using BIM or elements of BIM Level 2. |
| **Definition of benefit** | Not provided |
| **Benefits/key Performance Indicators measured by the tool/model? And how each is measured?** | Time savings<br>• Time savings in Stage 0: 'Strategy' – Stage 3: 'Definition'<br>• Time savings in 'Design'<br>• Time savings in 'Build and Commission'<br>• Time savings from answer requests for information (RFIs) (during 'Build and Commission)<br>• Time savings in 'Handover'<br>• Time savings in incident response<br>Materials savings<br>• Materials savings in 'Build and Commission'<br>• Environmental benefit from fewer materials used<br>Cost savings (time and materials)<br>• Cost savings from better clash detection<br>• Cost savings from fewer changes<br>• Cost savings in operations – facilities management<br>• Cost savings in asset maintenance<br>• Cost savings in refurbishment<br>• Cost savings in asset disposal<br>• Cost savings in litigation<br>Improved health and safety<br>• Improved health and safety in construction<br>• Improved health and safety in maintenance/demolition<br>Reduced risk<br>• Reduced project risk contingency in capital delivery phase<br>• Increase certainty in operating expenditure estimates<br>Improved asset utilisation<br>• Improved asset utilisation<br>Improved asset quality<br>• Improved asset quality<br>For each element, an "activity" is described, a description of "an enabler" (how BIM Level 2 is an enabler for the area) is provided, and a brief description of the "benefit" is given. Then, the impact is scored on a Likert scale of none, low, medium, high; and quantitative scores (number of days saved, and daily rates/wage) are required to monetise the benefits |
| **Quality and type of measurement offered by the benefit tool/model** | |

| | | | | | | |
|---|---|---|---|---|---|---|
| The tools aims to estimate forecast/probabilistic benefits. It is challenging to produce accurate estimates in the absence of baselines/base assumptions and without considering the project's contextual factor (size, complexity, procurement system) and the user/party standpoint (benefit owners). The intertwined nature of benefits requiring users to look into future stages when estimating benefits (for example, benefits from an activity at Stage 0 would require estimates of benefits occurring at all other future stages), and the varying benefit standpoints (benefit owners?) all add to the challenge of producing accurate estimates. Also, there seems to be an overlap in the estimated benefits from specific activities and those of whole project/schedule.<br>The tool does not produce any feedback and/or benchmark either qualitatively or quantitatively, or guidelines for tracking, realisation and optimisation of benefits. Ath completion of assessment, the tool displays the total amount saved for each benefit measure.<br>The quantification/monetisation is simplistic and adds trivial info to the tool's outputs.<br>The qualitative info (activity, enabler, benefit) can be used by early BIM adopters to understand the general benefits of BIM.<br>The tools is specific to the context of BIM level 2 projects. | | | | | | |
| **Means of assessment / data collection** | Offline questionnaire ☐ | | Online questionnaire ☒ | | On site ☐ | Automated collection ☐ |
| | Other: | | | | | |
| **Usability of tool/model** | NA[36] | 1 | 2 | 3 | 4 | 5 |
| Ease of use | ☐ | ☐ | ☐ | ☒ | ☐ | ☐ |
| | Absence of instructions to users as who should complete the assessment and when, and lack of clarity around assumptions, and lack of direct questions all affect this tool's ease of use. | | | | | |
| Quality/aesthetics of UI | ☐ | ☐ | ☐ | ☒ | ☐ | ☐ |
| Help, dictionary, documentation etc. | ☒ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Average time(s) (min) for measuring different benefits/KPIs? | At least 1 to 2 hours, mainly required to read the text for the "activity, enabler, and benefit" fields. The timing to complete the different sections is not specified (e.g. it is not clear if all sections need to be completed in full at the beginning of the project, or in parts as the project progresses). | | | | | |
| **Details of any case studies demonstrating application of the tool/model** | None | | | | | |
| **Additional information** | None | | | | | |

[36] For e.g. some of the usability criteria may not apply to matrices/templates providing KPIs / performance measures but are not embedded into tools and/or workflows.

# Appendix G: Individual evaluations: BIM benefits methods

## Appendix G.1 BIM Level 2 Benefits Measurement Methodology (BMM)

### Information Extraction Card

| Benefits Tool/Model | BIM Level 2 Benefits Measurement Methodology (BMM) | | | |
|---|---|---|---|---|
| **Supporting docs/links** | BIM Level 2 Benefits Measurement – Summary Guide<br>BIM Level 2 Benefits Measurement – Introductory note: approach and benefits framework<br>BIM Level 2 Benefits Measurement – Methodology<br>BIM Level 2 Benefits Measurement – Application of PwC's BIM Level 2 Benefits Measurement Methodology to Public Sector Capital Assets | | | |
| **Author / owner** | PricewaterhouseCoopers (PwC) | **Country/Origin** | UK | |
| **Date of release, and version assessed** | March 2018 | | | |
| **Benefits measured in** | Projects ☒ | Organisations ☐ | | |
| **Benefits are measured for** | Planning ☒ | Design ☒ | Construction ☒ | Operation ☒ |
| **Applicability** | Generic ☒ | Market-Specific ☐ | Discipline-Specific ☐ | |
| **Sector** | Building ☒ | Infrastructure ☒ | Other: | |
| **Intended use** | General[37] ☒ | Specialised[38] ☐ | | |
| | To evaluate the actual impact BIM deployment has on asset planning, delivery and operation.<br>The purpose of the BIM Level 2 Benefits Measurement Methodology (BMM) is to assist government construction clients and asset owners to assess and measure the benefits from application of BIM Level 2 on capital projects and assets in operation. The framework is also intended help to define potential BIM benefits from the project outset, following industry plan of work stages. | | | |
| **Intended users** | Government construction clients and asset owners | | | |
| **Benefit management[39] approach** | The framework incorporates the eight asset lifecycle stages:<br>0 – strategy, 1 – brief, 2 – concept, 3 – definition, 4 – design, 5 – build and commission, 6 – handover & close-out, 7 – operation & end of life.<br>The framework utilises an impact pathway to describe how application of BIM Level 2 could lead to benefits for users:<br>Activity → BIM Enabler → Intermediate benefit → End benefit<br>The methodology differentiates between when the benefit is enabled and when the benefit is realised to account for future realisation and therefore aims to prevent underinvestment.<br>A number of questions are considered in the framework development:<br>• When are the potential benefits realised across the asset lifecycle?<br>  ○ Benefits realised during asset delivery<br>  ○ Benefits realised in the asset's operation<br>  ○ Benefits realised through service delivery / business as usual<br>• Who do the potential benefits accrue to?<br>• Are benefits to government cash-releasing or non-cash-releasing?<br>• Benefits from the management and use of improved asset information to undertake organisational tasks quicker / more efficiently<br>• Benefits from economies of scale in managing a portfolio of assets<br><br>A range of quantification and monetisation techniques were used for the different types of benefits. "Quantification of the benefits involves identifying the form and scale | | | |

[37] To assess general BIM benefits to the adopting organisation.
[38] To assess specialised BIM benefits from specific technologies (e.g. mobile/site BIM technologies) for specific purpose (e.g. snagging)
[39] Benefits management is "the identification and structuring/definition of benefits, the planning of benefits realisation, the realisation and tracking of benefits, and the evaluation (review and optimisation) of benefits"

| | |
|---|---|
| | of the actual or expected benefit. Monetising each benefit involves placing an economic value on each."<br>The methodology acknowledged that the costs of implementing BIM can be easily quantified, while the less tangible and more complex benefits of BIM are more difficult to quantify.<br>More details about the methodology and the benefits measures is included in the [Benefits/key Performance Indicators measured by the Method] field of this table. |
| **Assumptions made** | - BIM Benefits can be measured using a "counterfactual situation" where BIM has not been used or available as a baseline situation. The counterfactual situation cannot be directly observed, and BIM benefits can be assessed using a combination of methods including empirical observation and expert judgement and their combination.<br>- There is a "relationship between BIM maturity and realised benefits. Many of the specific benefit pathways, identified within our framework, will only be achievable when clients have achieved a certain level of BIM maturity". |
| **Baseline used** | The methodology uses a "counterfactual situation". "This involves comparing the outcomes achieved with the application of BIM Level 2 and those that would have been achieved if BIM Level 2 had not been used or available".<br>It involves isolating changes in an outcome (e.g. risk, time, cost, quality) and attribute the change to the use of BIM Level 2. However, the methodology acknowledges the challenges of measuring the net benefits against an appropriate counterfactual, which cannot be directly observed and so the impact must be determined in some other way.<br>The methodology has used the following three approaches. "empirical observation" (Compare the outcomes between two otherwise similar projects where one uses BIM Level 2 and one does not), "expert judgement" (Compare elements of a project or asset with-BIM Level 2 to one without-BIM Level 2 by drawing on expert opinion / experience to assess the scale of the impact on the key benefit metrics), and a "Combination of empirical observation and expert judgement". Further approaches that assist benefit measurements that were suggested but not used include:<br>1. "Regression analysis: If there was a large database of relevant data, consisting of many projects, across varying asset types, regression analysis could be used to estimate the effects of BIM Level 2 on project outcomes such as the duration of project schedules, and costs. Data would need to be collected on all the BIM Level 2 parameters that might affect the project outcomes. This approach has the potential to control for the influence of confounding factors on project outcomes", and<br>2. Another way is to refer to 'Get It Right Initiative' Research Report (2016) which details the most common sources of error in construction. This may be used as one the sources in developing an understanding of what would have happened in the 'without BIM' counterfactual case, and in determining if application of BIM Level 2 has brought benefits. |
| **Definition of benefit** | The methodology uses an impact pathway (see below) in which different types of benefits are defined:<br>  <br>• **Activity:** An activity that is undertaken at a particular stage of the asset lifecycle (with or without BIM)<br>• **BIM Enabler:** A technical capability provided by using BIM Level 2, that can lead to one or more measurable benefits (that may accrue at the same stage of the asset lifecycle and/or later stages).<br>• **Intermediate benefit:** A direct effect of the BIM enabler.<br>• **End benefit:** The ultimate impact of the intermediate benefit (which needs to be assessed and potentially measured). |
| **Benefits/key Performance Indicators measured by the Method? And how each is measured?** | "The BMM groups the benefits into eight measurement categories, explained across its eight chapters (see summary of the eight categories on the next page). The eight measurement categories each contain a number of the 117 impact pathways from the benefits framework (described above). The categories are defined based on similarities in the measurement process, and are independent of the stage of the asset lifecycle at which the benefits are realised." |

| | |
|---|---|
| | The 117 benefit pathways were consolidated into 22 high level benefit areas which were grouped further into eight measurement categories:<br>• Time savings<br>• Materials savings<br>• Cost savings<br>• H&S Improvement<br>• Risk reduction<br>• Improved asset utilisation<br>• Improved asset quality<br>• Improved reputation<br>**Table 2: Benefit groupings** |

| High level activity through which benefit accrues | Measurement category | Benefit grouping | Number of corresponding pathways from detailed framework above |
|---|---|---|---|
| Asset delivery and Service delivery/ BAU | Time savings | Time savings in Stage 0: 'Strategy' – Stage 3: 'Definition' | 3 |
| | | Time savings in 'Design' | 15 |
| | | Time savings in 'Build and Commission' | 12 |
| | | Time savings from answering requests for information (RFIs) (during 'Build and Commission') | 2 |
| | | Time savings in 'Handover' | 4 |
| | | Time savings in incident response | 1 |
| Asset delivery / Operations | Materials saving | Materials savings in 'Build and Commission' | 5 |
| | | Environmental benefit from fewer materials used | 20 |
| Asset delivery / Operations | Cost saving (time and materials) | Cost savings from better clash detection | 6 |
| | | Cost savings from fewer changes | 5 |
| | | Cost savings in operations – facilities management | 4 |
| | | Cost savings in asset maintenance | 4 |
| | | Cost savings in refurbishment | 4 |
| | | Cost savings in asset disposal | 3 |
| | | Cost savings in litigation | 4 |
| Asset delivery / Operations | Improved health & safety (H&S) | Improved health and safety in construction | 3 |
| | | Improved health and safety in maintenance / demolition | 3 |
| Asset delivery | Reduced risk | Reduced project risk contingency in capital delivery phase | 5 |
| | | Increased certainty in operating expenditure estimates | 1 |
| Service delivery/ BAU | Improved asset availability | Improved asset utilisation | 5 |
| Service delivery/ BAU | Improved asset quality | Improved asset quality | 3 |
| Service delivery/ BAU | Other intangible benefits | Improved reputation | 5 |
| **Total** | | | **117** |

Source: PwC.

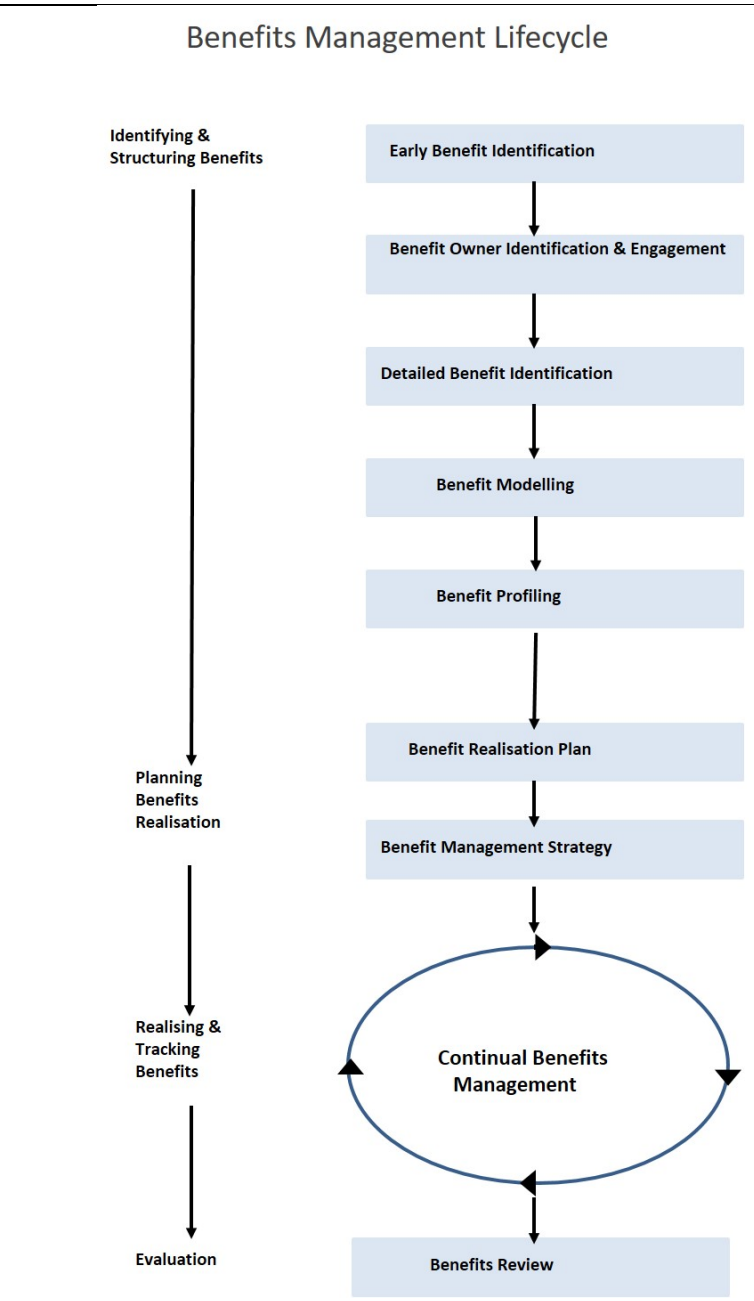
| | |
|---|---|
| **Details of any case studies demonstrating application of the tool/model** | Provided in the application document for an office regeneration project for the Department of Health and the Foss Barrier upgrade for the Environment Agency. |
| **Additional information** | "Costs related to implementing BIM Level 2 are not part of the scope of this work; and are not considered in this report. The benefit estimates in this report are, therefore, not alone sufficient to assess the return on investment in BIM Level 2 for the two projects/assets examined; or more generally for wider public or private sector organisations." |

## Appendix G.2 TfL BIM Benefits Management Strategy

### Information Extraction Card

| **Benefits Method** | TfL BIM Benefits Management Strategy | | | |
|---|---|---|---|---|
| **Supporting docs/links** | TfL BIM Benefits Management Strategy | | | |
| **Author / owner** | Transport for London (TfL) | **Country/Origin** | UK | |
| **Date of release, and version assessed** | Strategy dated 08/02/2017 | | | |
| **Benefits measured in** | Projects ☒ | Organisations ☐ | | |
| **Benefits are measured for** | Planning ☒ | Design ☒ | Construction ☒ | Operation ☐ |
| | "Concerns the adoption of BIM in the project (or CapEx) phase of the asset lifecycle. Work is currently underway to define the TfL approach concerning adoption of BIM within the operational and maintenance (or OpEx) phase of the asset lifecycle" | | | |
| **Applicability** | Generic ☒ | Market-Specific ☐ | Discipline-Specific ☐ | |
| | The assessment is designed and implemented by TfL but the questions are generic aligning to UK BIM framework so it is easily transferrable. | | | |
| **Sector** | Building ☐ | Infrastructure ☒ | Other: **see note to applicability** | |
| **Intended use** | General[40] ☒ | | Specialised[41] ☐ | |
| **Intended users** | Individuals leading the project being assessed such as programme/project BIM manager, and head of digital engineering are responsible for leading the implementation of the whole strategy, but input is required from a range of roles across the organisation. | | | |
| **Benefit management[42] approach** | BIM is aligned to the organisation's strategic objectives. The approach taken to roll out BIM benefits management within TfL follows: | | | |

[40] To assess general BIM benefits to the adopting organisation.
[41] To assess specialised BIM benefits from specific technologies (e.g. mobile/site BIM technologies) for specific purpose (e.g. snagging)
[42] Benefits management is "the identification and structuring/definition of benefits, the planning of benefits realisation, the realisation and tracking of benefits, and the evaluation (review and optimisation) of benefits"




**BIM Benefits Realisation Approach**

| BIM Programmes | Early Adopters | BAU roll-out |
|---|---|---|
| • Review assess and identify benefits<br>• Selection of early adopter projects<br>• Baseline measurable benefits<br>• Early benefits planning | • Enable early adopter projects new BIM templates, processes, technology, workflows and PBM support<br>• Validate benefits and identify new benefits<br>• Make adjustments and improvements to benefits approach<br>• Make adjustments to BIM templates, processes, technology, workflows and approach<br>• Complete benefits profiling and planning | • Enable new projects and business areas with new BIM templates, processes, technology, workflows and PBM support<br>• Execute benefits plans and track benefits<br>• Develop baseline data and reporting metrics<br>• Make adjustments to BIM templates, processes, technology, workflows and approach |

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|---|---|
| | It uses the early adopters to refine the BIM processes while tracking performance to enable refinement before BIM becomes business-as-usual (BAU).<br>"The TfL BIM team will establish a benefits map that captures and illustrates: relationships between the outputs produced; the business changes needed to take on new capability; the outcomes expected from the successful conduct of business change activity; the benefits (intermediate and wider benefits) that are anticipated to be realised because of those outcomes; and the TfL strategic objectives that will be achieved as a result."<br>The process is iterative with each step learning from experience and making improvements that will be fed into BAU.<br>• Planning the benefits<br>• Identifying and mapping the benefits<br>• Setting benefit priorities<br>• Benefit profiles<br>• Benefits Realisation Plan<br>• Executing the Benefits Realisation Plan<br>• Reviewing and evaluation benefits realisation<br>The strategy recognises that "Benefits planning is an ongoing and iterative activity, especially when changes are considered or implemented that are likely to impact the vision, business case, blueprint or implementation plans. Benefit plans will be reviewed annually and adjusted accordingly in light of changes and outcomes from benefit realisation reporting". |
| **Assumptions made** | The strategy requires individuals to explicitly state if any assumption is made during the measurement of the BIM benefits. |
| **Baseline used** | The strategy recognises that tracking benefits and establishing baseline data is a long process that can takes years. The methodology requires the establishment of baselines at Stage 4 (detailed design). Some baselines requires a detailed questionnaire in order to be established. |
| **Definition of benefit** | The strategy distinguish between two types of benefits: **intermediate benefits** (benefits that should apply to all programmes and projects where the minimum requirement for BIM has been applied); and **wider or end benefits** (benefits that are impacted by multiple factors such as reduced capital project risks and costs). In addition to these two categories of benefits, the strategy establishes some **"strategic objectives"** such as greater whole life cycle value from assets; improved customer experience; improved safety; and enhanced reputation. |
| **Benefits/key Performance Indicators measured by the tool/model? And how each is measured?** | The strategy includes a Benefits Statement setting out expected benefits and dis-benefits of adopting BIM on TfL projects. They are separated into two categories – intermediate benefits and end or wider benefits – and identified by one of four benefit types: direct monetary benefits (tangible); direct non-monetary benefits (tangible); indirect benefits (intangible); and dis-benefits.<br>Utilises a Benefits Profile Table that details for each benefit the following:<br>ID; Benefit Description; Change Logic; Target; Potential Measure(s); Measurement Methodology; Responsible for delivery; Trajectory |

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| | **Intermediate benefits**<br>– BIM maturity compliance*<br>– Improved supply chain management<br>– Improved management of asset production and handover<br>– Improved asset data quality and availability<br>– Improved risk management<br>– Improved stakeholder engagement and management<br>– Improved (better coordinated) designs<br>– More accurate construction plans<br>– Improved safety during construction<br>– Reduced cost to develop designs at concept and feasibility stages<br>– Cost of Programme BIM Manager and Information Manager | **End or wider benefits**<br>– Compliance<br>– Reduced capital project risks and costs (cost avoidance)<br>– Enabling key business improvement<br>– Enhanced TfL staff capabilities |
| **Details of any case studies demonstrating application of the tool/model** | NA | |
| **Additional information** | | |

## Appendix G.3 ROI Analysis

### Information Extraction Card

| **Benefits Tool/Model** | **ROI Analysis** | | | |
|---|---|---|---|---|
| **Supporting Docs/Links** | Giel, B.K. and Issa, R.R.A. (2013) 'Return on Investment Analysis of Using Building Information Modeling in Construction', *Journal of Computing in Civil Engineering*, 27(5), pp. 511-521. | | | |
| **Author / owner** | Giel and Issa (2013) | **Country/Origin** | USA | |
| **Date of release, and version assessed** | 2013 | | | |
| **Benefits measured in** | Projects ☐ | Organisations ☒<br>**ROI for organisations across projects** | | |
| **Benefits are measured for** | Planning ☐ | Design ☐ | Construction ☒ | Operation ☐ |
| **Applicability** | Generic ☒ | Market-Specific ☐ | Discipline-Specific ☐ | |
| **Sector** | Building ☒ | Infrastructure ☐ | Other: | |
| **Intended use** | General[43] ☒ | Specialised[44] ☐ | | |
| **Intended users** | Asset owners | | | |
| **Benefit management[45] approach** | The tool applied a model for estimating BIM ROI that reviewed RFI logs, change order logs and delay claims. Then interviews were held with people who worked on the project to collect additional data. | | | |
| **Assumptions made** | | | | |
| **Baseline used** | Three case studies were used that compared two similar projects done at different times by the same organisation where the first project was without BIM and the second project was with BIM. | | | |
| **Definition of benefit** | None | | | |
| **What are the benefits/key Performance Indicators** | Cost savings and man hours saved on:<br>• Original contract value | | | |

[43] To assess general BIM benefits to the adopting organisation.
[44] To assess specialised BIM benefits from specific technologies (e.g. mobile/site BIM technologies) for specific purpose (e.g. snagging)
[45] Benefits management is "the identification and structuring/definition of benefits, the planning of benefits realisation, the realisation and tracking of benefits, and the evaluation (review and optimisation) of benefits"

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| **measured by the tool/model? And how each is measured?** | • Total cost of change orders<br>• Original schedule duration<br>• Duration of schedule delay that was or was not experienced<br>• Building size<br>• Type of construction<br>• Use<br>The case studies reviewed requests for information (RFI) and change order logs as they were the most comprehensive documents. In addition, interviews were held to collect data not obtainable by these documents.<br>Direct (i.e. cost) and indirect (i.e. time) savings were assessed after the direct cost of BIM implementation (i.e. hardware and software) was subtracted.<br>The cost of BIM was represented as 0.5% if the initial contract value. |
| **Details of any case studies demonstrating application of the tool/model** | Various case studies were used to demonstrate ROI of BIM. |
| **Additional information** | This was a research project so there are limitations to the work. |