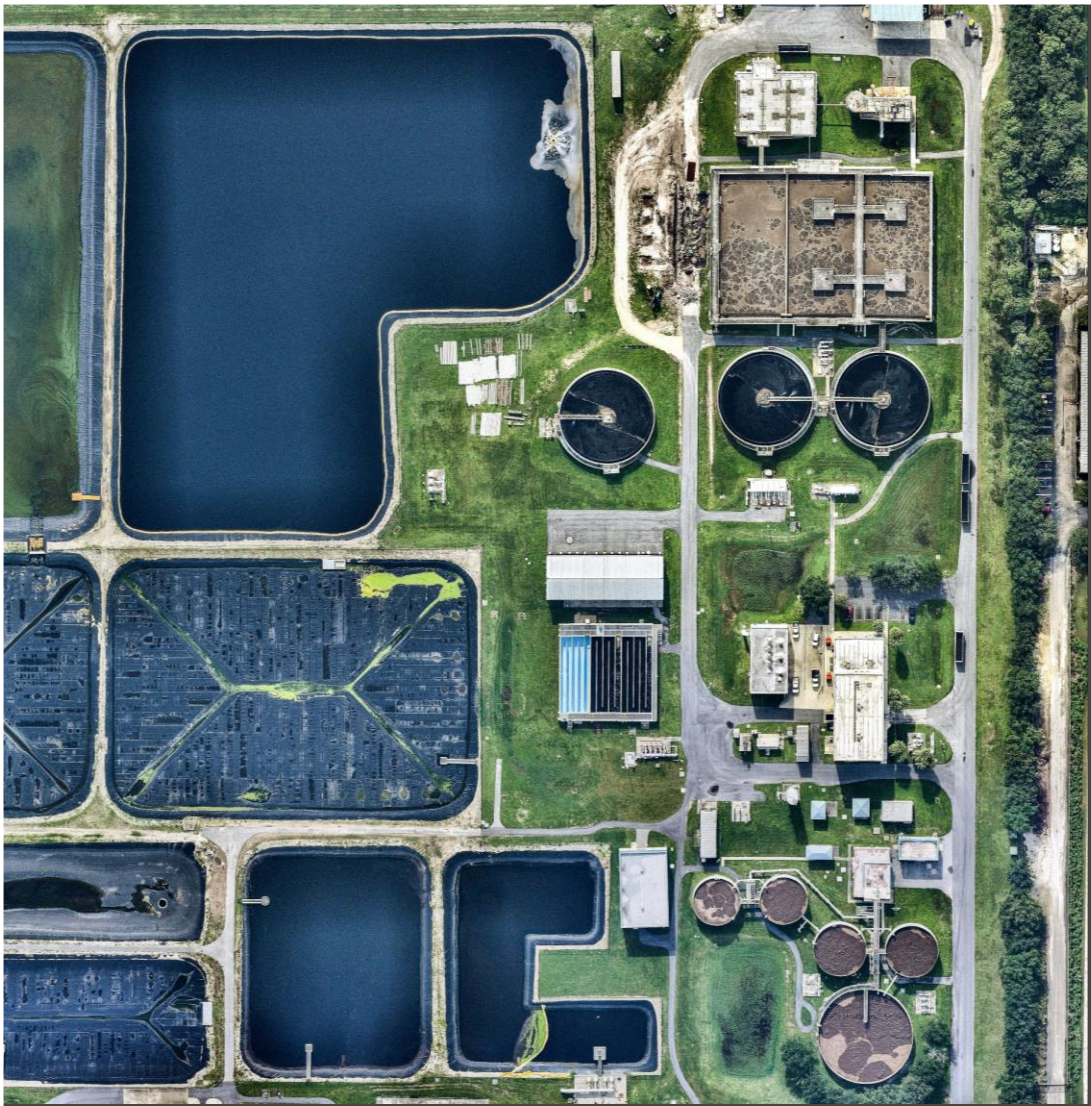
Assessment of the benefits of BIM in Asset Management

Part 1 - Context and Methodology

May 2020



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Contents

1 Introduction and context

1.1 Introduction

In 2016 the UK Government mandated the use of Building Information Modelling ('BIM') Level 2 on all centrally procured public construction projects. After three years of mandatory BIM adoption, senior figures across the construction industry and in government have called for greater clarity on 1) the benefits of BIM as it is currently used, and 2) the next phase of the digital transformation of asset management (i.e. extending the current uses of BIM) and the associated benefits.

In response, the Centre for Digital Built Britain (CDBB)[1] commissioned[2] PwC to develop two methodology[3] documents to outline an approach to provide clarity in the two respective areas introduced above. It is intended that in a subsequent phase of work, these methodologies will be applied to case study projects to collate the necessary evidence, and report on any benefits, in order to provide the clarity that industry and government have called for.

This report called '2020 PwC BIM Measurement Methodology for Asset Management' (2020 PwC BMM for AM) provides the methodology for the second item introduced above, i.e. to define the next phase of the digital transformation of asset management and to assess the associated benefits. This document builds on the '2018 PwC BIM Measurement Methodology' (2018 PwC BMM) and the related documents[4] for measuring the benefits of BIM Level 2, commissioned by Innovate UK. The '2018 PwC BMM' work is publicly available on the CDBB website[5].

This document extends the methodology in '2018 PwC BMM' and refers to the '2020 PwC BMM'[6] titled 'Assessment of the value of BIM, Part 1 – Context and methodology', which is also publicly available on the CDBB website. Together, these two methodology documents inform this '2020 PwC BMM for AM' document.

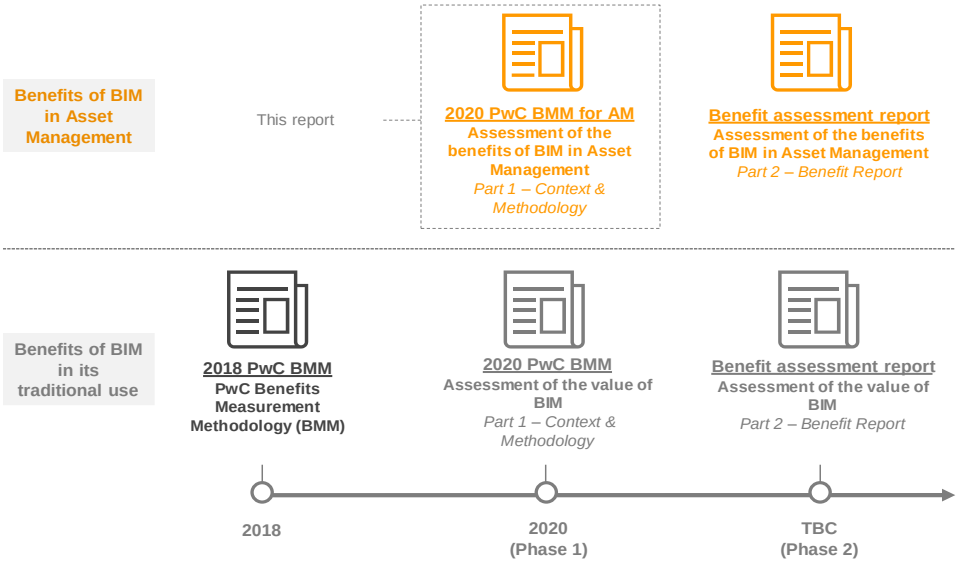

Figure 1. The timeline of the work carried out on the benefits of BIM.

[1] Centre of Digital Built Britain, 'About Us', available at: https://www.cdbb.cam.ac.uk/AboutDBB
[2] The terms of engagement between CDBB and PwC are defined in the letter 'CDBB 017-19 - Final PwC Agreement' 25/10/19.
[3] CDBB commissioned PwC to develop a separate methodology to define and assess the benefits for the next phase of the digital transformation of the asset management lifecycle, and how asset data (including BIM) enables this and generates associated benefits.
[4] The 2018 PwC BIM benefits work for Innovate UK comprised of four documents: 1) BIM Level 2 – summary guidance to BMM, 2) PwC Introductory note to BMM, 3) PwC Benefits Measurement Methodology, and 4) PwC BMM Application Report.
[5] Methodology documents available at: https://www.cdbb.cam.ac.uk/news/2018JuneBIMBenefits
[6] PwC, 'Assessment of the value of BIM, Part 1 - Methodology and Context', 2020.

1.2 Scope of this document

The scope of this document is to provide an initial outline methodology to assess and evidence the benefits of BIM beyond its traditional use, to enable wider digital transformation of asset management. This methodology should be read in conjunction with the '2020 PwC BMM' which outlines the key assumptions and principles applicable to this methodology.

This document sets out an approach to respond to the following hypothesis, and corresponding high-level requirement:

Hypothesis *- Greater benefits can be realised by extending the use of BIM beyond its traditional scope to enable wider digital transformation of the construction and owner/operations industries.*

Requirement *- Define the next phase in the digital transformation of the through-life management of assets, and how asset data (including BIM) enables this and generates associated benefits.*

The '2020 PwC BMM for AM' methodology is an extension of the '2018 PwC BMM'. The extension clarifies the beneficiaries of BIM and introduces additional benefit pathways for BIM-enabled asset management. This document also sets out the context for the methodology, the approach taken to develop the methodology, and a series of next steps to apply the methodology.

Guiding principles for the ultimate BIM benefit assessment report were established to inform the development of this methodology. They are as follows:

1. The final BIM benefit assessment report will be aimed at business decision makers, it will not be a technical report.

2. The final BIM benefit assessment report will set out where the benefits are and are not realised.

3. The final BIM benefit assessment report will be objective, be evidence-based and be clear on where the findings can or cannot be quantified. In this respect any quantified benefits are likely to be closer to lower bound estimates, rather than upper bound estimates.

4. The final BIM benefit assessment report will set out the limitations of the work.

The intent behind these principles is to demonstrate that any reported benefits of BIM in asset management have been assessed based on facts and evidence. This methodology and any subsequent BIM benefit assessment report aim to provide transparency into the methods, data, calculations, assumptions and interpretations, so that the basis of any reported benefits is clear.

1.3 The relationship between Asset Management and BIM

Asset management may be defined as "coordinated activities of an organisation to realise value from assets"[7] spanning the whole lifecycle of an asset. In the built environment, assets pass through the lifecycle stages of strategic planning, initial design, engineering, development, documentation and construction, day-to-day operation, maintenance, refurbishment, repair and end-of-life[8]. BIM enables information management across all lifecycle stages in a structured and consistent way.

The BIM Level 2 mandate focused primarily on improving information management in the design and construction phases. There is an opportunity to extend the adoption of BIM to benefit other lifecycle stages, including strategic planning and the operation and maintenance stages of the asset lifecycle.

Due to the long service life of built assets[9], the operation and maintenance stage is typically where most of the whole lifecycle cost is incurred[10], and therefore this stage represents a significant opportunity for cost efficiencies. Furthermore,

[7] ISO 55000:2014 - Asset management — Overview, principles and terminology, page 14, clause 3.3.1.
[8] BS EN ISO 19650-1:2018, page 1, Section 1 Scope.
[9] Examples of infrastructure asset service life is available at: https://www.ucsusa.org/sites/default/files/attach/gw-smart-infrastructure-table-life-expectancy.pdf
[10] Constructing Excellence, 'Never Waste a Good Crisis', 2009, page 25, Figure 18. Indicative ratio of costs and value over a building's life cycle, available at: https://constructingexcellence.org.uk/wp-content/uploads/2014/12/Wolstenholme_Report_Oct_2009.pdf

strategic decisions relating to asset investment will have a significant impact on the whole lifecycle costs. Therefore, the availability of appropriate and reliable asset information is vital for effective asset management, as it supports decision making and planning of asset management activities.

By providing a structured framework for the creation, collation and exchange of information about the assets, BIM supports effective asset management[11]. Asset data generated through BIM processes can enable the creation of 'Digital Twins'[12] and the application of advanced analytical techniques to support decision-making processes. The methodology described in this report excludes the assessment of benefits of digital twins, as this is being considered as part of the National Digital Twin programme[13]. This report focuses on the methodology for measuring benefits using the advanced analysis for decision-making in BIM-enabled built asset management.

1.4 Adoption of BIM-enabled Asset Management

Accurate asset information and knowledge underpins effective asset management[14]. However, currently, the handover of project information models to asset management functions is limited, with only a third of projects in the UK passing the models to those responsible for asset management[15]. Potential reasons for this low adoption are:

- The lack of involvement of asset management functions early in the project lifecycle;
- The lack of understanding of the benefits of BIM in asset management; and,
- The focus on capital rather than the whole lifecycle expenditure when making asset investment decisions.

Attitudes towards BIM as an enabler for operational and maintenance savings are changing[16] but it may take time to have an effect[17]. An indicative view of the potential future adoption, or maturity states, for the use of BIM data in asset management is shown in **Figure 2.**

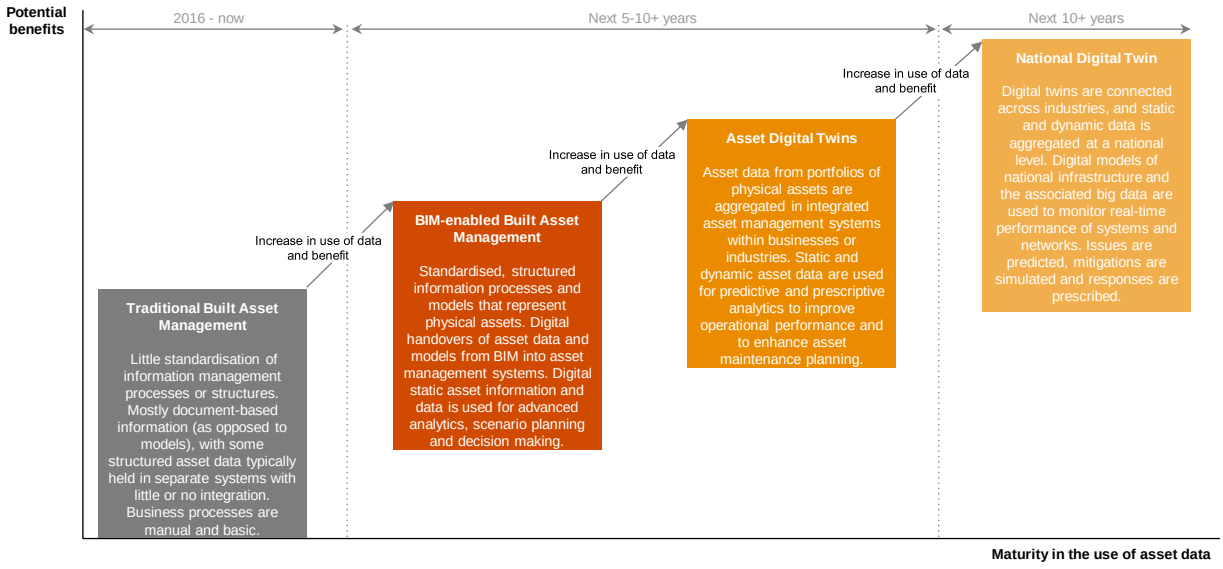

Figure 2. Indicative maturity states of BIM data use in asset management, and associated benefits, over time.

[11] ICE, 'Leveraging the Relationship between BIM and Asset Management', 2014, page 2, available at: https://www.ice.org.uk/getattachment/disciplines-and-resources/best-practice/relationship-between-bim-and-asset-management/BIM_Modelling-and-Asset-Management_Position-Paper.pdf.aspx

[12] Digital twin: A realistic digital representation of something physical. What distinguishes a digital twin from any other digital model is its connection to the physical twin. Definition based on Gemini principles.

[13] The work on benefits of National Digital Twin is carried out by a team from Atkins and Ordnance Survey. More information is available at: https://www.cdbb.cam.ac.uk/news/atkins-and-ordnance-survey-appointed-research-benefits-national-digital-twin

[14] The Institute of Asset Management, 'Asset Management - An Anatomy', 2015, page 16, available at: https://theiam.org/media/1781/iam_anatomy_ver3_web.pdf

[15] 'NBS - National BIM Report 2019', 2019, page 29 available at: https://www.thenbs.com/knowledge/national-bim-report-2019

[16] 'NBS - National BIM Report 2019', page 21 available at: https://www.thenbs.com/knowledge/national-bim-report-2019

[17] Based on the rate of increase in BIM adoption in construction since the BIM Level 2 mandate.

The focus of this document is the methodology to assess the benefits of BIM-enabled built asset management. Future work on benefit assessment in Phase 2 of the project will also include the assessment of maturity of the UK industry in BIM-enabled asset management, as well as measures to improve the use of BIM for asset management.

2 PwC BIM Benefits Measurement Methodology for Asset Management

The '2020 PwC BMM for AM' provides an initial outline methodology to assess the benefits and beneficiaries of BIM-enabled asset management using historic and potential future cases.

2.1 Summary of benefits methodology

The '2020 PwC BMM for AM' is based on the '2020 PwC BMM' and utilises the existing pathways from the '2018 PwC BMM'. It also contains the outline of new impact pathways for asset management activities that will be developed in more detail in Phase 2.

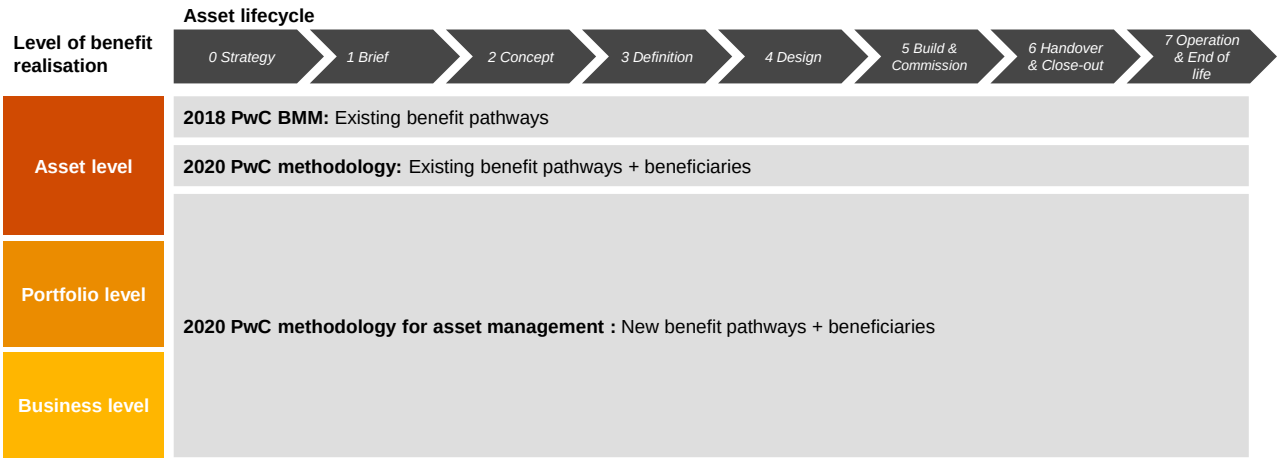

Figure 3. Summary of sources for benefit pathways included in this methodology.

2.2 Extended impact pathway

The original impact pathways will be extended to include the 'beneficiary'. The revised pathways will only assess the direct beneficiaries and will not include the indirect beneficiaries, this is based on the approach described in '2020 PwC BMM'.

Figure 4. Extended benefit pathway.

- **Activity** - A technical capability provided by using BIM, that can lead to one or more measurable benefits in asset management in the strategy, design, build, handover, operation and end of life stages of the asset lifecycle with various beneficiaries;
- **BIM enabler -** A BIM tool, process or application that results in a direct positive effect, which enables realisation of the benefit, at a specific stage of the asset lifecycle;
- **Intermediate benefit** - A direct measurable positive benefit resulting from application of the BIM enabler in the strategy, design, build, handover, operation and end of life stages of the asset lifecycle;
- **End benefit** - The ultimate impact of the intermediate benefit, which is assessed and potentially measured/ quantified. Multiple pathways can result in the same end benefit, e.g. time, material or cost savings; and,

- **Beneficiary** - Depending on the impact pathway multiple stakeholders can realise the benefit. Only direct beneficiaries will be considered as part of the '2020 PwC BMM for AM' together with the level of benefit realisation.

2.3 Benefit realisation

The benefits of BIM in asset management can be realised at three levels, as shown in **Figure 5**:

- At the asset level;
- At the portfolio of assets level; and,
- At the business level, where multiple portfolios of assets are managed.

Benefits can either be aggregated from asset to portfolio and business levels, or directly realised at each of the levels.

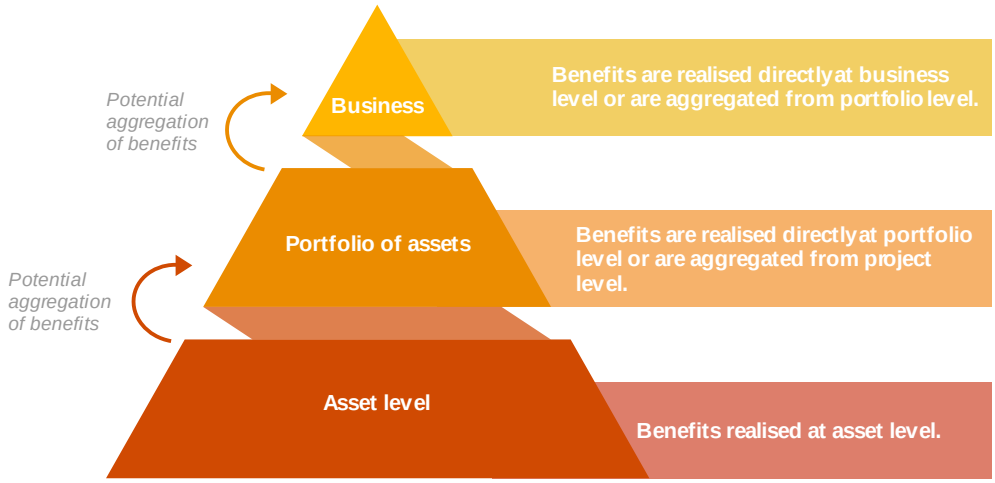

Figure 5. Level of benefit realisation.

To demonstrate the realisation and aggregation of benefits at different levels, three examples based on building maintenance are described below, where one building is assumed to be an asset. Each example describes an impact pathway for a corresponding level of benefit realisation.

Example 1. Benefit realisation at Asset level.

Figure 6. Asset level impact pathway.

To execute a maintenance operation for one building, the maintenance team can access the digital Asset Information Model ('AIM') of the building, which is likely to benefit maintenance and operation activities. The AIM can provide quicker access to the relevant asset information and may be easier to consume, when compared to the use of the electronic documented version of the Operation & Maintenance manual.

AIM contains structured, governed asset information and the asset's context. This allows the maintenance team to:

- be more confident in the information;
- plan the maintenance more robustly; and,
- potentially execute and complete the task in less time.

For example, having information about working constraints, found within the AIM, may allow a task to be resolved upon a single visit, rather than requiring multiple visits due to unforeseen conditions on site.

This approach can lead to time savings in maintenance which are realised by the asset manager responsible for the maintenance operation. This asset level benefit can be aggregated at portfolio and business level, based on the number of assets and maintenance operations.

Example 2. Benefit realisation at Portfolio level.

Figure 7. Portfolio level impact pathway.

To plan the maintenance of a portfolio of buildings and assets, the maintenance team can use multiple AIMs extracted from the asset information management system. Based on the requirements for maintenance and an understanding of conditions across the portfolio of assets, the maintenance team can optimise the activities to complete the maintenance faster, when compared to planning the maintenance on a single asset basis.

For example, the team can optimise the sequence of maintenance work across the portfolio by planning work based on the locations of multiple assets, to reduce the travel time to sites, resulting in a reduction of the total maintenance duration across the whole portfolio.

This approach can lead to time savings in maintenance which are realised by the whole function responsible for the maintenance of the portfolio.

Example 3. Benefit realisation at Business level

Figure 8. Business level impact pathway.

To plan the maintenance of multiple buildings, the centralised maintenance function can use the BIM-enabled asset data from the asset information management system to calculate the demand for material and equipment.

The demand requirements based on the asset data can inform the procurement strategy that utilises economies of scale to reduce the material and equipment cost by buying them in bulk or negotiating more beneficial contracts with suppliers, compared to procurement on an individual building basis.

Use of BIM-enabled asset data for intelligent procurement can lead to total cost savings in maintenance for the whole business and be realised by the asset owner.

2.4 Additional impact pathways

As mentioned in **Section 2.1**, the '2020 PwC BMM for AM' pathways leverage the relevant pathways from the '2018 PwC BMM', and include additional impact pathways, based on asset management standards such as PAS 1192-3 (2014)[18] and ISO 55001 (2018)[19]. **Table 1** summarises the existing and additional pathways contained in the benefits framework for the '2020 PwC BMM for AM'.

Methodology	Stage	Category of activities	Activity example	Comment
2018 PwC BMM (Asset level only)	0: Strategy	Strategic planning	Providing project business case & Information requirements	Using the Government Soft Landings approach to define information which is critical in order to achieve efficiencies at operation and end of life stages, e.g.

[18] PAS 1192-3:2014, 'Specification for information management for the operational phase of assets using building information modelling', 2014
[19] ISO 55002:2018, 'Asset management — Management systems — Guidelines for the application of ISO 55001', 2018

Methodology	Stage	Category of activities	Activity example	Comment
				operational cost reduction, enhanced reputation, or customer satisfaction.
	4: Design	Design authoring	Creation of design information	Using the Government Soft Landings approach to execute design with operational targets in place.
	5: Handover and commissioning	Asset handover	• Creation and handover of asset data • Asset testing • Training	Structured asset data is provided to the asset manager, informing management activities based on Asset Information Requirements.
	6: Operation and end of life	Refurbishment and upgrades	Minor works for an asset	Using the AIM to inform refurbishment planning and design.
		Asset disposal	Demolition planning	The AIM provides information to inform, plan and model asset demolition.
2020 PwC BMM for AM (Enhanced to include asset, portfolio and business levels)	0: Strategy	Strategic planning	Planning the delivery of a portfolio, or multiple portfolios of assets	Access to asset data can inform portfolio and business level decision making and planning for asset delivery and management.
	4: Design 5: Handover and commissioning 6: Operation and end of life	Financial Management	Costing and forecasting	BIM-enabled asset data can save time and improve the level of asset data detail when forecasting and managing asset management costs.
		Maintenance	Optimising maintenance at portfolio and business levels	Maintenance can be optimised by accessing digital asset information to inform asset maintenance and repair plans.
		Facilities Management	Optimising facilities management operations	Based on asset information the operation and maintenance of asset components affecting security and surveillance can be optimised and synchronised with janitorial services.
		Inspection and Monitoring	Automating inspection and monitoring	Digital asset data (e.g. on component deterioration) can inform and support predictive maintenance planning across multiple assets.
		Compliance Management	Regulatory compliance reporting	Regulatory or contractual obligations for reporting on assets can be met quickly and accurately by utilising digital asset data sets and tools.
		Health and Safety Management	H&S training	Digital asset information can support Health & Safety training related to specific operational and maintenance activities (e.g. by using 3D models before site visits to familiarise staff of hazards).
		Risk Management	Emergency response planning	Asset information is required to identify and review risks where an asset or its components could be exposed to natural hazards, extreme weather conditions or fire, in order to plan emergency response.

Methodology	Stage	Category of activities	Activity example	Comment
		People Management	Human resource optimisation and allocation	Based on staff suitability and asset information, the appropriate personnel can be identified to conduct specific asset management activities.
		Sustainability and Environmental Management	Energy efficiency management	Based on BIM-enabled energy efficiency information, an asset's energy consumption can be assessed and energy saving opportunities can be exploited.
		Quality Management	Quality control	Digital asset information can be linked to the relevant specification and standards to provide better quality management through the lifecycle of an asset. Digital asset information can also be subjected to data quality diagnostics and remediation to improve and maintain data quality.

Table 1. Existing and potential new impact pathways for '2020 PwC BMM for AM'.

2.5 Benefit assessment process maps

The benefit assessment process for the '2020 PwC BMM for AM' will use one of two process maps, depending on the available data for benefit assessment:

1. **Process map 1**. For assessment of the benefits from the traditional uses of BIM. This process relies on data from completed or current projects and is an account of events that occurred in the past.
2. **Process map 2**. For assessment of the future potential benefits of BIM in Asset Management (outlined in **Figure 10** below). This process relies on data from case studies and completed asset management activities to infer and estimate potential future benefits.

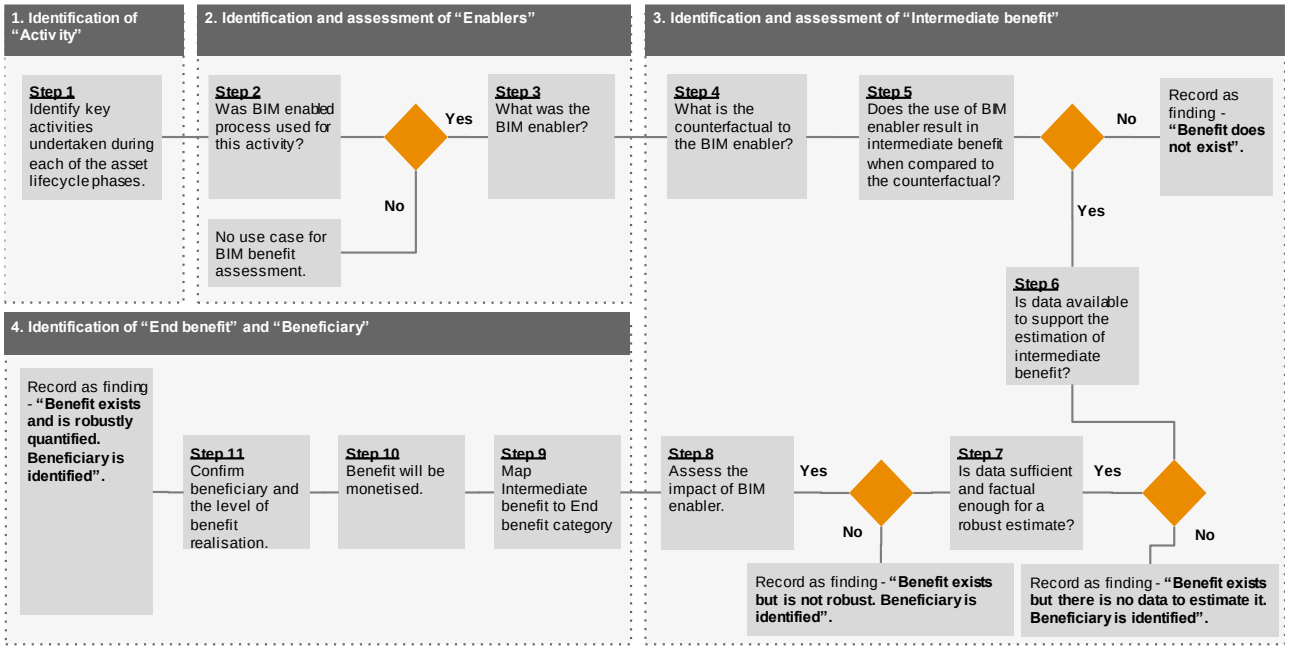

Figure 9. BIM benefit assessment process map 1.

Process map 1 should be used where there is existing, historical or current data relating to the traditional use of BIM. This process map is defined in further detail in **Figure 5** in '2020 PwC BMM', available from the CDBB website.

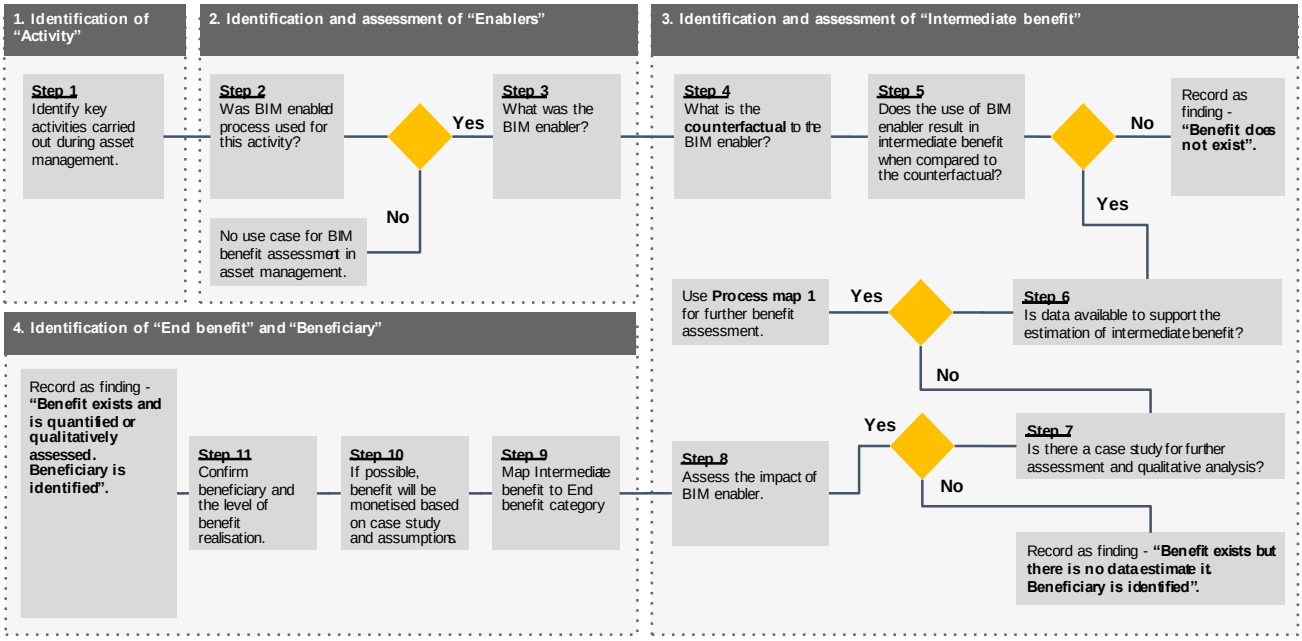

Figure 10. BIM benefit assessment process map 2.

Process map 2 outlined in this report (in **Figure 10**) and detailed in **Table 2** (below) builds on the original process map 1 by providing an additional approach to the use data for future benefit analysis. The map deviates from Process map 1 at Step 6 where a different approach is proposed when no historic data is available. Both process maps are required to assess the benefits using this methodology.

The key difference between the process maps is concerned with the robustness of data and therefore the certainty and confidence in any assessed and quantified BIM benefits. Process map 1 requires existing data relating to a specific scenario and applies a data robustness criterion to the data. This should result in a higher level of certainty and confidence in any assessed and quantified BIM benefits.

Process map 2, by design, allows for a broader range of information types to assess the benefits e.g. preparing case studies, or using benchmark data to infer future benefits. This approach allows for potential future benefits to be assessed, while recognising that the data used to inform these assessments may result in a wider range of certainty and lower level of confidence on any assessed and quantified BIM benefits.

Table 2 below details the inputs, resources, process control, and outputs required for benefit assessment relating to Process map 2.

Process stage	Description
1 Identification of "Activity"	**Inputs** – Asset management documentation (focusing on handover, operation and maintenance), data and consultations. '2020 PwC BMM for AM' and reference material. **Resources** – Facility managers and asset owners including consultants and/or contractors. External BIM and asset management experts. **Process/ control** **Step 1** - Consultation through workshops with asset managers and owners to identify the key asset management activities carried out from Handover to Operate lifecycle. The assessment of activities will be led by BIM and asset management experts. **Outputs** – A list of key asset management related activities within the Handover and Operate lifecycle stages to inform further benefit investigation.

Process stage	Description
2 Identification and assessment of "Enablers"	**Inputs** – Evidence of BIM enablers used in Asset Management. **Resources** - Facility managers and asset owners including consultants and/or contractors. External BIM and asset management experts. **Process/ control** **Step 2** – Assess how BIM processes and data were used to enable the delivery of an activity. If a BIM process was not used to deliver an activity, then it will not be used for benefit assessment. If BIM was enabled, then the enabler will be identified in Step 3. **Step 3** – Identify the BIM enabler. For example, obtaining information for maintenance planning can be done using a BIM-enabled or traditional process: 1. BIM-enabled - Using an Asset Information Model (AIM)[20] to extract the same information from a single source e.g. a model. 2. Traditional – Reviewing data sets and analogue documents from multiple sources such as PDF drawings, spreadsheets and documents to extract quantities, specifications, components descriptions and location. The AIM is the BIM enabler for obtaining information to inform maintenance planning quicker and in a more reliable way. Using the AIM, which includes the relevant asset data saves time compared to the manual maintenance planning process, which relies on collecting data from a range of sources. The assessment of enablers will be led by BIM and asset management experts. **Outputs** - The output for this phase is the list of BIM enablers for the corresponding asset management activities.
3 Identification and assessment of "Intermediate benefit"	**Inputs** – Specific project and asset documentation and data related to the identified BIM enablers from previous steps. **Resources** - Facility managers and asset owners including consultants and/or contractors. External BIM, asset management experts and economists. **Process/ control** **Step 4** - Identify a counterfactual (see **Section 2.7**) for the BIM enabler. Using the maintenance planning example in the previous section, the counterfactual for obtaining accurate asset data for planning based on the AIM is using a traditional, manual process to gather data from multiple sources. The assessment of the counterfactual will be led by BIM and asset management experts, then verified by the economists. **Step 5** - Identify the intermediate impact of the BIM enabler. The impact is expected to be discussed with the asset and facility managers to understand if it is positive or negative.

[20] BS EN ISO 19650-1:2018, page 4, clause 3.3.9.

Process stage	Description
	This part of the process will be led by economists and supported by BIM and asset management experts. If the impact is negative, the finding will be recorded as “Benefit does not exist.” If the impact is deemed to be positive, then data will be requested from the asset management teams. **Step 6** – Evaluate the available data that supports the estimation of the intermediate benefit and review the identification of the beneficiary. If historic data exists and is available, then process map 1 outlined in ‘2020 PwC BMM’[21] should be used. If historic data is not available, the benefit should be investigated further in Step 7. **Step 7** – In the absence of historic data, additional consultations with asset and facility managers or a review of case study material will be necessary to assess the potential benefits and beneficiary. Both qualitative and quantitative assessments will be performed. If no case studies or other information types are available from stakeholders to form the basis for the benefit estimate, then it is recorded as “Benefit exists but there is no data to estimate it. Beneficiary is identified.” **Step 8** - If data for estimation is available, the impact of the BIM enabler will be assessed. The impact assessment will be led by economists. **Outputs** – The key output of this phase is the list of identified intermediate benefits and their potential beneficiaries.
4 Identification and assessment of “End benefit” and “Beneficiary”	**Inputs** – BIM enablers and intermediate benefits from previous steps. **Resources** – Economists, BIM and asset management experts. **Process/ control** **Step 9** – The intermediate benefit will be mapped to the end benefit category based on the benefits framework. This will enable aggregation of the effects of benefits, by category. **Step 10** - If possible, the benefit will be monetised based on data obtained from consultation and assumptions for labour or material costs. This step is defined in more detail in the ‘2018 PwC BMM’. Where benefits cannot be monetised, benefit estimates will be quantified and expressed in terms of percentages or other units of measure. The benefit estimate can also be presented in ranges. **Step 11** – The beneficiary and level of the benefit realisation will be identified (e.g. asset, portfolio, business). Steps 9 to 11 will be led by economists and supported by BIM and asset management experts. **Outputs** – Once the analysis is completed, the output will be a record that a “Benefit exists and is quantified or qualitatively assessed. Beneficiary is identified”.

Table 2. Detailed Process map 2 for future benefit assessment.

[21] PwC, ‘Assessment of the value of BIM, Part 1 - Methodology and Context’, 2020, page 7.

Benefit process outcomes

The key outcomes using this process are:

- There is no use case for benefit assessment;
- The BIM benefit does not exist;
- The Benefit exists and there is data - use '2020 PwC BMM' to assess the benefit further;
- The Benefit exists but there is no data or case study to assess it. Beneficiary is identified; or,
- The Benefit exists and is quantified or qualitatively assessed. Beneficiary is identified.

2.6 Data for benefit analysis

Data collection is a key activity in the assessment of BIM benefits in asset management. Use of BIM-enabled asset data for enterprise asset management does not appear to be widely adopted in the UK infrastructure and buildings sectors as discussed in **Section 1.4**. This means that historic data sets might not be available for the benefit analysis. Therefore, case studies from any early adopters of BIM in asset management will be analysed, and consultations will be conducted with asset owners and managers to obtain the data. Similarly to '2020 PwC BMM', a structured methodology with a counterfactual, as defined in **Section 2.7** will be used, which will be supported by expert judgement.

Approach to data collection

As discussed in '2020 PwC BMM', the data collection approach will depend on the availability and willingness of stakeholders to share data for benefits analysis. A broad range of stakeholders including asset owners, asset managers, equipment manufacturers, engineering consultants and contractors will be approached for data. The outreach will be done using formal information requests through CDBB, BEIS, IPA and Construction Leadership Council. Stakeholders will be offered Non-Disclosure Agreements and data anonymisation, to manage how data is handled and ultimately presented in the ultimate benefit assessment report.

Data collection techniques will depend on the amount of data available. In a scenario of limited data availability, the methodology will rely on case studies, consultations and workshops with stakeholders. In a scenario of larger datasets, data will be extracted from the Common Data Environment and Asset Information Management systems.

One of the potential challenges in obtaining the right data is the variability of naming conventions for documents between different organisations. To enable benefit assessment, the required asset data points will be described in the information request or during the workshops with key stakeholders. As an example, to extract the number of maintenance operations performed on an asset, the team would need to review the documents that could be called "maintenance log", "record of maintenance" or "maintenance work schedule".

Asset information request

Appendix A: Data for benefit assessment in Asset Management contains the list of document and data types necessary to inform the benefit assessment. The list is based on the **Appendix C** in '2020 PwC BMM'[22] and tailored to be relevant for asset management. This list is not exhaustive, and documents and data sources might be named differently to those specified in the list.

2.7 Key assumptions and definitions

Key assumptions for the development of the methodology to assess the benefits of BIM in Asset Management are outlined in **Section 2.7** of '2020 PwC BMM'. Additional assumptions and definitions specific to this methodology are provided in the sections below.

Definition of a BIM-enabled asset information delivery process

Figure 11 provides the view of a BIM-enabled asset information delivery based on a UK BIM Framework BIM process[23] and based on the asset lifecycle stages outlined in '2020 PwC BMM', with the exclusion of the "Integrate" stage, and the inclusion of the "Handover" milestone.

[22] PwC, 'Assessment of the value of BIM, Part 1 - Methodology and Context', 2020, pages 9-10.

[23] https://ukbimframework.org/

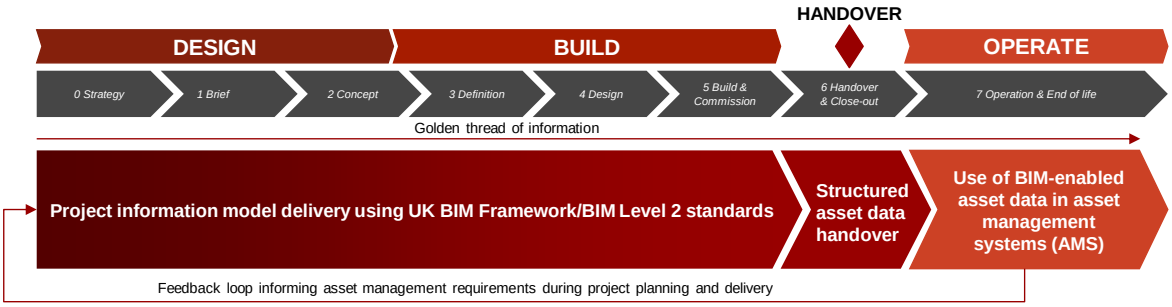

Figure 11. BIM-enabled asset data flow.

The following assumptions define a BIM-enabled asset information delivery process:

- During design and build stages, the project information model[24] is developed using the UK BIM framework or BIM Level 2 standards[25] including the principles outlined in the Government Soft Landings (GSL) document[26] and the Asset Information Requirements (AIR)[27];
- Upon completion of the build stage, asset data from the as-constructed project information model is structured using a data format (e.g. COBie[28] and Uniclass[29]) which facilitates the handover of both geometric and non-geometric data into the asset management systems;
- Once the asset data is input into the asset management systems, it can be used for decision-making by asset managers and owners responsible for delivering the asset management activities;
- For subsequent projects, the asset information requirements are revised based on the feedback from the asset management function;
- The whole process maintains a 'Golden thread of information'[30]; and,
- There is no connection between the asset information model and the physical asset in terms of data exchange.

Definition of a counterfactual case

A counterfactual case[31] for a BIM-enabled asset information delivery process is presented below. This case will form the baseline against which the impact will be assessed, and the benefits calculated.

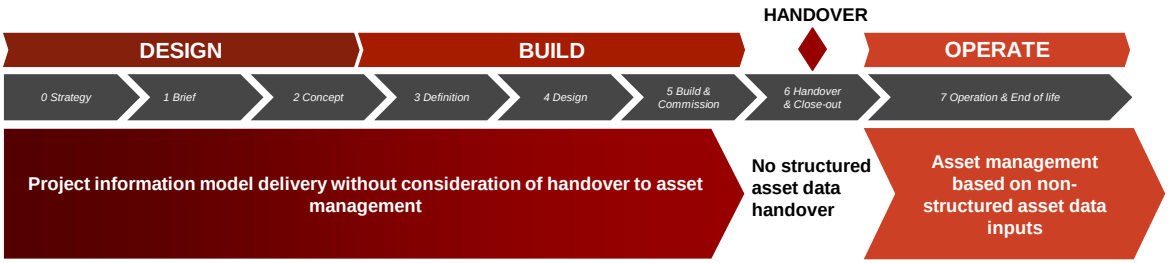

Figure 12. Counterfactual case without BIM enablement.

The following assumptions define a counterfactual case:

- GSL guidance is not used and the AIR are not defined or communicated;
- There is no feedback loop for information requirements from asset management into strategy, design, or project delivery stages;

[24] 'Information model relating to the delivery phase' defined in BS EN ISO 19650-1:2018, page 4, clause 3.3.10.
[25] PwC, 'Assessment of the value of BIM, Part 1 - Methodology and Context', 2020, pages 16-17.
[26] UK BIM Framework, 'Government Soft Landings. Revised guidance for the public sector on applying BS8536 parts 1 and 2. Updated for ISO19650', 2019.
[27] 'Information requirements in relation to the operation of an asset' defined in ISO 19650-1:2018, page 3, clause 3.3.4.
[28] National Building Specification, 'What is COBie?', available at: https://www.thenbs.com/knowledge/what-is-cobie
[29] National Building Specification, 'What is Uniclass 2015?', available at: https://www.thenbs.com/knowledge/what-is-uniclass-2015
[30] Chapter 8: Golden thread of building information. Building a Safer Future. Independent Review of Building. Regulations and Fire Safety: Final report. May 2018.
[31] The 'counterfactual' measures what would have happened to beneficiaries in the absence of the intervention, and impact is estimated by comparing counterfactual outcomes to those observed under the intervention.

- Asset information and data is not handed over in a standardised, structured format using data schemas;
- The handover process is primarily manual, and does not utilise standard, structured data uploads into to asset management systems;
- There is no connection between the asset information model and physical asset in terms of data exchange.

2.8 Benefit measurement expertise

Application of this methodology requires a combination of technical BIM, asset management, and economic expertise. Technical BIM and asset management expertise will be necessary to select and interview organisational users and stakeholders, identify relevant documents, and extract data points for benefit analysis. Economists will verify the counterfactual, measure the impacts of BIM-enabled asset information delivery through changes in time or resource, and monetise the value of those impacts.

3 Project planning

This section describes an indicative plan and key project management steps for the application of the '2020 PwC BMM for AM'.

3.1 Project plan

After completion of this methodology Phase 1, the project delivery plan consists of two phases: Phase 2a and Phase 2b. Phase 2a is a preparation stage for Phase 2b in which the benefit analysis will be carried out.

Phase 2a – Preparation phase

Phase 2a will focus on the following main activities:

1. **Methodology development** – Refining and tailoring the new asset management impact pathways for benefit analysis through consultation and workshops with key stakeholders.
2. **Stakeholder outreach** – Engaging key stakeholders and agreeing on the benefit assessment timeframe. The plan for the methodology application will be refined based on the confirmed availability of stakeholders, case studies and data. Updates on the plan will be discussed with BEIS and UoC.
3. **Data sourcing and collection** – Identifying, selecting and confirming access to data and case studies to complete the benefit assessment. This phase includes activities that provide access to data and/ or case studies which can be directly applicable for the methodology. If necessary, non-disclosure agreements and other arrangements can be agreed at this stage. Within this phase, available data and case study information will be collected where possible.
4. **Planning for data collection and processing** – Planning, structuring, collating, organising, manipulating, processing and storing available data and information. Necessary template documents, processes and tools to process data and information for benefits analysis will be defined in this phase.

Phase 2b – Benefits measurement phase

Phase 2b will be delivered in a series of Sprints. A Sprint is a two-week work period during which the engagement teams will proactively deliver the scope of work included in the sprint using the '2020 PwC BMM for AM'. The scope of work, and application of the '2020 PwC BMM for AM' will be based on the specific characteristics of the case studies and consultation with stakeholders. The results of Sprint 1 to 3 will be provided to BEIS and UoC for review and comment. A draft report with benefit findings will be created during the final sprints. A final report will incorporate the comments and updates for final submission.

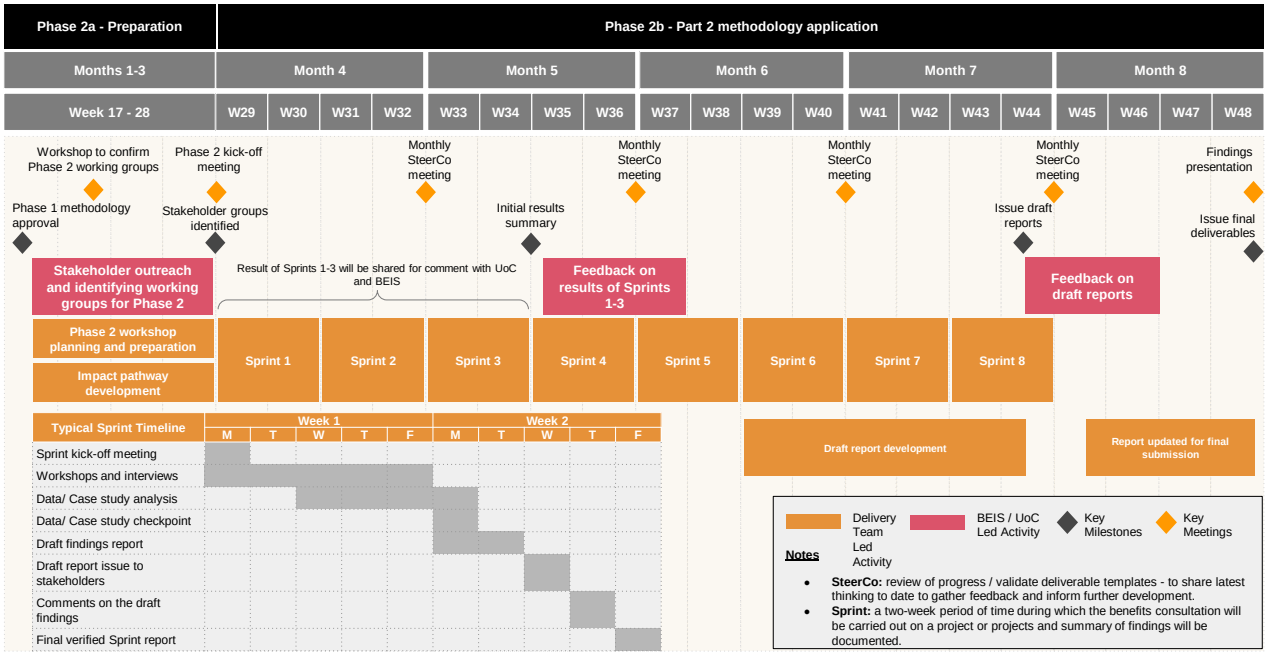

Figure 13. Phase 2 plan on a page.

3.2 Project risks, assumptions and dependencies

The section outlines the key project risks, assumptions and dependencies.

Risks

Key risks in applying the benefit measurement methodology and mitigation measures have been identified in **Table 3** below.

Risk	Mitigation measures
A lack of access to stakeholders who are willing to participate in the benefit measurement project will lead to fewer benefit assessments, which would reduce the confidence in any benefits identified.	Initial outreach to key industry stakeholders within Asset Owners and Asset Managers has already started with the support from senior and influential UK construction industry stakeholders.
Insufficient data and information to measure benefits from will reduce the clarity and robustness of any benefit estimates.	• Case studies and target stakeholders are identified to test the availability of asset data; • Asset data and asset management documents will be reviewed prior to full-scale measurement and workshops; • Initial consultations with the relevant Asset Owner and Asset Manager stakeholders to identify the available asset data and information; and • Non-Disclosure Agreements have been prepared to allow controlled data sharing for benefit estimation.
A lack of an appropriate counterfactual to enable benefit assessment will reduce the number of benefit impact pathways that can be measured, which will reduce the confidence in any benefits measured.	In line with prior experience of identifying counterfactuals, an assumed counterfactual for benefit estimation will be applied, based on examples from industry, expert opinion, and benchmarks.

Table 3. Key risks and mitigation measures for Phase 2 of the project.

Assumptions

Key assumptions that apply to the delivery of the '2020 PwC BMM for AM' project are listed below:

- CDBB and BEIS stakeholders will continue to assist with identifying potential organisations for engagement and help with initial stakeholder outreach (e.g. introductions); and,
- Workshops and consultations within the same asset management organisation will be carried out with a range of stakeholders to allow for a rigorous identification of benefits and beneficiaries.

Dependencies

Key dependencies that may be required to deliver of the '2020 PwC BMM for AM' project are listed below:

- The project team will have access to stakeholders to brief them on the purpose of the project, methodology and the required data and information types;
- Stakeholders will be available for benefit workshops and consultations within the agreed period;
- Stakeholders will share available data, information and expert opinions to assess the benefit and beneficiaries.

3.3 Target stakeholders

Target stakeholders to engage and apply the methodology in order to assess the benefits of BIM in Asset Management were identified as:

- Asset owners and asset managers
- Facilities managers
- IT platform suppliers

The list of stakeholders is not exhaustive.

Appendix A: Data for benefit assessment in Asset Management

No.	Document/ data type	Content and aim	Potential location	Preferred format
1	**BIM Execution Plan (BEP)**	Content: Information and plan which sets out and explains the role of BIM in project delivery and explains how asset data is handed over into enterprise asset management systems. Aim: This will provide an insight into how BIM processes were implemented on the project and which BIM enablers have been deployed.	• Client or Supply chain Common Data Environment (CDE)	pdf doc
2	**Organisational Information Requirements (OIR)**[32]	Content: Information requirements laid out by the client for asset management and operation systems and for other asset management related organisational functions. Aim: This will provide the information requirement on an organisational level and the context to understand the Asset Information Requirement document.	• Client or Supply chain CDE	pdf doc
3	**Asset Information Requirements (AIR)**	Content: Information requirements set out by the client for specific asset management tasks, such as legal, commercial, technical and managerial information - mainly on an asset level. Aim: This will provide a detailed overview of required data and information for asset management and context for the Asset Information Model (AIM).	• Client or Supply chain CDE	pdf doc
4	**Exchange Information Requirements (EIR)**	Content: It defines the information required by the client from his own team, the suppliers' project delivery, and for the operation and management of the built asset. It may also include information about standards on how information and data were created, named, exchanged in the information delivery plan. Aim: This will provide detailed information of required data for asset delivery, operation and management. It will also give context the Project Information Model (PIM).	• Client or Supply chain CDE	pdf doc
5	**Contracts with design/ construction supply chain**	Content: Legal agreement between client and designers. Aim: The contract could include the following information: • Average daily/hourly wage including overheads or professional rates including overheads • Procurement route • Original scope of works/services • Agreed project programme • Cost of delay • Extensions of original scope • Total cost of works/services	• Client or Supply chain CDE • Contract management system	pdf

[32] 'information requirements in relation to organizational objectives' definition based on ISO19650-1:2018, page 4, clause 3.3.8

6	**Contracts with maintenance supply chain**	Content: Contract describing arrangements with maintenance providers. Aim: This will provide the total annual cost of asset maintenance services: • Average daily/hourly wage including overheads or professional rates including overheads • Original scope of works/services • Penalties cost when asset is out of operation for longer than expected • Extensions of original scope • Total cost of works/services	• Client or Supply chain CDE • Contract management system	pdf
7	**Contracts with operations supply chain**	Content: contract with facilities management providers. Aim: This will provide the annual cost of facilities management operations on a project using AIM including: • Average daily/hourly wage including overheads or professional rates including overheads • Utility bills	• Client or Supply chain CDE • Contract management system	pdf
8	**Facilities management cost plan** • Cost data	Content: contract with facilities management providers. Aim: This will provide the annual cost of facilities management operations on a project using AIM including: • Average daily/hourly wage including overheads or professional rates including overheads • Cost of CAFM systems • Utility bills	• Client or Supply chain CDE • Cost management system	xls
9	**Asset maintenance cost plan** • Cost data	Content: Document that includes information about the breakdown of total asset maintenance costs per year. Aim: This will provide the following information: • Total annual maintenance cost • Total annual cost of holding inventory for an asset • Total maintenance training cost	• Client or Supply chain CDE • Cost management system	xls
10	**Asset utilisation reports**	Content: Reports showing how utilised the asset is i.e. road is at 80% capacity based on the average traffic flow, or the number of desks occupied in the office. Aim: to assess whether BIM processes improve the asset utilisation.	• Client or Supply chain CDE • Enterprise asset management system	pdf xls
11	**Maintenance log/reports**	Content: Reports showing the number of maintenance cases per asset Aim: to assess whether BIM processes reduces the number of maintenance operations required	• Client or Supply chain CDE • Enterprise asset management system	xls pdf
12	**Post-Occupancy Evaluation Forms**	Content: Form comparing asset operating performance against the design targets. Aim: to assess whether there is increased certainty in asset operational performance.	• Client or Supply chain CDE • Enterprise asset management system	pdf

Table 4. Examples of data and documents for benefit assessment in asset management.

Appendix B: CDBB Steering Group and Working Group

The CDBB steering group and CDBB working group that was consulted during the development of the Extended PwC BMM comprised of the following individuals:

Steering Group	
Alexandra Bolton	CDBB
Barry Blackwell	CDBB and BEIS

Working Group	
Rachel Atcherson	Department for International Trade
Marcus Deeley	Department for International Trade
Amelia Burnett	Centre for Digital Built Britain
Mark Enzer	Mott Macdonald and National Digital Twin Programme
Alana Gluck	Centre for Digital Built Britain
Anne Kemp	Atkins and UK BIM Alliance
Alex Luck	Centre for Digital Built Britain
Adam Matthews	Centre for Digital Built Britain
Fiona Moore	Centre for Digital Built Britain
David Philp	Aecom
Terry Stocks	Faithful & Gould
Pauline Tzachrista	Centre for Digital Built Britain

CDBB Working Group Meetings were held on the following dates:

Working Group Meetings	
22nd January 2020	JJ Tompson Room, Maxwell Centre, JJ Tompson Avenue, CB3 0HE, Cambridge
14th February 2020	JJ Tompson Room, Maxwell Centre, JJ Tompson Avenue, CB3 0HE, Cambridge
16th March 2020	JJ Tompson Room, Maxwell Centre, JJ Tompson Avenue, CB3 0HE, Cambridge