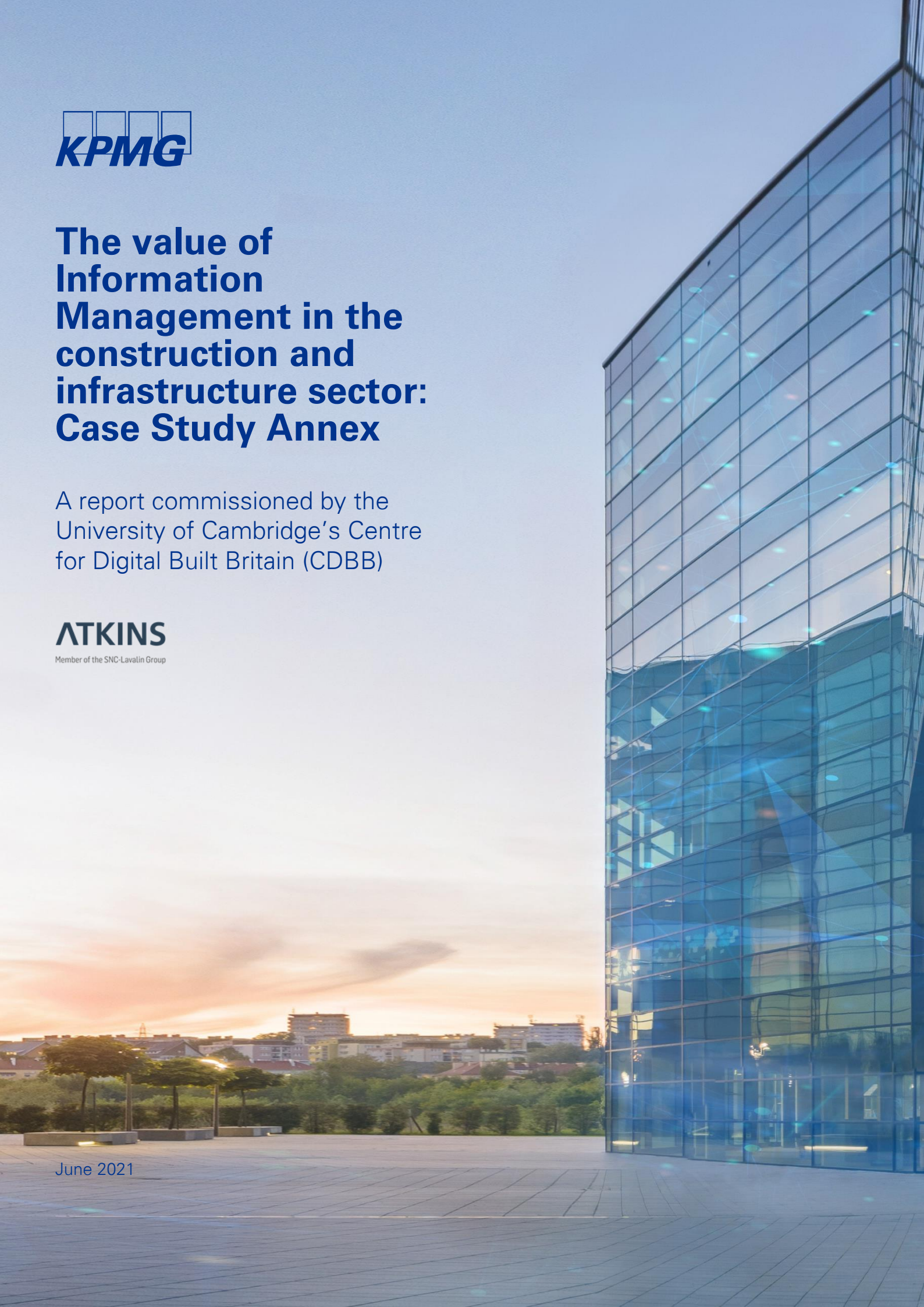

KPMG

The value of Information Management in the construction and infrastructure sector: Case Study Annex

A report commissioned by the University of Cambridge's Centre for Digital Built Britain (CDBB)

ATKINS
Member of the SNC-Lavalin Group

June 2021

Contents

1 Important Notice

This Case Study Annex report has been prepared by KPMG LLP ("KPMG") as part of the full report, 'The value of information management in the construction and infrastructure sector' dated June 2021 and prepared solely for the University of Cambridge ("the Client"), in accordance with the terms of engagement agreed by the Client with KPMG, which include the scope of work in Appendix 2. The findings presented in this Case Study Annex report should be read in conjunction with that full report.

This Case Study Annex report should not therefore be regarded as being suitable to be used or relied on by any other person for any purpose, except for the Client. Should anyone other than the Client choose to rely on this report, they do so at their own risk. Without prejudice to KPMG's liability to the Client, subject to and in accordance with the terms of engagement agreed between them, KPMG will accordingly accept no responsibility or liability in respect of this report to any person. This report does not give rise to a client relationship between KPMG and any person (other than the Client).

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Our work for the client was conducted between 30th September 2020 and 11th June 2021. This Case Study Annex report relates to research and analysis of eleven case studies undertaken as part of our work for the Client, which comprised desk-based analysis of publicly available information and the analysis of information and assumptions provided by stakeholder organisations. In some of the case studies, technology vendors have been included for the purposes of providing context for the analysis. This does not constitute a recommendation or promotion of the services and products provided by these companies.

For the avoidance of doubt, our work is not a comprehensive analysis of all the facts and the costs related to Information Management in the construction and infrastructure sector, and we have only sought to answer the following specific questions set by the Client:

How are construction and infrastructure organisations creating, managing and making use of quality and timely information?

What value does this deliver for those organisations as well as their customers, wider society and the economy?

Where limitations in the information available have been identified and impacted our analysis, these have been set out in the relevant sections of this Case Study Annex report and in KPMG's main report, 'The value of information management in the construction and infrastructure sector'.

This Case Study Annex report makes reference to 'analysis'; this indicates only that we have (where specified) undertaken certain analytical activities on the underlying data to arrive at the information presented. KPMG does not provide any assurance as to the appropriateness or accuracy of sources of information relied upon unless specifically noted in this report, and

KPMG does not accept any responsibility for the underlying data used in this report. Furthermore, KPMG accept no responsibility or liability for the findings or reports of other advisers even though we have referred to their findings and/or reports in our report.

The economic analysis contained in this Case Study Annex report is for indicative purposes only. The decision as to which items should be included or excluded in the economic analysis is judgement-based. Furthermore, the items identified are necessarily limited to those that we have identified in course of the work performed by us, which is subject to the restrictions in the scope of work, as set out in the terms of our engagement. They have also been subject to the limitations on our access to, and the nature and extent of, the information which has been made available to us. Accordingly, there is no basis on which to state whether, in the economic analysis presented, the items that have been included are appropriate, or that all items that might be appropriate have been included. KPMG have indicated in this Case Study Annex and in our main report the basis on which items have been included, excluded or adjusted. You may choose to analyse the information presented differently.

Where the analysis in this Case Study Annex report contains illustrative forecasts, projections or estimations, these are based on assumptions provided by the Client and stakeholder organisations involved in the case study analysis, together with models operated by KPMG. KPMG does not make any guarantee that these forecasts, projections or estimations will be achieved. It is your responsibility to assess these illustrative forecasts, projections or estimations against your requirements and to make decisions regarding your operations. The forecasts, projections or estimations should not be relied upon as a single source for any decision you make, and it is your responsibility to take all relevant factors into consideration.

For this Case Study Annex, the Client has not engaged KPMG to perform an assurance engagement conducted in accordance with any generally accepted assurance standards and consequently no assurance opinion is expressed.

The opinions and conclusions expressed in this report are (subject to the foregoing) those of KPMG and do not necessarily align with those of the University of Cambridge.

2 Introduction

2.1.1 Context

This Case Study Annex report should be read in conjunction with our published full report, 'The value of information management in the construction and infrastructure sector', dated June 2021, for the University of Cambridge's Centre for Digital Built Britain (CDBB). The full report provides detailed context on the scope and purpose of our study for CDBB and a detailed explanation of our overall approach to the study and its limitations. This includes important information on the boundaries of the study, such as what we mean by 'Information Management' (IM)[1] and its use in the 'construction and infrastructure' sector (see Section 3 of our main report) and the potential types of value it can unlock within and beyond the organisations which use IM (see Section 5 our main report). In particular, this Case Study Annex should be read alongside Section 6 of our main report, which details our approach to the case study analysis, including the selection of a representative sample of case studies and sourcing of qualitative and quantitative evidence of their IM use cases and benefits.

This Case Study Annex report presents the detailed case study evidence collected and analysed through KPMG and Atkins's research of eleven case studies over a five-month period. This research was completed through in-depth stakeholder engagement comprising: workshops; one-to-one follow-up interviews; and data/information requests for input information and supplementary evidence, which were tailored to the particular circumstances of each case study.

In the rest of this section we summarise the purpose of the case study analysis and provide an overview of the case studies analysed. The rest of this Case Study Annex report then presents the detailed findings from our analysis of each of the eleven case studies, ordered alphabetically as follows:

— Section 3 — Babcock

— Section 4 — BDP

— Section 5 — Connect Plus Services

— Section 6 — EDAROTH

— Section 7 — Environment Agency

— Section 8 — Government Property Agency

— Section 9 — Heathrow

— Section 10 — The Met Office

[1] In short, the definition of IM in the construction and infrastructure sector developed for this study relates to the process by which an organisation collects, structures, stores, uses and shares its data to perform its core business across asset lifecycle activities. In the construction and infrastructure sector, IM is enabled by the application of the UK BIM Framework and supports wider digital transformation approaches (data analytics, data science, Internet of Things, Artificial Intelligence/ Machine Learning applications). Together, these approaches improve the quality, availability and timeliness of the information available to organisations – facilitating more efficient and effective decisions and investments across the asset lifecycle. See our main report for more details.

— Section 11 — Transport for Greater Manchester

— Section 12 — VolkerWessels

— Section 13 — Yorkshire Water – BIM4Water: Gouthwaite Reservoir Spillway Improvement Works

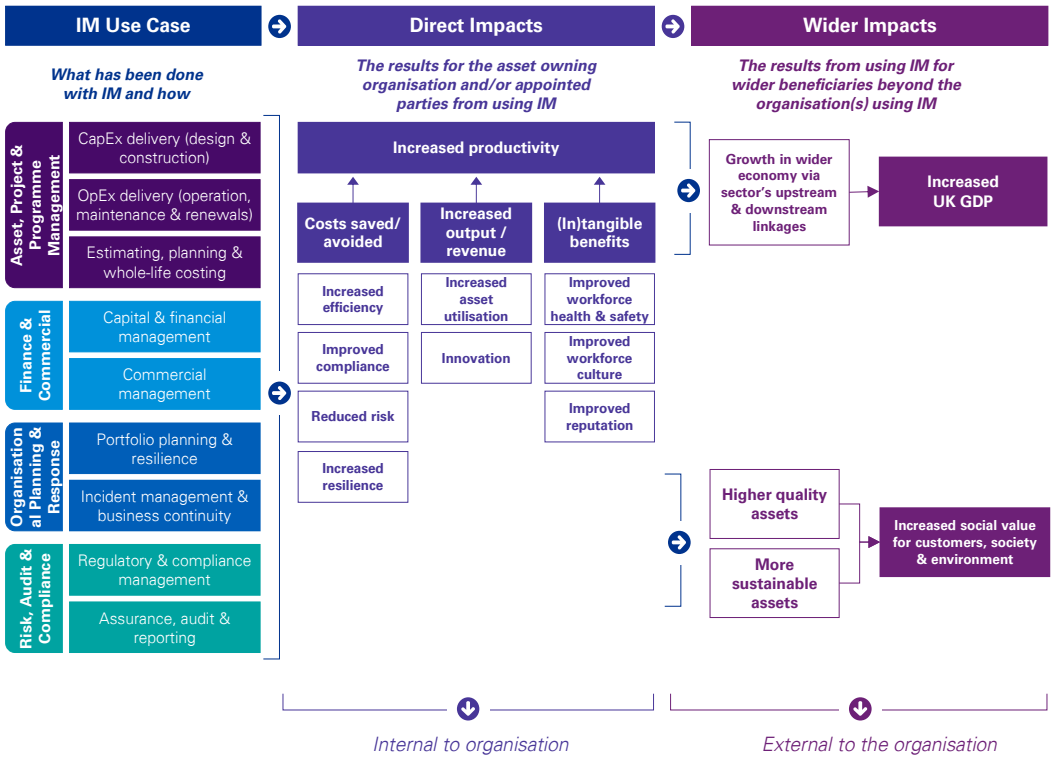
For each case study presented in this Case Study Annex report, we typically provide: context and background to the organisation's strategy and the role of IM in helping to deliver the organisation's objectives; their journey of IM adoption over time (where relevant); their specific use cases for IM at the project- and/or organisation-levels; and the direct and wider impacts (benefits) this has delivered, or is expected to deliver.

2.2 Purpose of the case study analysis and key limitations

The purpose of the case study analysis was to test and validate the 'Information Management Benefits Framework' (Figure 1) developed for our study for CDBB and to provide new evidence on the uses and benefits of IM at the project- and organisation- levels (addressing some of the key gaps in the existing literature, which are highlighted in our main report). The Benefits Framework serves to provide a summary of how the inputs and activities associated with the use of IM at the project- and organisation-levels could ultimately lead to end impacts for organisations (increased productivity and intangible benefits) and broader impacts for customers, society, the environment and the wider economy. It is important to note that the IM uses cases and benefits are highly context specific, as highlighted throughout our main report for CDBB and in the existing literature on the benefits of IM, as well as across the case studies themselves[2].

[2] The use of IM has a broad range of applications across the construction and infrastructure sector, involving the use of standards and processes in different ways, which in turn results in a wide range of possible outcomes for projects, organisations and external parties. Therefore, the Framework is not intended to provide a detailed or prescriptive methodology for measuring and quantifying individual impact pathways, but rather to provide a strategic overview of the range of uses and benefits of IM to provide decision-makers with a consistent and integrated basis for considering the value of investing in IM. See Section 5 of our main report for more details.

Figure 1: Information Management Benefits Framework



Source: KPMG and Atkins Analysis. 2021

We applied the Framework to each case study in order to identify the range of use cases for IM for the given organisation/project (unpacking the first stage of the Framework) and to identify the range of potential direct and wider impacts (benefits) that have been realised, or are expected to be realised, from stakeholders' use of IM at the project- and/or organisation-levels (the second and third stages). For wider impacts, our research focused solely on the potential social value unlocked by the use of IM (termed 'wider benefits to UK society' in subsequent sections of this report) from higher quality and/or more sustainable built assets, in line with our Benefits Framework. This is because the potential impacts of IM adoption on UK GDP require a permanent step change in sector-wide productivity from IM adoption, and thus is not appropriate for analysing at the individual project- or organisation-level. These potential UK, economy-wide GDP impacts were analysed separately in our study for CDBB through top-down economic modelling – see Section 7 of our main report for details.

For each case study, we worked with stakeholders to quantify the direct and wider impacts of their use of IM wherever possible[3]. Where this was not possible, a qualitative assessment of impacts has been provided. In both cases:

— The benefits identified are based on a comparison of the impacts of using IM with the impacts arising under a comparable situation in which IM is not used – referred to as the 'counterfactual' scenario. In practical terms, this was achieved through one of two

[3] It is important to note that the different approaches used by stakeholders to measure or estimate the benefits of their IM investments (as well as limitations in what could be shared for commercial sensitivity reasons) makes comparisons of the estimated scale of benefits across the case studies difficult.

means: (i) by asking stakeholders to compare the impacts of the IM use case with a similar project/ business scenario in the past that did not use IM, controlling for the effect of other factors as far as possible; or (ii) by asking stakeholders to use their expert judgement on what would have happened in the absence of using IM. The limited availability of robust data on projects/ situations that were directly comparable to the case studies meant that, in most cases, a judgement-based approach was required.

— Our research was limited to the information available, which varied considerably across the case studies. The information provided by stakeholders came from a combination of their original business cases for investing in IM, their internal lessons learned evidence and evaluation exercises, and their own professional judgement. The analysis and findings for each case study are therefore based on the views, information and assumptions provided by stakeholder organisations, and not those of KPMG or Atkins[4].

— Isolating the specific benefits attributable to IM as opposed to other inputs and processes (such as people/ skills, DfMA/ MMC, contractual arrangements/ business models, etc) is inherently difficult. This methodological challenge is further explained throughout our main report.

[4] Throughout the remaining sections of this Case Study Annex report, any statements or figures reported for a given case study have been provided by the respective stakeholder organisation(s) unless specifically stated otherwise (e.g. in some instances, we reference publicly available information which was suggested to us by stakeholders).

2.3 Overview of the case studies analysed

The table below contains an overview of the eleven case studies we have analysed, including details of their sub-sector, IM use cases and the extent to which direct and wider impacts were identified and quantified or valued. The IM use cases and benefit streams presented in the table are mapped to the Information Management Benefits Framework described previously.

Table 1: Summary of the case studies analysed[5, 6]

Sector		Organisation name	Project name	IM use case(s)[4]	IM use case description	Direct Impacts: Benefit Streams	Direct Impacts: Quantified/ valued?	Wider Impacts: Identified?	Wider Impacts: Quantified/ valued?
	Defence	**Babcock**	**Devonport Royal Dockyard[3]**	✓ ✓	Application of BIM on five live major capital projects at Devonport Royal Dockyard.	Efficiency; Risk; Workforce health and safety			
	Flood, coastal and waste	**Environment Agency**	**Delivering Asset Data to the Requirements Library[2]**	✓ ✓ ✓ ✓	Supporting use of common asset library, data transfer and BIM delivery methodologies across the whole asset lifecycle.	Efficiency; Risk; Workforce health and safety	✓	✓	
	Transport – Highways operations & maintenance	**Connect Plus Services[1]**	**Road Booking System[2]**	✓ ✓ ✓	Digital initiative enabling improvements in planning and co-ordination of road works on the M25 motorway network.	Efficiency; Compliance, Reputation	✓	✓	✓

Key: Asset, Project & Programme Management; Finance & Commercial; Organisational Planning & Response; Risk, Audit & Compliance

Source: KPMG and Atkins analysis 2021.

Note: 1. Lead Appointed Party or Appointed Party; 2. Organisational use case; 3. Project or Programme use case; 4. Covers both established and emerging use cases

[5] Note that all but the Gouthwaite Reservoir Spillway Improvements case study were produced through primary evidence gathering and analysis, undertaken in line with the approach detailed in Section 6.2.3 of the main report. The Gouthwaite Reservoir Spillway Improvements case study was instead an existing case study provided by BIM4Water on behalf of Mott MacDonald and Yorkshire Water, based on a published case study already in the public domain.

[6] EDAROTH is wholly owned subsidiary of Atkins Ltd, a member of the SNC-Lavalin Group, providing end-to-end development solutions which focus on delivering social and affordable housing at the point of need.

Table 1: Summary of the case studies analysed (cont.)[7, 8]

Sector		Organisation name	Project name	IM use case(s)[4]	IM use case description	Direct Impacts: Benefit Streams	Direct Impacts: Quantified/ valued?	Wider Impacts: Identified?	Wider Impacts: Quantified/ valued?
	Housing – Design and construction	**EDAROTH[1]**	**N/A[2]**	✓ ✓ ✓ ✓	An off-site manufactured approach to building sustainable social housing on publicly-owned brownfield land using IM and MMC.	Efficiency; Risk; Innovation	✓	✓	✓
	Multiple sectors – Design and construction	**VolkerWessels UK[1]**	**Digital Toolbox[2]**	✓ ✓ ✓ ✓	Roll-out of a "Digital Toolbox" for five pilot projects in the firm's VolkerFitzpatrick business as part of its adoption across VolkerWessells UK.	Efficiency; Risk; Compliance	✓		
	Non-residential buildings	**Met Office/ Skanska[1]**	**Camborne and Lerwick Balloon Sheds[3]**	✓ ✓ ✓ ✓	Application of BIM and point cloud survey technology for Met Office Balloon Shed projects at Camborne and Lerwick.	Efficiency; Risk, Resilience, Compliance; Innovation; Workforce health and safety	✓	✓	

Key: Asset, Project & Programme Management; Finance & Commercial; Organisational Planning & Response; Risk, Audit & Compliance

Source: KPMG and Atkins analysis 2021.

Note: 1. Lead Appointed Party or Appointed Party; 2. Organisational use case; 3. Project or Programme use case; 4. Covers both established and emerging use cases

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Table 1: Summary of the case studies analysed (cont.)[9, 10]

Sector	Organisation name	Project name	IM use case(s)[4]	IM use case description	Direct Impacts: Benefit Streams	Direct Impacts: Quantified/ valued?	Wider Impacts: Identified?	Wider Impacts: Quantified/ valued?
Non-residential buildings – Health	**BDP**[1]	**London Nightingale Hospital**[3]	✓ ✓	Rapid, agile design and construction of a temporary hospital at the London Excel Centre as part of Government's emergency response to COVID-19.	Efficiency; Resilience, Workforce health and safety			
Non-residential buildings – Commercial office space	**HMRC/ GPA**	**Government Hubs Programme**[2]	✓ ✓	Deployment of a "B²IM" strategy across the Government Hubs Programme, comprising a Functional Model for asset information to enable alignment of BIM information models with facilities management and operational data (at project handover).	Efficiency; Risk; Compliance; Resilience	✓	✓	

Key: Asset, Project & Programme Management; Finance & Commercial; Organisational Planning & Response; Risk, Audit & Compliance

Source: KPMG and Atkins analysis 2021.

Note: 1. Lead Appointed Party or Appointed Party; 2. Organisational use case; 3. Project or Programme use case; 4. Covers both established and emerging use cases

[9] Note that all but the Gouthwaite Reservoir Spillway Improvements case study were produced through primary evidence gathering and analysis, undertaken in line with the approach detailed in Section 6.2.3 of the main report. The Gouthwaite Reservoir Spillway Improvements case study was instead an existing case study provided by BIM4Water on behalf of Mott MacDonald and Yorkshire Water, based on a published case study already in the public domain.

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Table 1: Summary of the case studies analysed (cont.)[11, 12]

Sector		Organisation name	Project name	IM use case(s)[4]	IM use case description	Direct Impacts: Benefit Streams	Direct Impacts: Quantified/ valued?	Wider Impacts: Identified?	Wider Impacts: Quantified/ valued?
	Transport – Highways design & construction and Airports Asset Management	**Heathrow**	**Cargo Tunnel Project[3]**	✓ ✓ ✓ ✓	Application of BIM and ICE Project 13 Integrator Model to the renewal of Heathrow's Cargo Tunnel – a critical asset for airport operations.	Efficiency; Risk; Workforce health and safety	✓	✓	
	Transport – Light rail scheme – design & construction	**Transport for Greater Manchester**	**Manchester Metrolink Trafford Park Line extension**	✓ ✓	Application of BIM for delivery of a major new extension to TfGM's Manchester Metrolink network – the Trafford Park Line.	Efficiency; Risk; Resilience; Reputation	✓	✓	
	Water	**BIM4Water / Yorkshire Water**	**Gouthwaite Reservoir Spillway Improvements[3]**	✓	Application of BIM by Yorkshire Water for its Gouthwaite Reservoir Spillway Improvements project.	Efficiency; Workforce health and safety	✓		

Key: Asset, Project & Programme Management; Finance & Commercial; Organisational Planning & Response; Risk, Audit & Compliance

Source: KPMG and Atkins analysis 2021.

Note: 1. Lead Appointed Party or Appointed Party; 2. Organisational use case; 3. Project or Programme use case; 4. Covers both established and emerging use cases

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3 Babcock

3.1 Context

Babcock is a major provider of critical, complex engineering services across the defence, emergency services and civil nuclear sectors in the UK and overseas. Babcock's clients include the Ministry of Defence and the Royal Navy. They also operate strategic infrastructure and assets on behalf of their clients. Babcock's strategic framework (illustrated in Figure 2) is underpinned by the following strategic priorities[13] that are focussed on delivery:

— Deliver operational excellence for our customers;

— Grow our international business in focus markets;

— Grow market share and expand offering in the UK;

— Develop our people;

— Use technology to strengthen our offering; and

— Focus on value creation.

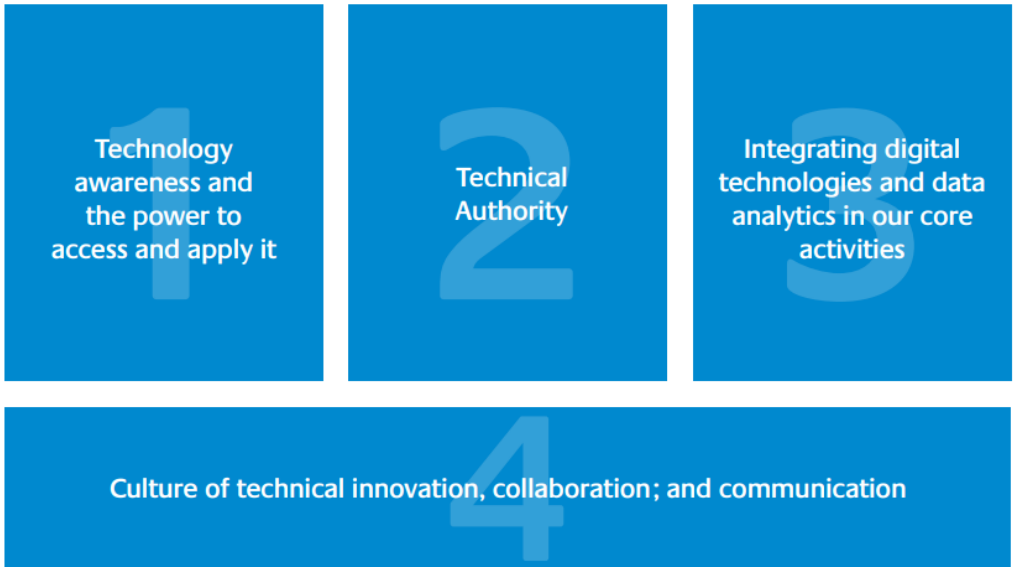
Figure 2: Babcock's strategic framework

Source: Babcock, 2021

Babcock's Major Infrastructure Projects (MIP) division is the most advanced in the application of Information Management (IM) across the business, which it pursues as part of the organisation's technology strategy (illustrated in Figure 3).

[13] Babcock (2021), Our Strategy, link

Figure 3: Babcock's technology strategy



Source: Babcock, 2021

The MIP division comprises some 500 plus staff and is responsible for safely and efficiently delivering approximately £1 billion of infrastructure upgrades at Devonport Royal Dockyard – the focus of this case study – over the next five years to support the UK Government's submarine programme.

Babcock's journey of BIM adoption commenced in 2017 with several projects where BIM was part of the employer's requirements. The MIP division recognised it as a specialist technical area requiring additional resource and appointed a dedicated BIM Manger in mid-2019. Whilst there is not a single BIM mandate across the business, Babcock's MIP division has established a comprehensive set of standards, processes, and tools in compliance with ISO 19650 in order to exploit the benefits of BIM in the design and construction of capital projects and meet their clients' requirements.

3.2 Babcock's use of Information Management on Devonport Royal Dockyard

3.2.1 Background on Devonport Royal Dockyard

Babcock's Devonport Royal Dockyard ('Devonport') facility in Plymouth, co-located with HM Naval Base Devonport in Plymouth, is an operational training and support base for both submarines and surface ships and represents the largest naval support site in Western Europe. It comprises 14 dry docks, four miles of waterfront and 25 tidal berths, and is the base for numerous surface vessels as well as the base and refit centre for nuclear-powered submarines.

At Devonport, Babcock provides complete naval base management services to support all activities on the site – from the provision of waterfront services, through to the management of extensive above and below ground infrastructure and plants and the control and supply of utilities and logistics. This involves the operation, maintenance and renewal of both historic and modern standards and regulatory control.

Currently, Babcock's MIP division are delivering five major capital projects at Devonport. Each of the five projects is at a different stage of design and construction, with the first project due for completion by 2023 and last project in 2025. Babcock is the lead appointing party on these projects, but also operates as lead appointed party taking on design responsibility for selected work packages. Babcock are supported in these projects with a number of external organisations supporting on both design and construction activity. They also serve as the principal client under Construction, Design and Management Regulations. The wider team comprises of other multi-disciplinary design teams, contractors, and sub-contractors. Three of these projects are subject to contractual BIM requirements stipulated by Babock's client, the Ministry of Defence (MoD), however Babcock is endeavouring to use a standardised approach to IM across all five projects.

3.2.2 The role of Information Management on Devonport

Babcock's MIP division has adopted BIM as the standard method of delivering capital projects at Devonport, independent of whether it is mandated by the client. This is in recognition of the benefits unlocked by comprehensive, consistent and reliable asset information during both the construction and operations phases.

It is recognised by the business "as the right thing to do", given the shift in adoption across industry and the need to drive digital construction to help drive efficiencies and bring down delivery costs.

Babcock has adopted a structured approach to BIM in capital delivery which comprises the following key elements:

— Client BIM requirements (where available) are embedded in the scope of works for contracts and appointments along with Babcock's BIM specifications and information standards to constitute the EIR (Exchange Information Requirements). BIM models for design and existing conditions are shared with design houses and contractors as part of the design and construction tender process. Where accurate information is not available for existing buildings and infrastructure, BIM models are generated from point cloud surveys and topographical data.

— The use of a standard BIM maturity assessment tool to qualify the supply chain prior to engaging them and at stage gates during delivery. All supply chain members selected to date have demonstrated a satisfactory level of competency in fulfilling the requirements.

— Continuous improvement through documenting and communicating lessons learnt and best practices, reuse of intelligent 3D components, etc.

— Structured training provision, comprising thirteen modules, which has been deployed across the MIP division to develop a base level of BIM capability across all staff.

— Dedicated BIM support personnel to each major project, complemented with good practice guides, such as 'the six steps to successful BIM', for the wider team.

— Monitoring the ongoing success of individual project teams' BIM adoption every 6-12 months through the use of maturity assessment tools, measuring each team's ability to deliver BIM confidently and in line with the MIP division's information requirements.

Figure 4 below summarises Babcock's MIP division's application of BIM on the five live projects at Devonport Dockyard.

Figure 4: Summary of Babcock's use of Information Management on Devonport

Function / sub-function	Information management use case
CapEx delivery (Design & Construction)	There is extensive use of BIM across the design and construction phases which is enabling Babcock and the supply chain to achieve greater efficiency and improved safety in the delivery of major projects. Project controls teams use BIM to reduce risk. 4D BIM is actively utilised for testing buildability, logistics planning, designing temporary works and challenging design decisions. Quantity take offs from BIM is an emerging use case and the estimating communities are seeking to consume BIM in combination with cost estimating tools, which is expected to provide Babcock with greater certainty on cost.
OpEx delivery (Renewals, Operations & Maintenance)*	Babcock's BIM strategy is focussed on the whole asset lifecycle, and whilst the current use cases are in CapEX stage of delivery, BIM will continue to be adopted into OpEX with Estate Management and Maintenance teams having standardised document control processes as the first step towards exploiting the information delivered using BIM processes to improve operations and maintenance.
Regulatory & compliance management	The use of 3D beacons for hazards and the ability to visualise the risk register is enabling Babcock to fulfil CDM requirements.
Assurance, audit & reporting	Introducing data standards, quality assurance processes and tools in relation to BIM has enhanced Babcock's ability to fulfil its assurance, auditing and reporting relating to MoD requirements and meeting the user group requirements. BIM brings greater visibility of the evolving design and construction activities across the Devonport programme with greater efficiency and accuracy.

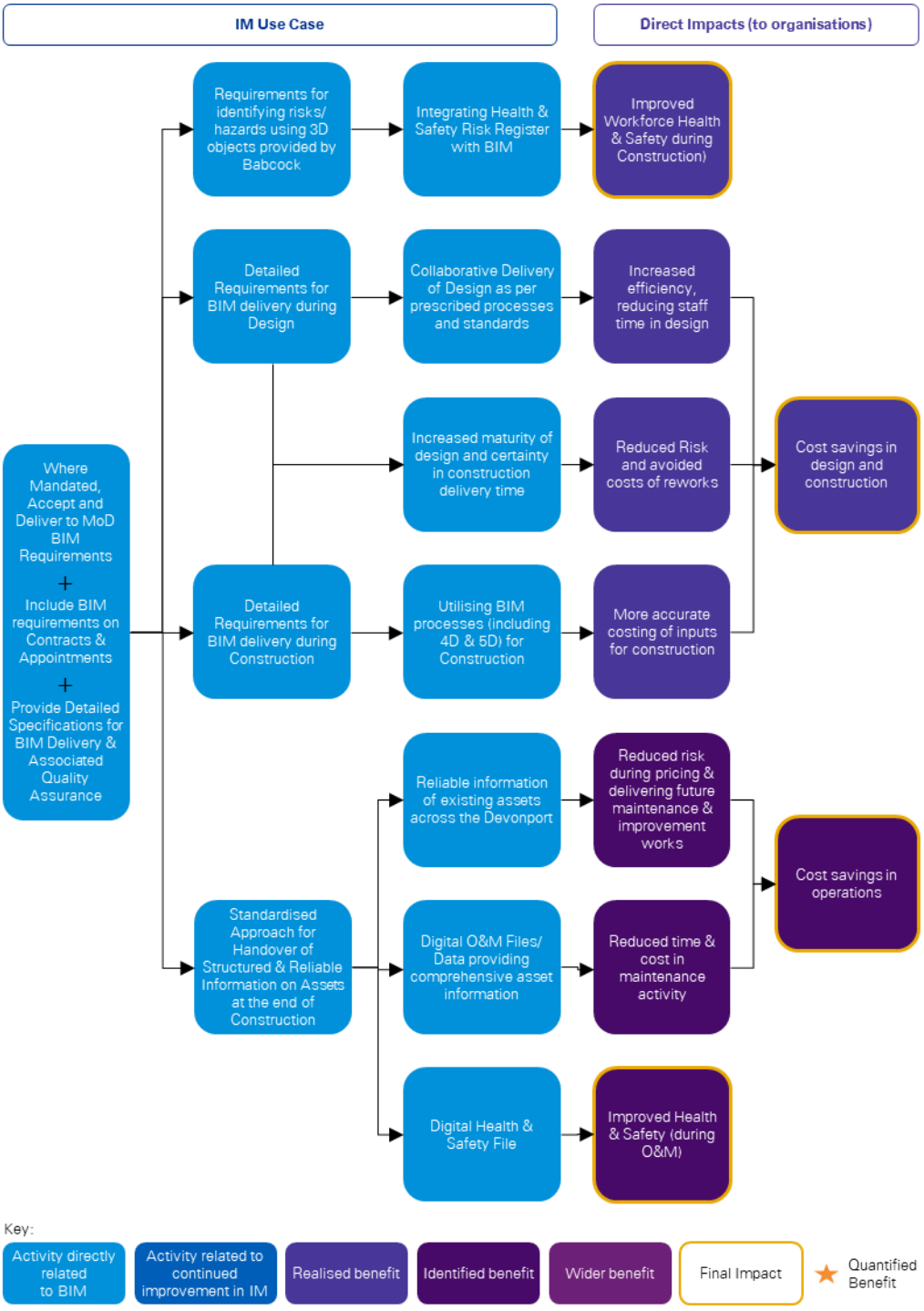
Notes: (*) Emerging use-case with some organisational elements in discovery or early implementation phase
Source: KPMG and Atkins analysis based on information and evidence supplied by Babcock, 2021

3.3 The direct benefits for Babcock and its partners from the use of Information Management

With two years of experience utilising BIM for delivering capital projects, Babcock is in the early stages of BIM adoption. However, this process is expected to unlock a range of direct monetisable and intangible benefits for Babcock and its supply chain organisations, as summarised in Figure 5.

With focused effort in setting up the necessary standards, templates and processes that are based on industry best practices and compliant with ISO 19650, Babcock is already expecting to realise cost savings in delivering major projects at Devonport, as well as improvements to workforce health and safety conditions. The remainder of this section describes each source of benefit in more detail.

Figure 5: Summary of the benefits from Babcock's use of Information Management on Devonport



Source: KPMG and Atkins analysis based on information and evidence supplied by Babcock, 2021

3.3.1 Cost savings in construction

Having detailed requirements aligned with industry standards and supported by standard templates for use by the design and delivery teams is expected to generate cost savings in the capital delivery phase of the Devonport Dockyard programme through:

— Fostering greater collaboration between the various consultants during the design stage which, compared to the traditional process, is helping to achieve better coordination of disciplines and reduce staff time required to complete key stages of the design process;

— Access to better quality information on which to review and challenge design decisions, which is helping to reduce oversights and omissions compared with the traditional design assurance processes, and in turn avoid the costs of reworks during construction;

— Supporting more effective quantity take off, enabling more accurate estimates of materials and labour requirements and avoiding unforeseen costs during construction; and

— Enabling the buildability of projects to be tested at an early stage, in turn providing greater confidence in scheduling of construction works and logistics planning, thereby avoiding the costs of reworks and reducing delays to the construction timetable.

3.3.2 Cost savings in operations

Historically, a lack of accurate, up to date and reliable information for existing assets delivered decades ago has been a pain point for the project teams delivering asset improvements and refurbishments. This has cost Babcock additional time and expenses to carry out upfront surveys to validate existing information and plug information gaps. Complying with BIM processes is expected to ensure quality information on projects is available to Estate Management teams, which in turn is expected to benefit both the operations and maintenance of the site as well as future improvement works.

Babcock will begin to exploit the use of IM in operations once the projects at Devonport Dockyard are completed (by 2023-25). The MIP division's BIM team are conducting a study on the use of BIM for asset management. As a first step, Babcock will be extending the use of the Common Data Environment as a single source of truth for operations and maintenance, warranty and installation records to the teams, making documents digitally accessible with ease. The plan is to connect the asset management datasets with BIM in a bi-directional way. This will form part of the asset information model (AIM) build in the handover from capital delivery (Babcock's Stage 6 – Handover Stage).

3.3.3 Improved workforce health and safety

Beyond direct cost savings, a significant benefit Babcock is expecting from its use of BIM is the ability to improve health and safety conditions for the on-site workforce. Principally this is expected to arise in two ways:

— **The ability to surface risks at the design stage, avoiding incidents during both construction and operation**: Babcock has developed a digital library of components and standard processes for embedding health and safety information in BIM, which is mandated for use by its consultants and subcontractors. The 3D visualisation of residual risks that is enabled by linking the components with the health and safety risk register facilitates deeper engagement from stakeholders, with the potential to mitigate them effectively at design stage. The 3D representation of residual risks when seen in the context of time through 4D sequencing is also allowing Babcock to develop effective visual method statements for mitigating them.

— **The ability to provide virtual health and safety inductions for operative staff**: The use of virtual reality (VR) is widely used in Babcock's MIP division already and supports many of its engineering activities. To further support these practices, Babcock plans to

evolve the use of VR and augmented reality (AR) within the Devonport Dockyard capital programme. Once the requirements for digital operations and maintenance and health and safety files are realised, this is expected to lead to safer operations of the facilities.

4 BDP

4.1 Context

4.1.1 Background to the Nightingale Hospital Programme

When the COVID-19 pandemic hit the UK, the Government quickly established the need for temporary field hospitals as an "insurance policy" in the event that permanent facilities reached maximum capacity during the peaks of the crisis. This led to the construction of seven Nightingale Hospitals across England between April and May 2020 on behalf of NHS England and Improvement ("NHS") and the Department for Health and Social Care (DHSC).

Five of the hospitals were constructed at prominent event venues, including the ExCeL centre in London, the NEC in Birmingham, Manchester Central, Harrogate Convention Centre, and the UWE Bristol Exhibition and Conference Centre. The London Nightingale Hospital at the ExCel centre, which is the focus of this case study, was the first of the temporary hospitals to be built and was designed by the multidisciplinary design practice BDP.

Most of the Nightingale hospitals' capacity has been unused throughout the pandemic, however individual sites have been used for alternative purposes. The London Nightingale Hospital, for example, is now being used as a mass vaccination centre.

4.1.2 Background to BDP and their Information Management approach

BDP is the UK's second largest architecture practice. During BDP's financial year ending June 2020, BDP recorded a turnover of £131 million and employed 1,200 staff. The UK healthcare sector constitutes the second largest sector for the practice, accounting for around 13% of its turnover.

BDP's early experience of BIM was developed through a handful of demonstrator projects delivered in 2007/08 using Bentley Architecture. This highlighted to BDP the potential efficiency benefits from better quality and more coordinated information in the design process, which generated interest at the board level as part of a wider efficiency and cost reduction drive. However, it was in 2011 when BDP introduced its organisation-wide BIM policy, largely in response to the Government's BIM Mandate and recognition that 40% of the company's UK turnover was reliant on work from the public sector. With board level buy-in, the rollout of the company's BIM policy was driven by its Chief Information Officer, initially requiring each one of BDP's studios and sectors to deliver at least one project using BIM, with a view to building capability over time across the business.

The practice adopted a three-pronged approach, which comprised: ensuring BIM competency of new recruits; re-charging the costs of training for new recruits (where entry level skills did not exist) to individual projects; and upskilling existing technical staff in large numbers through online training. This soon translated to efficiencies for BDP, with these being particularly evident early on in the health sector, with BIM allowing far greater coordination of healthcare fixtures, fittings and equipment (FF&E) within 3D models[14] relative to traditional design approaches.

[14] Construction News (2014), The Pacemaker: Inside Laing O'Rourke's Fastest Ever Hospital, link.

In 2014, BDP became the first business in the UK to be recognised as Level 2 BIM compliant under the BRE Level 2 Business Systems Certification scheme and the company's BIM capability was cited as a significant investment driver by its new owners, Nippon Koei Co. Ltd[15] in 2016. In addition, being represented on many professional committees that led the way in supporting BIM adoption[16] has enabled BDP to influence emerging standards and maintain an understanding of how the wider Architecture, Engineering and Construction industry was progressing.

The acceleration of BIM and wider digital transformation has contributed to some 25% growth in BDP's revenue with just an 8% increase in technical staff during 2015.

4.1.3 Background to the London Nightingale Hospital Project

BDP's healthcare team led the way in the organisation's BIM adoption over the last 10 years through the efficient delivery of room data sheets, code compliance and medical equipment requirements. This experience in the sector meant BDP was equipped to rapidly respond to the Government's requirements for the Nightingale Hospital programme at the outset of the COVID-19 pandemic. Since the COVID-19 outbreak, BDP's healthcare team has helped to establish six large-scale temporary hospitals across the UK.

BDP's brief from the NHS for the London Nightingale Hospital facility was to repurpose the Excel exhibition centre into a 4,000 ICU bed hospital for intubated patients with minimal new construction, and with 500 of these beds being available within seven days. BDP received the brief on the day they first attended site.

The brief followed on from a study that BDP undertook a week before the project in response to some early engagement with the NHS, which proposed the use of exhibition centres for large-scale temporary Intensive Care Unit (ICU) facilities in North London. Through the study, BDP put forward a high-level proposal for a 400 bed ICU at Islington Design Centre, informed by their experience in master-planning several major hospitals elsewhere in the country, including Birmingham Queen Elizabeth, Alder Hey, Clatterbridge and Southmead. Equipped with this preparatory work, BDP was well placed to rapidly respond to the NHS's brief for the design of a London-based temporary hospital. The whole process from planning to inauguration of the facility took place in less than two weeks, with the first 500 beds delivered in just nine days.

In using BIM to design the hospital, BDP worked closely with a range of other parties involved in the design, construction and operation of the facilities (see Figure 6), including the ExCel's facilities management team, NHS clinicians, the British Army, engineering consultants Richard Stephens Partnership, ETA Projects and contractors CFES and Mace leading on the construction of the facility. The aim was to ensure that every bed could be fitted with all the equipment required to treat seriously ill patients and cared for by dedicated staff in full PPE equipment.

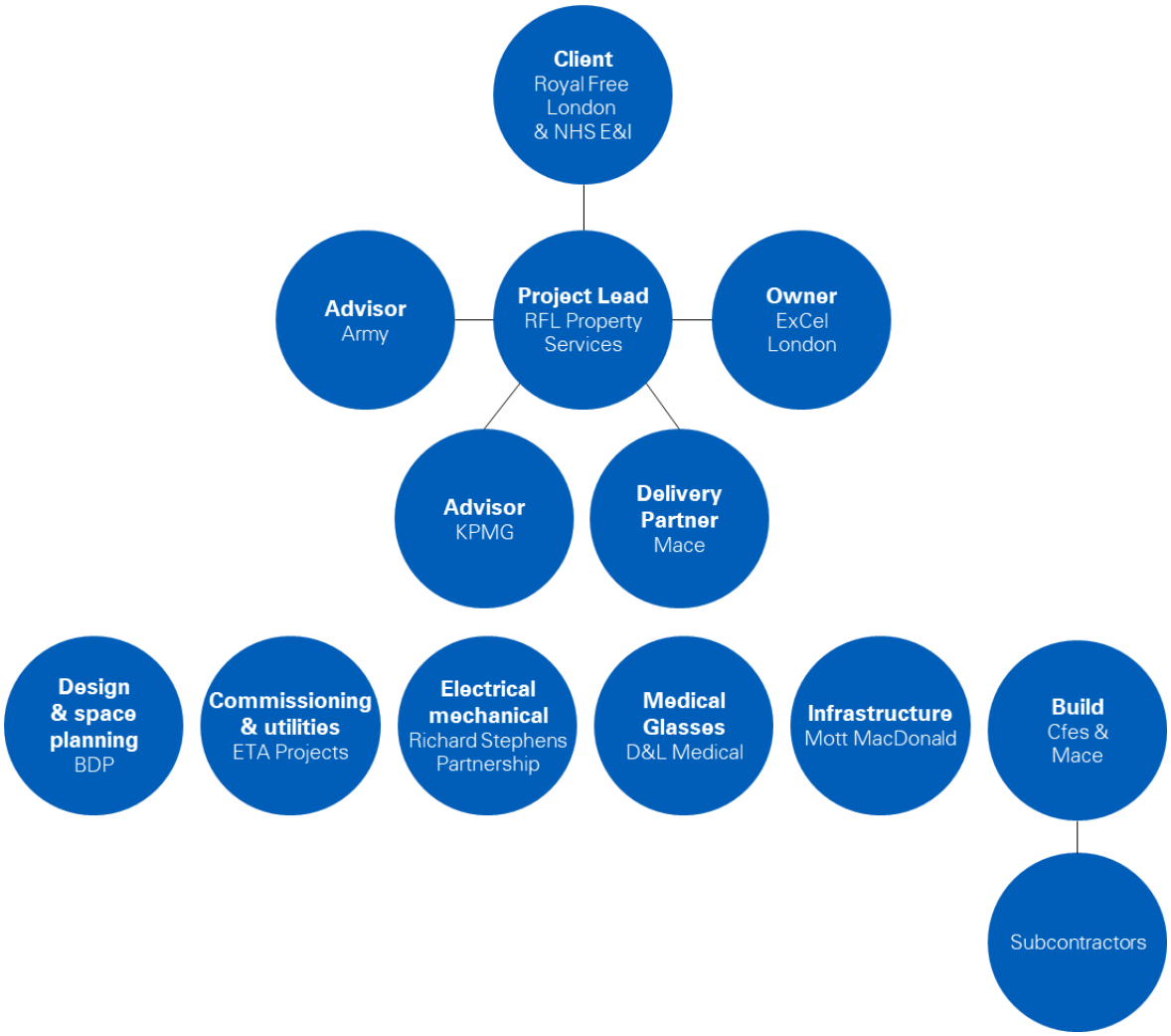
The bed heads and service corridors were constructed from a component system that is usually used to construct exhibition stands, with some simple reinforcement to allow

[15] Nippon Koei (2016), Acquisition of BDP Supplementary Material, pg. 18, link

[16] Including BSRIA Soft Landings and BG6, RIBA Plan of Work 2013, Association for Consultancy and Engineering (ACE), Institution of Civil Engineers (ICE), Institution of Structural Engineers (IstructE), Chartered Institute of Architectural Technologists (CIAT), AEC (Architecture, Engineering and Construction) UK BIM Standards and the development of the BIM Toolkit.

services to be fitted to the walls. The 3m section of bed head dado trunkings were prefabricated by electricians on site. The medical gas installation comprised two distribution ring mains run around the basement car park at high level, rising up to feed each bed head through the services floor boxes and then distributed to the bed head via the service corridor.

Figure 6: The parties involved in the design and build of London Nightingale Hospital

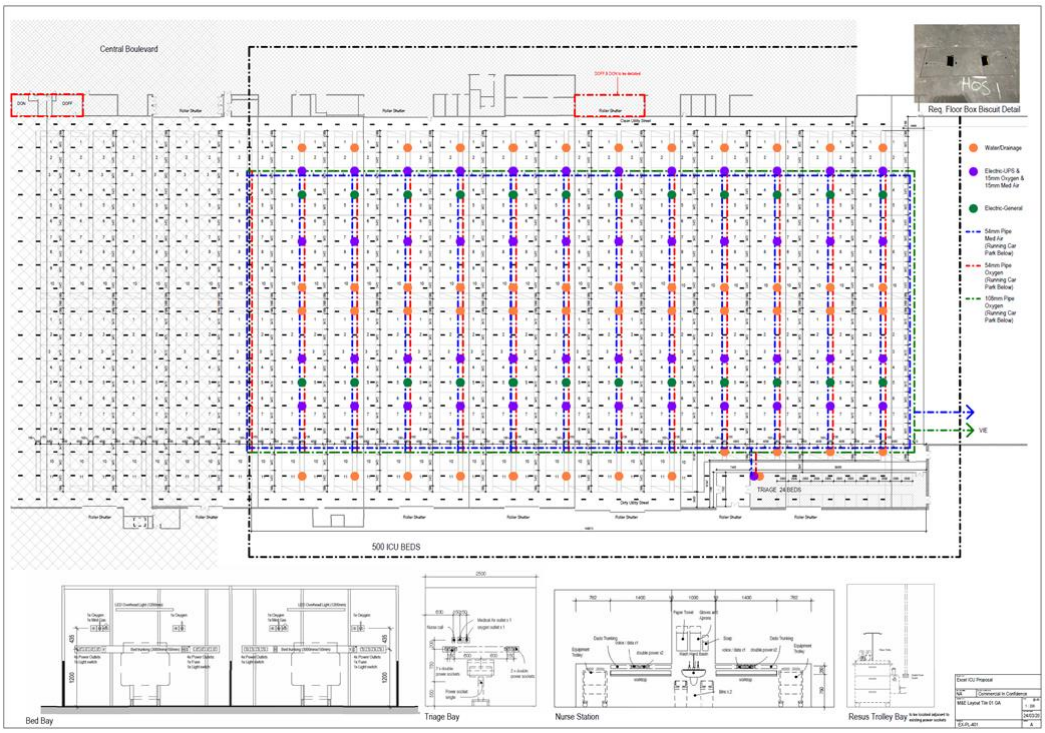


Source: Autodesk (2021), Building Nightingale, link

4.2 BDP's use of Information Management on the London Nightingale Hospital Project

Operating under COVID-19 lockdown conditions and responding to the short delivery timescales required by the brief, BDP adopted an agile approach to design based on simple, repeatable modules and minimum building intervention to help ensure rapid delivery. This combined well-established digital processes and tools with manual processes and face-to-face interactions.

Figure 7: Example BIM output used in the design and build of London Nightingale Hospital



Source: BDP, 2021

Using the 2-Dimensional CAD layouts obtained from the Excel's facilities management team, BDP rapidly established a BIM model of the facility covering approximately 115,000 m^2. BDP's experience delivering hospital projects in BIM over the past decade meant that they were not starting from scratch. BDP's central library of intelligent parametric components complete with data, along with compliant modules harvested from previously executed hospital projects enabled BDP to swiftly put together a 3D layout of the temporary hospital which aligned with established design principles and fulfilled the NHS's brief for ICU bed arrangements. Using the 3D model, BDP was able to quickly test out various configurations to arrive at the maximum number of bed spaces that could be achieved relative to the target numbers provided by the NHS, and completed this activity within 90 minutes of being commissioned.

Adding the Excel centre's inventory of standard kits (e.g. portable distribution board, display stands etc.) to BDP's digital library allowed them to maximise the use of the venue's temporary structures and minimise dependency on externally sourced materials and equipment. This presented a major advantage for maintaining the pace of fit out and avoided timetable delays that could have been incurred if the project had been overly reliant on external suppliers during lockdown conditions.

BDP adopted a hybrid approach that combined CAD and BIM processes with manual sketching using iPad drawings and flip charts to enable swift decision-making. Once finalised, BDP's sketch designs and other subcontractor elements of the overlay were immediately updated in BIM to ensure that the model remained a single source of the truth throughout the project. This ability to access up-to-date information centrally enabled BDP to translate ad-hoc requirements at short-notice (e.g. temporary storage for 4,000 PCs) into

parametric constraints, test them out remotely in BIM and communicate a decision back to site for swift implementation. It allowed better coordination of the fit-out elements (e.g. floor boxes with the bed units) in advance, thereby eliminating rework on site during construction and overall delays to the delivery timetable.

Figure 8 below summarises the various IM use cases as per BDP's experience in the design of the London Nightingale Hospital project.

Figure 8: Summary of BDP's use of Information Management on the London Nightingale Hospital

Function / sub-function	Information management use case
CapEX Delivery (design & construction)	BDP used BIM processes and tools as part of a hybrid approach to deliver the design for Excel Nightingale Hospital. The BIM model of the Excel facility was quickly established and developed incrementally using BDP's standard library components to arrive at the overlay design. The digital process quickly provided the base module with enough flexibility to respond to the evolving client brief. The kit of parts approach enabled delivery of a simple and repeatable design that maximised the use of materials and components available with Excel and its suppliers. Where design and construction decisions had to be taken on site in a more traditional process, BIM was used to capture and validate these changes.
Portfolio planning & resilience*	BDP's digital library of hospital components and compliant layouts gave them a head start with designing the Excel Nightingale Hospital. The project served as the blueprint for other Nightingale hospitals. Its design principles were documented in an instruction manual and published online to enable its use globally by anyone having to respond rapidly to similar requirements for emergency ICU.

Notes: (*) Emerging use-case with some organisational elements in discovery or early implementation phase
Source: KPMG and Atkins analysis based on information and evidence supplied by BDP, 2021

Following their experience on the London Nightingale Hospital, BDP published the NHS Nightingale instruction manual[17] outlining the fit-out strategies and processes adopted in order to disseminate the information quickly across the UK and globally (generating interest from New Zealand, Australia, Peru and Israel, among others).

The IM experience and outputs from the London Nightingale Hospital project also helped BDP to deliver the emergency hospital fit outs at Harrogate, Manchester, Birmingham, Exeter and Cardiff efficiently. Across these other projects, BDP's well established digital processes together with new tools like Microsoft Teams facilitated smooth collaboration and rapid decision-making at these other sites, while keeping on-site staff numbers to a minimum to avoid infection and thus enable BDP to protect the health and safety of its workforce.

4.3 Lessons learnt and looking forward

The London Nightingale Hospital example of repurposing a major existing built asset as part of a national emergency response has highlighted several lessons for maximising the use of and benefits from IM in any future planning and response to future global or national disasters:

[17] BDP (2021), NHS Nightingale Instruction Manual, link.

Easy access to accurate information

The project highlighted the need for reliable and readily accessible digital information of the asset. Decisions like locating a large scale concrete base for supporting oxygen tanks could have been straight forward if accurate information (in this instance, load capacity of the floor) was readily available. Keeping the information up to date during the operations phase while maintaining full traceability to earlier phases (i.e. brief, deign or construction) ensures that emergency fit outs do not inadvertently compromise safety aspects of the host building.

At a strategic level, a national database of facilities (in this case, assembly halls) complete with accurate data on key parameters, would enable swift decision-making on locating such emergency facilities and maximise the effectiveness of any interventions. This could be targeted as one of the early outcomes from the Government's National Digital Twin initiative.

Enabling a smooth transition from construction to operation

Collaborating in real time with NHS clinicians, contractors and the existing asset's FM team to deliver a hospital that was operational from day eleven was a demonstration of soft landing at its best. The hospital staff and the FM team were there to ensuring the NHS received a 'fit for purpose' temporary facility. Additionally, the FM team kept a comprehensive log of amendments to the building's structure so that the facility could be restored to its original use with ease.

Purpose driven process

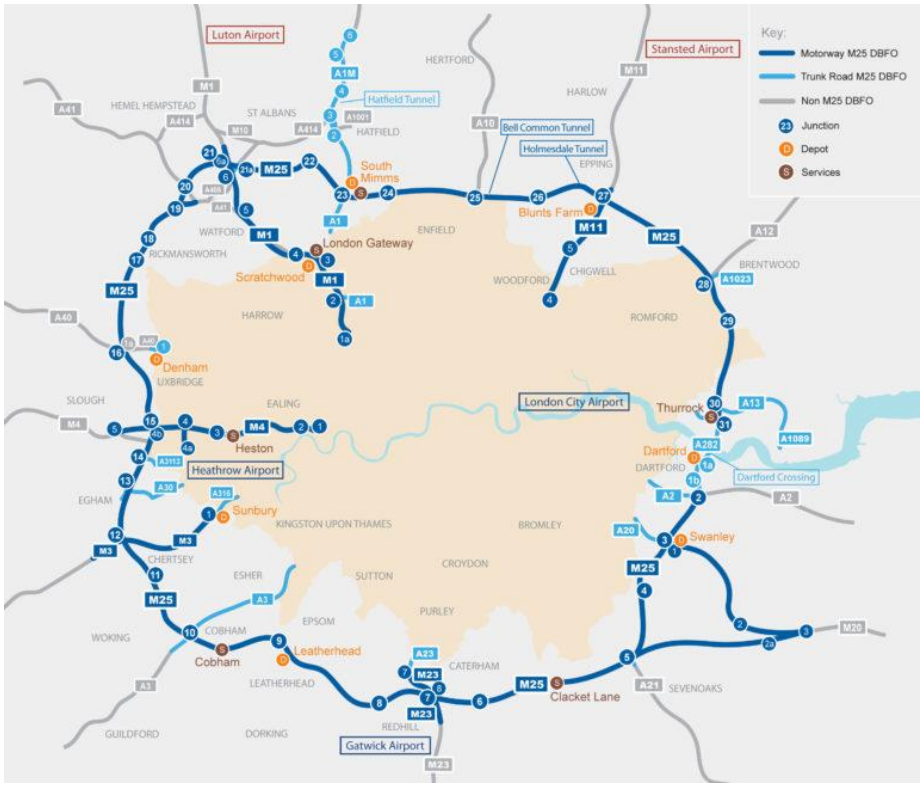
The London Nightingale Hospital project can be seen as a ten-day project that demonstrates the benefits in the entire value chain coming together and being available on site or remotely for prompt decision-making to iteratively build a critical piece of national infrastructure while learning and adapting on the go. It was a purpose driven endeavour that utilised technology and IM to enable the process alongside conventional methods (such as the large-scale model rendered on site to help the army fully understand the design). This hybrid approach to IM combined with agility were crucial to meeting the hard stop completion date.

5 Connect Plus Services

5.1 Context

Connect Plus Services (CPS) is responsible for operating and maintaining the M25 motorway network, including all adjoining trunk and slip roads, on behalf of Connect Plus Ltd (CP). CP is twelve years through a thirty-year contract with Highways England (HE) which commenced in 2009. The M25[18] (see Figure 9 below) is one of the busiest road networks in Europe, and one of the UK's most strategically important road assets. The network extends over 273 miles, carries roughly 15% of all UK motorway traffic, and is used, on average, by between 150,000 and 200,000 vehicles a day.

Figure 9: The M25 network within CPS's remit



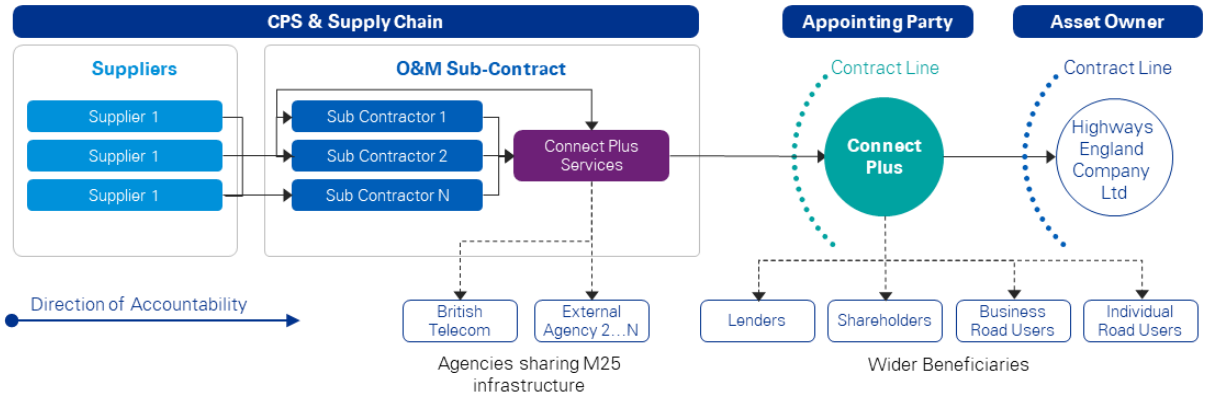
Source: Connect plus services, 2021

CPS is a Joint Venture (JV) between Balfour Beatty (52.5%), Atkins (32.5%) and Egis (15%). The JV employs a workforce of around 600 people, based at seven locations across the network. CPS carries out routine maintenance and whole-life management of thousands of M25 assets (such as bridges and culverts) in addition to managing the operation of the road network. CPS's Network Operations Centre (NOC) delivers real-time coordinated control of on-road resources, and monitors and captures all aspects of network performance.

[18] CPS 2021, Our Story, link

CPS are responsible for improving network operating efficiency, and over the past 10 years CPS and Connect Plus have delivered over £1.4bn worth of road improvements and junction enhancements.

Figure 10: The structure of Connect Plus Services



Source: KPMG and Atkins presentation of information and evidence supplied by Connect Plus Services, 2021

5.2 CPS's use of Information Management

5.2.1 Background on CPS's Digital Transformation Strategy

CPS is in the process of migrating away from traditional, legacy approaches to business operations towards a more digitally-based ways of working. This modernisation programme is being driven by a Digital Transformation Strategy that includes a range of change initiatives designed to deliver against the following benefit areas:

— Make the network safer to operate and work on;

— Make the network more efficient; and

— Manage the asset in a cost-effective manner.

A number of improvement projects are currently underway, with more planned in the remaining years of the JV. Current projects include:

— A Road Space Booking Improvement Programme (RSBIP) – the focus of this case study. This project is looking to deliver improvements and efficiencies in the way in which road space is booked, and through which works are undertaken on time and to budget.

— Engineering Data Quality Improvement – a project that has highlighted issues with data quality within CPS systems, and a disconnect between the needs of the business and the data used in operational systems.

— A Management Dashboard – reporting on the performance of the stakeholder communities using the Road Space Booking (RSB) system, identifying those who change or cancel road space bookings at the last minute (a particular area in need of improvement).

— The creation and exploitation of a 3D map of the road network to provide a better understanding of network conditions and performance.

— The creation and exploitation of a GIS-based Spatial Common Data Environment (CDE) through which greater understanding of the condition and performance of the road network can be maintained.

— The adoption of increasingly digital surveying techniques, reducing the need for manual approaches, or the need to stop traffic to conduct them.

— Utilising the consistent and reliable data collected to better plan and coordinate works across the network, by applying machine learning and predictive analytics.

5.2.2 Background on CPS's Road Space Booking (RSB) System

As part of the process of planning and co-ordinating planned works on the network, CPS and its subcontractors (collectively referred to as 'applicants') are required to book road space in advance (i.e. specific lanes along specific segments of the network) in order to manage the closures of the road and carry out the works.

As per the terms of CPS's contract with HE, the company has to provide HE with accurate information about these bookings, related updates (i.e. changes, cancellation etc.) and details of work carried out (including cone up and cone down times[19]). This process is managed using a bespoke application called NOMS (Network Occupancy Management System). This was initially developed and implemented in 2009, with an upgrade in 2012.

Applicants are tasked with booking road space using the NOMS platform, and with providing all relevant details regarding the nature of the work, its location, when it is due to start and finish, and so on. Over time, applicants have learnt to use NOMS in different ways, which has led to inconsistent approaches to booking creation, data entry errors, and regular changes or cancellations to bookings. Furthermore, NOMS has allowed applicants to provide updates to their bookings in the system by using part of the system that is not searchable by CPS co-ordination staff. This requires CPS staff to manually track booking changes, leading to inefficient operation of the booking system, errors and missed changes.

At present, there is no financial cost to applicants for booking road space, nor are there penalties for cancelling at the last minute. As a result, some applicants have tended to make more road bookings than they require to provide themselves with a range of flexible dates for when they might carry out their works, and often cancel those they do not need at short notice. The practice of overbooking does allow the parties to avoid some of the risks and costs associated with over-running of works, to the detriment of better contractor coordination and minimised bookings and booking duration.

In contrast, CPS receive contractual penalties for poor occupancy rates (the ratio of bookings to actual occupancy), a problem in part due to the RSB practices adopted by the supply chain. HE has identified RSB as a process in need of improvement, and the Office of Road and Rail (ORR) have set a 90% accuracy target to be achieved within 1-2 years.

To enable the most efficient usage of road space, applicants are encouraged to coordinate their bookings and share the road space where it is at a premium and there are efficiency savings for all parties. However, there is no explicit incentive for applicants to coordinate

[19] This refers to times at which the traffic cones are placed on the road and when they are removed, effectively providing the time that a section or lane is closed to road users, and traffic is impacted.

with others and it can be seen as an added overhead which increases complexity for the applicant(s).

A relatively high percentage (approximately one third on average) of bookings are unused due to early completion or works not being required at all. This has knock-on impacts on:

— Road users (travelling for work, business or leisure), who can experience traffic disruption and thus delays to their journeys due to lane closures that could otherwise have been avoided.

— Freight users (i.e. HGVs), which rely on published planned maintenance information to use in their route planning systems. This results in HGV drivers using sub-optimal routes when maintenance changes are not communicated in time, creating delays to their operations and thus knock-on costs for businesses.

5.2.3 The role of Information Management in CPS's Road Space Booking Improvement Programme (RSBIP)

The RSBIP represents one of CPS's more established digital transformation initiatives. It was started in 2020 to investigate potential improvements both to the NOMS software, and the processes and practices adopted by the applicant community, in order to identify and implement improvements. A number of improvements have been identified, and the following are in the process of being implemented

— A Good Practice Guide (GPG) that describes the expected behaviours of the applicant community and detailing approved processes to be followed when creating bookings. It also includes guidance on when cancellations or changes are permitted.

— A Minimum Data Standard (MDS) which describes a data schema that mandates data content for a booking.

— A Management Dashboard that provides up-to-date reports on applicant compliance with the GPG and the MDS.

The RSBIP aims to accomplish the following outcomes.

— Overcome the inefficiencies associated with lack of integration between NOMS, NEMS (HE's equivalent of the same system) and applications used by external parties (mostly spreadsheets) for road space bookings.

— Encourage good practice throughout the road space booking process.

— Eliminate the need for manual review of the NOMS chat history to track amendments to bookings.

— Encourage better coordination between the various parties undertaking roadworks.

— Reduce the number of unused bookings and in turn reduce disruption for road users.

— Meet or exceed the ORR's target for 90% accuracy of bookings.

— Improve CPS's ability to provide performance reporting against its KPIs to HE.

Figure 11 below summarises CPS's use of IM on the RSBIP.

Figure 11: Summary of CPS's use of Information Management on the RSBIP project

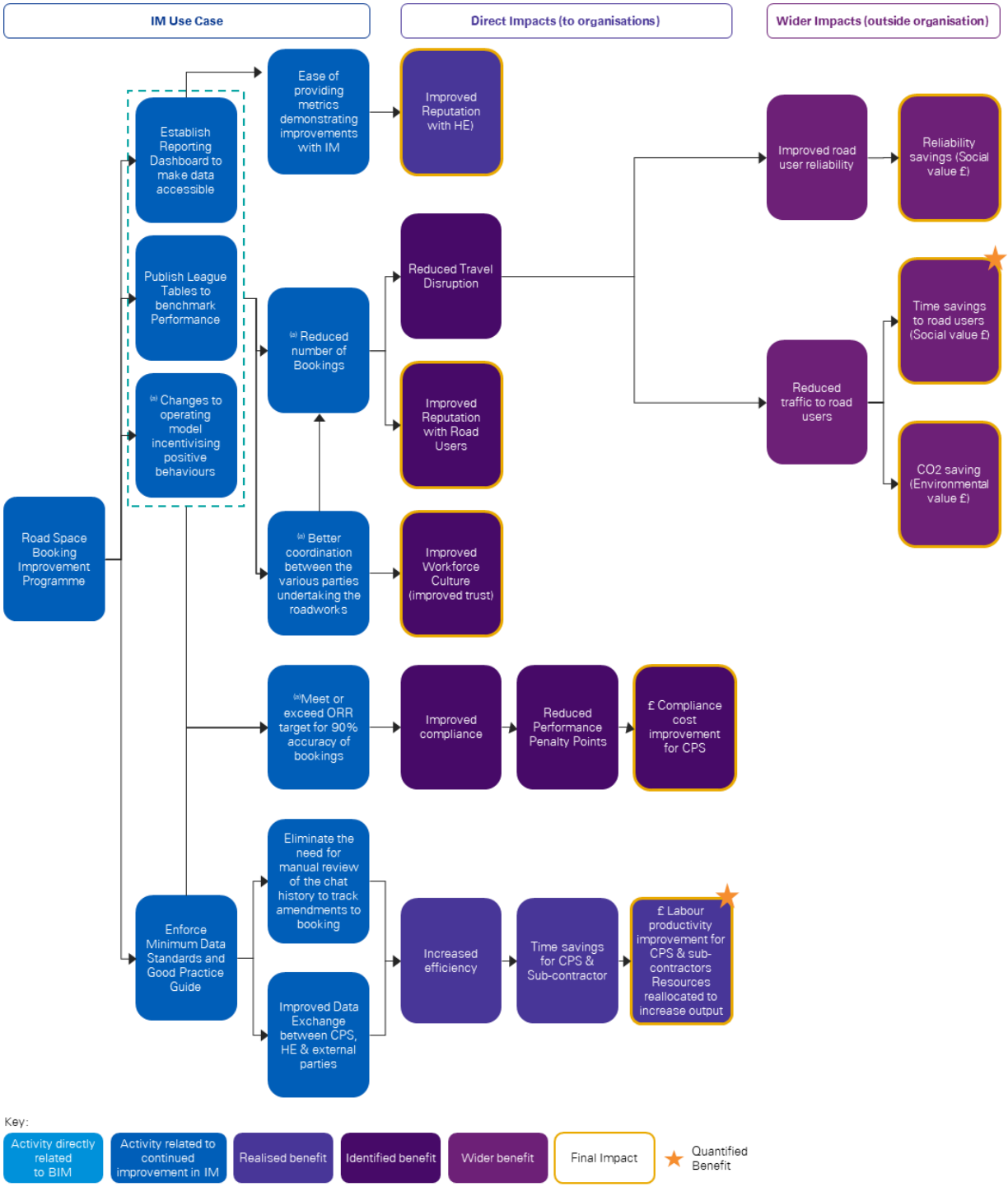
Function / sub-function	Information management use case
Commercial management	The RBSIP should result in improved accuracy and traceability of bookings and related amendments. The league table and dashboard should enable easy monitoring of behavioural data and performance metrics. The next step for CPS is to analyse the trends and incentivise positive behaviour by modifying the current operating model. Ultimately, this could translate into financial savings for all parties.*
OpEx delivery (Renewals, Operations & Maintenance)	Improved data exchange between the various parties resulting from the adoption of minimum data standards and the good practice guide should introduce labour and productivity savings on the reporting front. As a result CPS is able to reallocate resources to its core O&M activities. In due course, it is expected that enhanced trust and coordination between the various parties will translate to better management of planned road works with less disruption to road users.*
Regulatory & compliance management	The RSBIP should improve reporting accuracy thereby enabling CPS to comply with HE's requirements, both existing and emerging.
Assurance, audit & reporting	The RSBIP should enable CPS to fulfil their reporting obligations with HE with greater efficiency and accuracy.

Notes: (*) Emerging use-case with some organisational elements in discovery or early implementation phase
Source: KPMG and Atkins analysis based on information and evidence supplied by Connect Plus Services, 2021

5.3 Summary of the direct and wider benefits from CPS's use of Information Management

The adoption of IM as part of the RSIB is expected to unlock a broad range of direct benefits for CPS as an organisation, as well as wider benefits for road users, society and the environment, as summarised in Figure 12.

Figure 12: Summary of the benefits from CPS's use of Information Management



Source: KPMG and Atkins analysis based on information and evidence supplied by Connect Plus Services, 2021

5.4 The direct benefits for CPS and its contractors

5.4.1 Summary

The use of IM in the RSBIP is expected to deliver cost savings to CPS through efficiencies and avoidance of financial penalties, as well as an enhanced reputation with its external stakeholders. There are also efficiencies and thus cost savings which are expected to accrue

to CPS's contractors from the introduction of the RSBIP. The remainder of this section describes each source of benefit in more detail.

Where quantified evidence was available, it suggests that the introduction of the RSBIP could potentially unlock labour productivity savings of £5.10 for CPS for every £1 spent on implementation.[20]

5.4.2 Improved labour productivity for CPS from increased efficiency

RSBIP allows for streamlined processes and consistent data management through the GPG, MDS and Management Dashboard (see Section 5.2.3 above for more details), and is expected to result in reduced time required to operate the RSB system for CPS's staff. This reflects a labour productivity improvement for CPS, as staff time is freed up, allowing them to dedicate their time to other important tasks across the business, and potentially enable CPS to reduce its labour costs in the future. Specifically, bookings are subject to an average of 3 rounds of checking per booking, and with current booking volumes of 7,500-8,000 bookings per annum, this results in personnel undertaking approximately 24,000 booking reviews each year. The RSBIP has an aim of reducing booking checking down to an average of 1.5 checks per booking – a reduction of 12,000 booking checks. From efficiencies such as this, a conservative estimate of efficiency gains of 2-3 FTE's worth of effort per annum is estimated.

Based on these efficiencies, it is estimated that **for every £1 of implementation costs, CPS could potentially realise labour productivity savings of up to £5.10 in present value terms over the remaining life of the CPS contract** (this is dependent on the supply chain embracing and using the system).

In quantifying these efficiencies, labour time savings were assumed to last for the remainder of the contract, and a three year ramp up period was applied to conservatively reflect learning and implementation constraints. Time savings were conservatively valued at the UK minimum wage.[21] Cost estimates provided by CPS incorporated the investment/labour cost required to implement the new RSIB changes. To be conservative, factors were applied to costs and benefits to account for optimism bias. All benefits and costs were discounted at the HM Treasury (HMT) Green Book recommended 3.5% annual rate to compare them in present value terms.

5.4.3 Improved labour productivity for other organisations using the improved Road Space Booking system

Similar to efficiencies generated for CPS, the streamlined processes and consistent data management associated with the RSBIP is expected to result in reduced time for other parties who use the system as they also experience a more efficient functioning system with more consistent data, standardised processes, and greater certainty over what is expected of them regarding contingent bookings and late cancellations. This would again represent a labour productivity saving for those other organisations. It is possible these

[20] Consulting costs to implement the RSBIP, including development of minimum data standard, good practice guide, a reporting dashboard, and a performance league table of various involved parties.

[21] This reflects the reservation wage of the employee/employer, which is lower than the market wage, indicating that labour time freed up may be spent on tasks of lesser importance. If freed up time is spent on relatively productive tasks (which CPS expects), or if it allows CPS to reduce their labour requirements, the market wage would be more appropriate and the expected savings would be greater. The reservation wage is therefore a conservative approach.

savings could be lower in order of magnitude to those experienced by CPS, as there is currently no requirement for these other parties to manually check the chat function for cancelled bookings and so they would not share in this material saving. The magnitude of these savings has not been tested with external parties and are not included in the efficiency estimates set out above.

Further, the more reliable collection and presentation of data, and development of applications and polices enabled by IM (such as the booking occupancy dashboard) is expected to improve trust and coordination between parties over time, reducing the need for overbooking (or contingency bookings). The expectation is that this will provide more flexibility for contractors which need urgent additional bookings at different points in their work programme, providing them access with minimal inconvenience. In addition, the standardised processes defined in the GPG have the potential to drive out further efficiencies for CPS, as these processes can form the basis of an automated RSB optimisation platform (in which applicant bookings are automatically sequenced and scheduled).

5.4.4 Reduced costs to CPS from improved compliance

One of CPS's objectives for introducing the RSBIP was to improve its road occupancy metrics and improve its KPIs as per its contract with HE. Using its new system, CPS is targeting a 50% improvement over the next 1-2 years, helping to achieve the ORR target occupancy rates, and reducing the number of penalty points that CPS receives from HE. Clearly, such improvements will be through a portfolio of improvement initiatives, all of which are reliant on the implementation of improved IM.

This improvement requires broader behavioural changes, and potentially other policies and procedures to support these changes. For instance, the introduction of an easy to use dashboard with an 'occupancy booking' league table has provided better and more reliably information, but it could also spur competition amongst contractors and external parties, potentially reducing unrequired bookings. CPS could use this information in the future to make better decisions regarding their expectations of sub-contractors, and could potentially consider how financial penalties may be shared across parties in the future. None of these potential policies targeting behavioural change could be reliably implemented without first implementing good IM practices, which allows CPS to more effectively collect and analyse the data to make these decisions.

5.4.5 Improved reputation with Highways England (HE) and road users

Through CPS's improved use and management of data, as well as through improvements in its KPIs and standing as an increasingly innovative organisation, CPS has gained an improved reputation with HE. The HE's IT Directorate have indicated a desire to learn from the CPS experience and is looking to incorporate both the GPG and the MDS into their programme of process standardisation and data quality improvements. In 2020 CPS achieved the highest Highways England Lean Maturity Assessment (HELMA) score awarded to any organisation in the Highways England supply chain to date (3.4 out of 4)[22]. HELMA aims to encourage organisations in the Highways England supply chain to adopt Lean principles[23], and promotes integrated work planning and clearer processes, standardised procedures, an enhanced understanding of customer needs, and the elimination of unnecessary steps and rework

[22] CPS (2020), M25 team's approach to LEAN recognised as industry leading, link
[23] HMG (2018), Guidance: Highways England Lean Maturity Assessment (HELMA), link

(waste), all of which contribute to delivering value and improved journeys for road users. CPS considers IM a core enabler of these outcomes.

CPS also considers that delivering a more reliable booking occupancy system is key to improving its reputation (and indeed HE's reputation) with road users, especially HGV users.

5.5 Wider benefits to UK society

The integration of IM into the RSB system as part of the RSBIP is expected to unlock benefits for users of the M25 as well as wider society and the environment. These impacts are typically quantified and valued by the Department for Transport (DfT) when considering the social costs and benefits of public investments and policy interventions in the transport sector.

5.5.1 Reduced traffic disruption and congestion on the M25

5.5.1.1 Benefits from more reliable journey information

From better collection and presentation of road booking data, CPS is expecting to be better able to communicate more reliable information to its stakeholders, including HE and road users. This improved frequency and reliability of information should allow road users to make better decisions on when and where they travel.

This is especially important for HGVs which rely on published planned maintenance information, passed on from CPS through HE, to use in their route planning systems. This information is unreliable when planned maintenance is changed at late notice, and is further impacted by slow communication of changes between CPS, HE and the public as a result of requirements for manual checks and poor data consistency in RSB system.

By automating the many processes and improving data consistency and communication (as well as striving to reduce late cancellations, drawing on the system improvements to help drive broader behavioural changes), CPS is expecting to improve the reliability of the planned maintenance information it provides, and the speed in which it can update HE with changes. More reliable route planning information could potentially lead to more efficient route choices by HGVs and therefore less time and miles travelled, which in turn provides societal benefits in terms of:

— Reduced journey times and vehicle operating costs for businesses operating HGVs;

— Reduced costs to businesses reliant on the goods transported by these HGVs;

— Reduced journey time and vehicle operating costs for other road users on the network as a result of the knock-on/network effects; and

— Reduced carbon emissions.

5.5.1.2 Benefits from reducing the number of unnecessary bookings

Late cancellations and changes regularly lead to unrequired or extended lane closures that otherwise could have been avoided. These lane closures or extended works cause traffic disruptions on the M25, as these temporarily reduce the capacity of the motorway and can also lead to journey re-routing, which has knock-on impacts for traffic congestion and extended journey times. Improving road booking occupancy, and in turn reducing overall road bookings, could help to reduce instances of traffic disruption and congestion. This could generate a range of potential societal benefits, which includes:

— **Benefits to all road users from reduced journey times** as a result of improved lane capacity and higher traffic speeds, and reductions in instances of re-routing.

— **Reduced vehicle operating costs for road users** such as fuel and maintenance from less stop and start traffic and reduced distance travelled due to re-routing.

— Benefits to the environment from improved air quality, reduced noise, and reduced carbon emissions resulting from more free flowing traffic on the M25.

— **Benefits to society from reducing the risk of accidents** specifically in cases where instances of extended lane closures are reduced, and workers would have otherwise remained on site. Further, direct safety benefits to road users as lane closures can result in unexpected changes in route, speed and traffic, and more instances of unexpected lane merging, which can also lead to accidents.

CPS's targets for reducing late cancellations and their related target for reducing works that overrun suggests that the introduction of the RSBIP could potentially generate the types of economic benefits presented above. Of these benefits, we have quantified the potential journey time savings for road users[24]. In the absence of transport modelling outputs from CPS[25], the following information and assumptions were used to quantify the potential scale of these journey time benefits in social value terms, drawing on:

— Information / assumptions provided by CPS on the rate of booking cancellations, the expected reductions in overall cancellations and overruns that specifically affect lane closures and re-routing, and the distribution of road bookings throughout the day (all planned at off-peak times);

— DfT publicly available data on annual average daily flow (AADF) vehicle counts on the M25 by vehicle type (e.g. Car, LGV and HGV)[26];

— DfT analysis looking at estimates of average vehicle delay data from road works, suggesting that delays range between 11 seconds and 3.3 mins per vehicle[27]; and

— DfT Transport Appraisal Guidance (TAG) estimates of the monetary Value of Time, roughly £15 per car and £20 per HGV/LGV in 2021 prices[28].

To account for the uncertainty and optimism bias, a conservative approach was applied. The lower bound delay of 11 seconds per vehicle was applied to a proportion of off-peak traffic assumed no longer impacted by lane closures, and a high delay of 198 seconds (3.3 minutes) was applied to the proportion of off-peak traffic assumed no longer impacted by re-routing (as well as the DfT's 'Rule of Half' to account for road users not being rerouted at the time, but instead anticipating changes due to planned works and optimising behaviour by changing their travel patterns throughout the day, or using alternatives modes of transport).

[24] Journey time savings are typically the most considered economic benefit in transport scheme appraisals.
[25] The absence of detailed modelling means the results of the analysis should be treated as illustrative only; providing an indication of the potential scale of social value benefits that could arise from CPS's use of IM as part of the RSBIP.
[26] DfT (2019), AADF counts, 2019 M25, bidirectional link
[27] Halcrow Group Ltd (2004), Assessing the Extent of Street Works and Monitoring the Effectiveness of Section 74 in Reducing Disruption, 3rd Annual Report, Volume 3 – Estimation of the Cost of Delay from Utilities Street Works, September, Department for Transport. As discussed in Goodwin 2005, 'Utilities' street works and the cost of traffic congestion, p15 link
[28] DfT (2020), TAG databook, link

The benefits have been estimated for the remaining life of CPS's contract for the M25, with a slow ramp up of benefits in the first six years, reflecting that it would take time for booking behaviours to change and benefits to be realised. The annual savings were discounted to today's value (2021) using the HMT Green Book recommended 3.5% annual rate. Based on this analysis, it is estimated that **the introduction of IM as part of the RSBIP could potentially generate journey time savings for road users worth at least £11m in present value terms.** Achieving these benefits is likely to require CPS to introduce broader policies and procedures as part of its RSBIP, alongside the use of IM, to incentivise behavioural change of parties using the system.

6 EDAROTH

6.1 Context

EDAROTH is wholly owned subsidiary of Atkins Ltd, part of the SNC Lavalin Group, and was estimated to respond to a significant challenge faced by Local Authorities and the UK Government; the undersupply of social and affordable housing. EDAROTH brings together specialist development expertise and modern methods of construction to develop sites providing 100% social and affordable housing for its clients. Its end-to-end solution is underpinned by an Atkins-designed, off-site manufactured housing product range and an established supply chain.

As part of the Government's aim to deliver at least 300,000 new homes each year across England to meet future growth and address issues of low affordability (against an average annual rate of around 236,000 net additional homes per annum 2017-2020[29]), there is a further need to deliver 90,000 new homes every year for social housing rent[30]; levels not achieved since 1980.[31] In 2020 around 244,000 net additional homes were delivered, of which only 17% (58,000) were classified as 'affordable housing', and within that only 6,600 (11%) delivered for social rent.[32] In the same year, there were around 1.15 million households on the Local Authority Waiting List for social housing, which represents roughly 4% of all households in England.[33] This gap between social housing need and supply is expected to grow year-on-year as annual additional housing supply falls below current targets, meaning closing the gap in future years is likely to become increasingly challenging.

EDAROTH works with local authorities to increase the supply of social housing on vacant or underutilised publicly owned sites which are not attractive to conventional developers, often owing to their location in difficult-to-access areas where traditional construction methods are not viable. The company works with local authority clients through the completion of site feasibility/ selection studies, planning, financing and construction management through to development completion and handover (see Figure 13).

[29] MHCLG (2021), Live Tables on Dwelling Stock (Including Vacants), Table 120, (Accessed April 2021)
[30] House of Commons Housing, Communities and Local Government Committee (2020), Building more social housing Third Report of Session 2019–21, p. 3, link
[31] Unlocking Brownfield land, A social housing first policy, p4 link
[32] MHCLG (2021), Additional Affordable Housing Supply; detailed breakdown by Local Authority, Table 1011C: Completions, link, (Accessed April 2021)
[33] National Housing Federation (2020), People in housing need, link

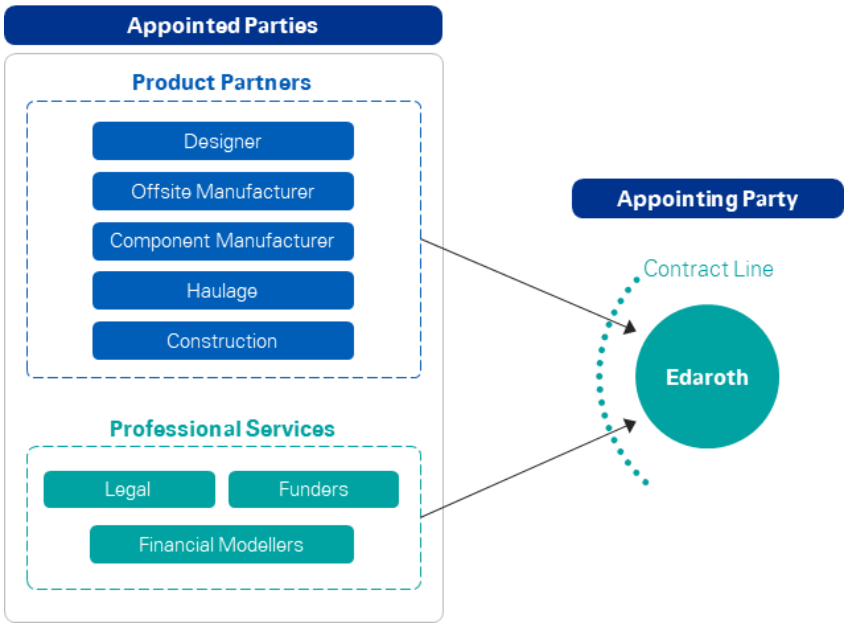
Figure 13: Extract from EDAROTH market brochure with detail on the range of services

Source: EDAROTH, 2020

The EDAROTH business was established following delivery of a pilot scheme in partnership with the London Borough of Lambeth in 2020. The Hillside Gardens pilot site was occupied by a derelict garage block with the EDAROTH solution delivering four new homes to Lambeth council's housing stock.

Since completion of Hillside Gardens, the company has expanded its service offering through 2020/2021, working with local authorities across the UK and aligning their supply chain across the UK and globally. EDAROTH focuses on delivering high quality social housing and targets reductions in delivery time against traditional methods to decrease social housing waiting times. The company is reliant upon a well aligned global supply-chain, including professional services partners such as funders or financial modellers, to help support the funding strategies and joint development appraisals as shown in Figure 14.

Figure 14: EDAROTH organisational supply chain



Source: KPMG and Atkins presentation of information and evidence supplied by EDAROTH, 2021

6.2 EDAROTH's use of Information Management

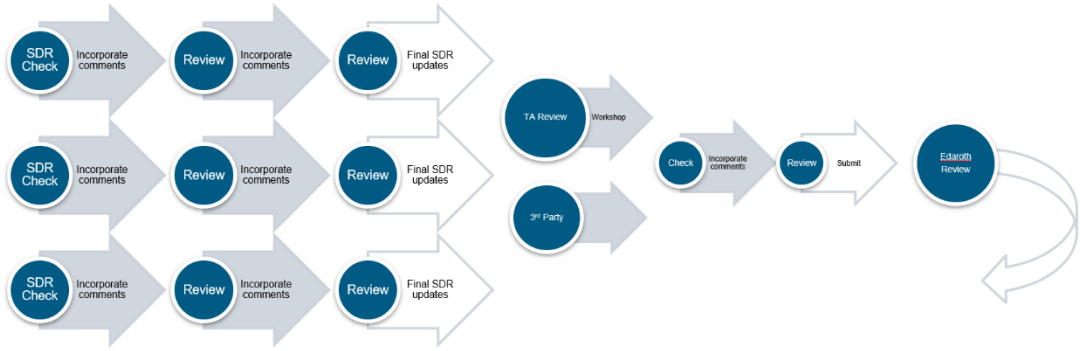
6.2.1 Overview of EDAROTH's Information Management approach

The nature of EDAROTH's service offering means it has placed significant emphasis on the importance of data and IM in the delivery of a high-quality social and affordable housing product within existing communities and infrastructure.

EDAROTH's main application of IM has been in the development of a core housing product. The company's approach to IM is to develop and maintain a digital ecosystem to efficiently manage the end-to-end delivery process, from initial planning and financial appraisals through to component sourcing, offsite manufacturing, onsite assembly and construction into handover.

The product is based on offsite manufacturing principles established through design for manufacture and assembly (DfMA) approaches and delivered through an aligned delivery supply chain. As the sole owner of the housing product across the design, manufacture, build and handover process, the company has placed emphasis on end-user/customer quality and supply chain alignment. Product quality is managed through internal product development activities which are iterated as shown in Figure 15.

Figure 15: Example product development improvement cycle process



Source: EDAROTH product presentation, 2021

To enable effective management and improvement, the housing product is aligned to a clear breakdown and associated component schedules aligned to cost, schedule and manufacturing requirements. Common BIM software (BIMTrack – see Figure 16) is used to visualise the housing product in 3D, supporting end-user engagement, defect tracking or focus improvements throughout the design and product development process, with a common log of tracked issues raised across component elements. This detailed approach supports EDAROTH's operational teams' investment in product development.

Figure 16: Example use of BIMTrack software to track and visualise product components.

Source: EDAROTH product, 2021

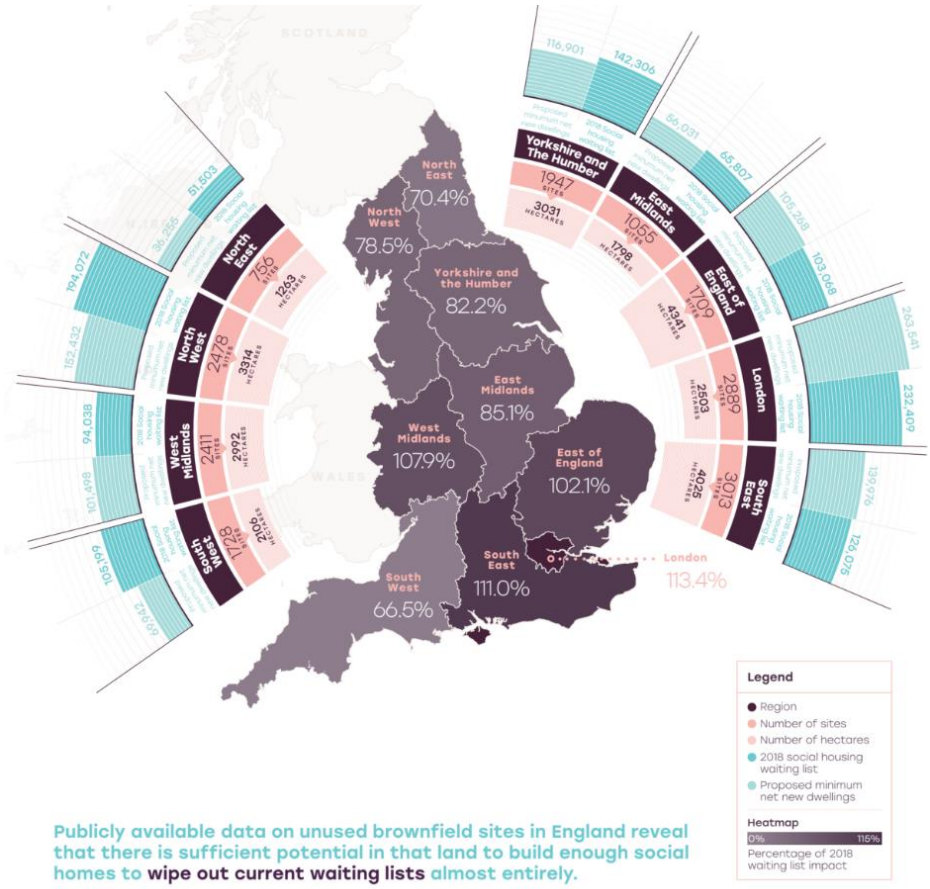
6.2.2 Overview of EDAROTH's digital transformation approach

The company has embedded continuous improvement in its delivery approach with a focus on the benefits from digital transformation activities. Post-delivery of the Hillside Gardens pilot, EDAROTH undertook extensive factory-based prototyping to test and validate the refinements of their off-site manufactured housing products. The process was enabled by the digital ecosystem supporting the housing product. The outcomes of which enabled

quality assessment of in-situ air tightness and further design refinement to improve end customer quality.

Through 2020, EDAROTH developed new services which utilise external public datasets and a centralised internal model dataset to improve its process of housing development. As an example, the company has established an early stage site selection and development appraisal approach for marginal, local authority owned brownfield land that has the potential for onward housing development using free and publicly available datasets, driven by the UK Government's Open Data Strategy (see Figure 17).

Figure 17: Extract from EDAROTH market brochure demonstrating potential land capital available to support social housing need across regions of the United Kingdom



Source: EDAROTH, 2020

6.2.3 Summary of EDAORTH's use cases for Information Management

The primary use case for IM for EDAROTH has been within the capital delivery of their social housing solution. The business aims to leverage BIM artefacts and model breakdown/federation approaches to develop designs for offsite manufacture and logistics planning/delivery. However, the wider application of IM has supported EDAROTH's management and operations teams in developing high quality housing, giving the ability to align their global component suppliers and UK-based manufacturing supply chain – providing further uses in commercial management, regulatory and compliance management, assurance, audit and reporting, and portfolio planning and resilience.

EDAROTH has developed centralised IM approaches which support the improvements in the delivery of an offsite manufactured housing solution as shown in Figure 18 below. Emerging use cases for IM have also been identified as shown in Figure 19. The potential benefits arising from these use cases are explained in Section 6.3 and Section 6.4 below.

Figure 18: Summary of EDAROTH's established use cases for Information Management

Function / sub-function	Information management use case
Commercial management	The use of IM in developing and managing component schedules mapped to granular elements within the house design gives the ability to track product life-cycle costings through the central manufactured model, with detailed cost breakdown to housing product elements. The development and onward use of central component schedules has supported the increase of standardisation of design elements to support offsite manufacture and delivery.
CapEX delivery (design & construction)	The use of IM has allowed for the management of the housing product and the development/production of detailed design drawings from a central product federated model. The use of IM has allowed for the development of a detailed product breakdown at component schedule level for the EDAROTH housing product, and alignment with specific manufacturing requirements. The breakdown of offsite manufacturing requirements as supported by the EDAROTH product element library has supported planning and performance monitoring with offsite logistics partners. The breakdown of the EDAROTH housing product has supported manufacturing alignment and process improvements in the delivery of manufactured parts from overseas suppliers.
Regulatory & compliance management	The management of EDAROTH housing product in a federated model environment allows for compliance and performance modelling to support and evidence regulatory requirements, including ethical sourcing requirements, building and fire safety requirements.
Assurance, audit & reporting	The development of a centralised model approach allows for the tracking of defects or improvements to common manufactured elements. The central management of the EDAROTH housing product allows for compliance and performance modelling to support and evidence regulatory requirements and wider auditing activities.
Portfolio planning & resilience	The management of the EDAROTH product in a centralised model breakdown supports EDAORTH's product management and continuous improvement activities across the leadership and operations teams. The use of IM in product development has enabled clear communication from the company across a global supply chain. The approach to product breakdown and detailed whole life energy and carbon performance modelling has supported EDAROTH's team in embedding design improvements in elements of energy consumption and Net Zero outcomes.

Source: KPMG and Atkins analysis based on information and evidence supplied by EDAROTH, 2021

Figure 19: Summary of EDAROTH's emerging use cases for Information Management

Function / sub-function	Information management use case
Commercial management	The EDAROTH approach to full life-cycle product ownership allows for the assessment of delivery costs across all phases of product delivery which are tracked through central product models.*
CapEX delivery (design & construction)	The detailed approach in offsite manufacture and construction, supported by IM, has the potential to lead to reductions in the onsite construction period with efficiencies during construction, improved workforce health and safety conditions, and less disruption for local communities (e.g. noise reduction in construction).*
Portfolio planning & resilience	The ability to model quality improvements across the EDAROTH product, and to demonstrate overall reductions in delivery times for the housing product supports the company's pipeline development and business planning activity.*

Notes: (*) Emerging use-case with some organisational elements in discovery or early implementation phase
Source: KPMG and Atkins analysis based on information and evidence supplied by EDAROTH, 2021

6.3 Summary of the direct and wider benefits from EDAROTH's use of Information Management

EDAROTH integrates technology and IM into all aspects of its service offering, and it is a core enabler of its business model and product to local authority clients. This is expected to unlock direct benefits for EDAROTH as an organisation as well as wider benefits for society, as summarised in Figure 20.

Figure 20: Summary of benefits from EDAROTH's use of Information Management

Source: KPMG and Atkins analysis based on information and evidence supplied by the EDAROTH, 2021

6.4 The direct benefits for EDAROTH

6.4.1 Summary

Through its integration of IM, EDAROTH is seeking to achieve cost savings and quality improvements in its processes relative to more traditional builds, as well as improving on its own processes and pilot programmes over time by further integrating IM into the way it identifies opportunities, and designs and provides information in the manufacturing, transportation and construction of homes.

The analysis of information and assumptions provided by EDAROTH suggests that **IM could potentially account for at least 6% cost savings per home built relative to a more**

traditional build without the use of IM. The majority (3.5%) is expected to be saved in design and engineering consultancy requirements, and an additional 2.5% across manufacturing, logistics and construction. IM also plays a critical role in enabling more effective and efficient DfMA process, which in itself is expected to lead to both savings in offsite build costs and onsite construction time and costs, net of the additional manufacturing costs. Further, EDAROTH's business model and product is an innovation that brings together IM and digital transformation activities (e.g. data science and analytics), with DfMA to produce net additional high quality social housing, enabling EDAROTH to enter this new market and grow its own revenue over time.

The remainder of this section explains in more detail how EDAROTH expects these cost savings to come about.

6.4.2 Improved total factor productivity from increased efficiency

EDAROTH uses IM across multiple functions to improve quality, increase efficiency and ultimately drive down costs, compared with a more traditional approach that does not utilise IM to the same extent. These efficiencies arise in the following four ways:

— Improved efficiency in design;

— Improved disaggregation and standardisation for manufacturing;

— Improved logistics and transport; and

— Improvements in onsite construction from IM as a key enabler of the DfMA process.

6.4.2.1 Improved efficiency in design

EDAROTH uses BIM to scope and design its social housing product, as well as map out its design into its different manufactured elements. This has allowed EDAROTH to streamline the time and effort required to undertake this process, reducing its overall technical design and engineering consultancy requirements and costs, which is **estimated to translate into a potential saving of 3.5% of the average cost per house compared with more traditional builds that do not utilise IM to the same extent.**

6.4.2.2 Improved disaggregation and standardisation for manufacturing

IM has allowed EDAROTH to more easily standardise elements across different types of housing build, and to easily view and cut this information in a way that is efficient for manufacturers to easily design and build off-site. This in turn has enabled EDAROTH to tap into a global supply chain, minimising costs in the manufacturing process. The efficient integration of this information is **estimated to translate into a potential saving of at least 0.5% of the average cost per house relative to EDAROTH's previous build costs using more traditional approaches.**

This improvement in IM incorporates the currently realised ongoing improvement in the efficiency of the company's processes over time. For example, in its pilot programme, EDAROTH sent two employees to China for two months to oversee the complex information handover process with its steel frame manufacturer to ensure reliability and accuracy throughout. The process involved taking EDAROTH's 3D BIM model, transforming it into 2D drawings so it could be uploaded and transformed into the manufacturer's 3D model before being exporting into typed code to be uploaded into the manufactures machine. This process has now been standardised in line with IM principles, with EDAROTH being able to export its 3D BIM model into the manufacturer's machine code directly,

eliminating the need for multiple reviews and constant on-the-ground oversight of the process.

6.4.2.3 Improved logistics and transport

EDAROTH is also realising efficiencies from IM in its logistics and transportation process. Drawing on consistent 3D design information has allowed EDAROTH to both design, pack and aggregate different product elements to maximise container loads, minimising freight trips and costs to the company. Compared to the Hillside Gardens pilot project, EDAROTH's process has identified a saving of 1.5 containers for every 4 houses, which is **estimated to translate into a potential saving of nearly 1% of the average cost per house.**

6.4.2.4 Improvements in onsite construction from IM directly, and as a key enabler of the DfMA process

As already outlined above, IM is a critical enabler of the DfMA process. As well as driving down costs in the offsite build process, this is enabling EDAROTH to significantly reduce the onsite construction programme and preliminary costs. DfMA has resulted in around a 50% reduction in onsite construction duration compared with a more traditional build[34], translating into approximately a 40% reduction in the overall house building programme[35]. While this saving is directly attributable to an extensive offsite manufacturing programme, effective IM has been a critical enabler of this process, and EDAROTH views it as being unlikely that this process would be commercially viable without it. When considering the specific savings in construction preliminaries directly enabled by IM, specifically the easily accessible creation and sharing of necessary documentation and information, including the housing design, **this estimated to translate into a potential saving of nearly 1% of the average cost per house compared with more traditional builds that do not utilise IM to the same extent.**

6.4.3 Increased revenue / output from unlocking traditionally 'unviable' land

EDAROTH's business model and product is an innovation that brings together IM and digital transformation activities, with DfMA to produce high quality social housing. Without these elements coming together, arguably EDAROTH would not be able to deliver on its corporate aims of providing social housing that is *additive* to the social housing market, by targeting marginal brownfield land which otherwise would be unviable for traditional development. This additional social housing provides benefits to wider society as outlined below in Section 6.5, but also enables EDAROTH to enter into this new market and grow its own revenue over time.

In addition to the elements outlined in Section 6.4.2, a key part of this is the initial site identification and assessment, which brings together opensource registry of brownfield land with other key data sources including key amenities such as location of transport and schools. This allows EDAROTH to work with Local Authorities and target redevelopment on multiple small sections of brownfield land, usually in close proximity in urban areas. This helps EDAROTH to deliver a low-cost high-quality product that is financially viable. Without this identification process, and the efficient process that sits behind the design manufacture

[34] EDAROTH (2020), Thinking differently to help you meet social housing targets using your under-utilised land, pg. 8

[35] This is because offsite manufacturing can be completed in parallel to the onsite groundworks, with the house assembly/construction then following. It is worth noting that the exact timing and duration can vary depending on site and scope specific variables, and this affects the extent of the programme time saved.

and construction of the social housing, the small brownfield sites would otherwise remain unviable and thus undeveloped.

6.5 The wider benefits to UK society

The integration of IM in EDAROTH's business model is expected to enable wider social value through:

— Reduced blight and disruption during the construction phase;

— Increasing the availability of high quality social housing to individuals/ households;

— Regenerating disused or underutilised brownfield land; and

— Reducing CO2 emissions through the construction and operation of more sustainable housing development, as well as some operational costs (heating costs).

The remaining sections expand on these wider benefits in more detail and, where quantitative evidence was available from EDAROTH, outlines the potential scale of these benefits using established valuation approaches from UK Government appraisal guidance. **Through this analysis, it is estimated that the social value benefits from (i) increasing the availability of high quality social housing to individuals/ households; (ii) regenerating disused land; and (iii) improving the carbon performance of this new housing (reducing CO2) could potentially amount to approximately £61,000 per home on average[36] (in present value terms).**

6.5.1 Societal benefits from shorter onsite construction

DfMA (enabled by IM) allows for reduced time on site by up to 50% compared to a traditional build, due to the extent of pre-manufactured value which replaces onsite work with more efficient offsite work (manufacturing).[37] This could potentially provide benefits for local residents and businesses in the form of reduced construction blight and disruption to their quality of life, including reductions in noise, traffic and air quality in the construction phase when compared with traditional builds.

6.5.2 Societal benefits from the provision of net additional social housing

As outlined above, by targeting marginal brownfield land and using IM and DfMA to lower build costs, EDAROTH aims to help local authorities unlock additional housing supply that would have otherwise been deemed unviable. The societal benefits of (i) converting land into more productive uses and (ii) specifically increasing social housing provision are well documented by the Ministry for Housing, Communities and Local Government (MHCLG) in its economic appraisal guidance, which is used to inform public spending decisions relating to new housing. Note that this is distinct from other forms of 'wider economic impact' analysis typically quoted in the housing and construction sector.[38]

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[36] This Present Value per home figure is based on EDAROTH housing projections of 61,000 new homes by 2051 (averaging 200 homes per annum over the first 5 years and ramping up to 2000-2500 per annum in later years). See sections below for other key assumptions and calculation details.

[37] Pre-manufactured value is the is the financial proportion of a construction project's Gross Construction Cost derived through pre-manufacturing.' It reflects how 'offsite' a particular solution is.

[38] The analysis undertaken in this case study concentrates on the social value generated by the delivery of additional social housing using MHCLG methods. This is distinct from demand side input-output analysis, such as

The conversion of land into more productive uses is typically valued in terms of Land Value Uplift and is covered in the next section. Meanwhile increasing social housing provision relates to the social value benefits that arise from reducing the overall social housing waiting list, and in turn shifting people out of undesired (or in some cases no) accommodation into higher quality accommodation. This provides societal benefits in terms of:

— Improving the economic wellbeing of individuals/families who are typically some of the poorest and most disadvantaged in the community – reducing crowding compared to their previous accommodation and in turn providing health benefits and potentially improved educational outcomes or improved productivity at work.

— Indirectly reducing the fiscal costs to Government of other public services, in particular healthcare costs for the NHS and expensive temporary accommodation costs for local authorities.

The potential public health benefits of EDAROTH's housing programme have been quantified using MHCLG's estimate of the annual health impact associated with additional Social and Affordable Housing. This annual health impact uses a model developed by the Building Research Establishment (TBRE) to estimate the impact of poor housing on the NHS's expenditure, identifying 29 different hazards associated with poor quality housing (incl. the risks from cold, damp, falling on stairs etc) and the associated medical costs to the NHS (the health costs associated with rough sleeping are then also added). Given these benefits are more likely to materialise if a new rented Social or Affordable Housing unit (a) enables a household to move away from a housing situation that was imposing an external cost and (b) the housing is net additional to housing supply, the MHCLG guidance scales this impact to account for the probability a new tenant had previously been living in a poor condition, overcrowded property or was rough sleeping.

The estimated annual social benefit is based on EDAROTH's future housing delivery projections for England over a 30 year period, which include 61,000 homes by 2051 (averaging 200 homes per annum over the first 5 years and ramping up to 2000-2500 per annum in later years), and the assumption that only 50% of the homes would be net additional.[39] In line with HMT Green Book guidance, the estimated annual benefit has been escalated by the growth in real GDP per household and discounted at a 3.5% discount rate to arrive at a present value. **Through this analysis, it is estimated that the social value benefits from increasing the availability of high quality social housing to individuals/ households could potentially amount to approximately £1,600 per home on average (in present value terms).**

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that conducted by the National Housing Federation (2016), link, which focuses on estimating the GDP/economic benefits arising from additional construction investment (rather than social value which does not typically have a market price / is not traded in the economy). The two evaluations are therefore not comparable. Input-Output analysis is also subject to a range of limitations and are not entirely aligned with HMT Green Book principles. These limitations are covered in detail in Section 7 of our main report.

[39] This assumption is on the low side of MHCLG 50-75% medium additionally assumption for a supply side impact of affordable and social housing (MHCLG (2016), The DCLG Appraisal Guide , pg. 43, link). It suggests that of the homes built, 50% would have been built by another developer for private development (not social housing). Another way of viewing the assumption is, separate from EDAROTHs ability to deliver these houses, the market expectation is that of sites under consideration for rezoning, there is a 50% likelihood that housing development would be viable i.e. 50% of the land value uplift would occur at the point of a local council planning policy change, and 50% in a later phase when the viability was proven (construction commences or housing is sold).

6.5.3 Societal benefits from regenerating disused or underutilised land

Social benefits from regenerating disused or underutilised land include the new value society places on the change in land use itself, as well as the urban amenity improvements that come about as result of the change. These benefits are primarily felt by the landowners (which in the case of EDAROTH, is likely to be local authorities) as well as the surrounding community. As representatives of local communities, Local Authorities also benefit reputationally from successfully increasing the size of its social and affordable housing portfolio, as well as from the improvements to urban local communities and reduction in urban blight, as referred to in MHCLG guidance.[40]

The potential land value uplift benefits to land-owners have been estimated using EDAROTH's future housing delivery projections and assumptions on the net additional increase in supply (as described above) together with MHCLG's appraisal guidance and land values estimates appendix (which provides benchmark land values for brownfield site by region of the country).[41] The analysis assumes a change in land use from industrial to residential use and a split in developable land located in and outside of London (according to EDAROTH's projections)[42], as well as a 20% downward adjustment to account for the lower land value of affordable and social housing relative to the private sector.[43] The estimated annual land value uplift benefit has been escalated by the average annual real terms growth in residential land values as per MHCLG guidance, and discounted over 30 years using the HMT Green Book 3.5% discount rate.

Through this analysis, it is estimated that the social value benefits (land value uplift) from regenerating disused or underutilised land could potentially amount to approximately £49,200 per home on average (in present value terms).[44]

Since EDAROTH's developments typically occur in small pockets of land within already populated urban areas, it is also expected that that this regeneration of brownfield land and the associated reduction in urban blight could have a significant positive impact on the surrounding local communities that live or work close to the new development sites. MHCLG guidance indicates that high-quality social housing and reduction in urban blight typically leads to areas of better urban amenity and public realm, and in turn can lead to reduced crime, increased employment participation, and improved health outcomes in the local surrounding community.

Finally, there could also be a distributional benefit of building affordable housing over private housing that needs to be accounted for. Typically, the majority of Land Value Uplift is captured as a windfall gain by the landowner. However, we apply a 20% reduction that reflects the lower value of affordable housing, which in effect represents the cost to the taxpayer of subsidising such housing (or the opportunity cost to the land owner, which in

[40] MHCLG (2016), The DCLG Appraisal Guide, pg. 83, link
[41] MHCLG (2015), DCLG Land value estimates for policy appraisal, link
[42] Differentiating between these areas is important as the densities are considerably higher in London compared with the rest of the country, and overweighting London could lead to overestimation of the benefits
[43] Affordable housing is typically 80% the rental cost of private housing (MHCLG (2016), The DCLG Appraisal Guide , pg. 85, link)
[44] Note that while this benefit is net of the costs of development, this does not include remediation costs. It also does not include other additional government or private sector costs associated with delivering development above the England (excl London) average, but at the same time does not include the greater uplift that may be associated with that delivery (i.e. small plots in urban areas may have a higher average cost per home to deliver, but they may also deliver a higher uplift given their location).

most cases is the local authority, of renting that home on the private market). Since affordable housing provides homes to lower income households, £1 of saving in housing cost is worth more to social housing tenants when compared with the average UK household. Using HMT Green Book distributional weights and accounting for differences in housing costs, the average distributional benefit is £1.72 for every £1 spend (or taken from the average taxer payer). Applying this figure to the initial downward adjustment to Land Value Uplift, suggests **the distributional benefits of the net additional increase in housing supply could potentially amount to a further £8,800 per home on average (in present value terms)**.

6.5.4 Societal benefits from more sustainable housing development and operation

The use of IM has allowed for tracking and analysis of information throughout the identification, design, manufacture and build stages of EDAROTH's development process. This means that impacts on the environment at various stages can be more effectively identified compared to a traditional build where this information typically remains unknown. This has enabled EDAROTH to explore and refine its processes, and to continue to drive down the environmental footprint of both the construction and operation phases of its new build housing projects. For instance, reducing the onsite construction programme (outlined in above in Section 6.4.2) is expected to have helped drive down CO2 emissions.

Further, through the use of thermal analysis supported by IM, the design of EDRAOTH's latest housing build has been optimised to reduce ongoing heating usage relative to a traditional build. EDAROTH estimates that this could potentially generate:

— Savings in the average heating costs per home worth some £37 per annum; and

— Savings in CO2 emissions of around 1.14 tonnes per annum which (using HMT's central estimates of non-traded 2021 values of carbon) translates into an estimated societal benefit of £85 per home per year.

Taking these estimated savings in heating costs and carbon together for the 61,000 houses projected by EDAORTH, this translates into a potential total benefit, in present value terms, of £1,500 per home on average (assuming a 30-year appraisal period from 2021-2050 and using HMT's recommended 3.5% discount rate and annual real terms growth in carbon values).

7 Environment Agency

7.1 Context

The Environment Agency is a non-departmental public body, established in 1996 and sponsored by the UK Government's Department for Environment, Food and Rural Affairs (Defra), with responsibilities relating to the protection and enhancement of the environment in England. The environmental assets covered by the Environment Agency's remit includes 13m hectares of land, 35,000km of river and 5,000km of coastline seawards to the three-mile limit, which includes 2m hectares of coastal waters.

The Environment Agency is the principal flood and coastal erosion risk management (FCERM) authority, responsible for managing flood risk from designated main rivers, reservoirs, estuaries and the sea. The Environment Agency's statutory FCERM strategy for England (2020) sets out a vision of: "*a nation ready for, and resilient to, flooding and coastal change – today, tomorrow and to the year 2100*"[45]. As part of its statutory duties, the Environment Agency is responsible for operating, maintaining and replacing over £20bn worth of FCERM assets to reduce the risk of flooding to people and property, including 'hard' flood defences and water control assets, such as barriers, weirs and embankments, and 'soft' assets such as coastal habitats like saltmarsh.

7.2 The Environment Agency's use of Information Management

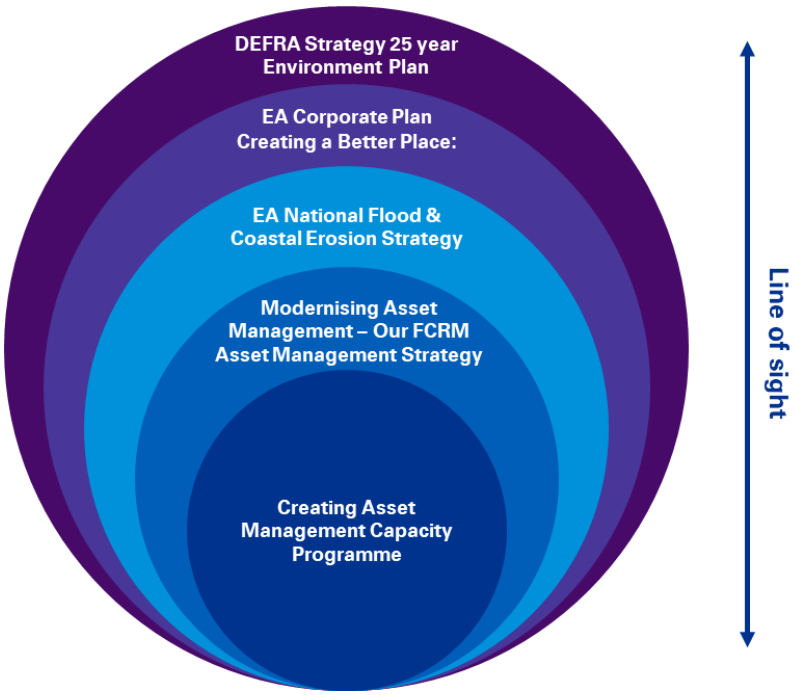
7.2.1 The Agency's Asset Management Data and Information Strategy

The Environment Agency's Asset Management Data and Information Strategy (AMDIS) sets out the vision and plan for managing and maintaining the organisation's FCERM assets. As a key part of the Environment Agency's broader FCERM Asset Management Strategy (AMS), the AMDIS sets out the Environment Agency's ambition to ensure that appropriate, trusted, and reliable data is available for coherent and evidence-based whole life decision-making in the management of FCERM assets, and forms the basis of the Environment Agency's ISO55001 certification.

Structured data and effective IM sit at the heart of the Environment Agency's wider approach to digital transformation and asset modernisation, as well as the Government's ambition to enable a Digital Built Britain[46].

[45] Environment Agency (2020), National Flood and Coastal erosion Risk management Strategy, link
[46] HM Government (2015), Digital Built Britain Level 3 Building Information Modelling - Strategic Plan, link

Figure 21: The Environment Agency's Asset Management Data and Information Strategy



Source: Extract from the Environment Agency's Creating Asset Management Capacity (CAMC) programme (see information video, 2021, link

The implementation of the Environment Agency's AMDIS is facilitated through the organisation's Digital Assets Data and Information (DADI) programme, with the following vision:

"For the Environment Agency and its partners to have information they can trust and rely on, even when it is produced by someone else, to make sound business decisions quicker and faster. Enabling Environment Agency staff and partners to be productive anytime, anywhere, from any device using the most appropriate technology. To use smart technology in a coherent way and build our capability to prepare ourselves for more digital working in the future."

The DADI programme is delivered by the Environment Agency's asset management team who are responsible for leading digital innovation and automation to drive business transformation (under the FCERM strategy). The DADI programme comprises a number of projects as shown in Figure 22 below.

Figure 22: Summary of the Environment Agency's Digital Assets Data and Information (DADI) Programme

Source: Extract from the Environment Agency's Digital Asset Data and Information at the Environment Agency video, 2021, link

7.2.2 The Environment Agency's journey with Information Management

In 2011, the Government's UK Construction Strategy set the mandate for all Government funded projects to be BIM Level 2 (the current UK BIM Framework equivalent) compliant by April 2016. This enabled the Environment Agency and its delivery partners[47] to begin the journey to transform how they deliver capital schemes and asset information in a more digital way. The Environment Agency has adopted an incremental and collaborative approach to digital transformation, to support a wide range of challenges in capital delivery across a range of asset types.

Across the Environment Agency's DADI programme, an approach of continual development, testing, piloting and then scaled adoption through the expansion of the Environment Agency's organisational data requirements, has helped to support the gradual adoption of digital engineering and information delivery on the Environment Agency's capital schemes.

Between 2013 and 2019, a 'BIM Basics'[48] approach was developed and adopted by the DADI programme to help meet the Government's 2016 BIM mandate, and put in place the foundations of BIM and information delivery throughout its supply chain. The focus of 'BIM Basics' was on adoption of data management processes, 3D modelling, visualisation and collaboration technologies, and adoption of information management roles and responsibilities. In 2019, with 'BIM Basics' adoption now becoming business-as-usual, the

[47] Delivery partners are Environment Agency's contractors and consultants in design build and operations of capital programme (Tier 1 supply chain)

[48] 'BIM Basics' was the Environment Agency's approach to meet the UK Governments 2016 mandate for all Government funded projects to be BIM Level 2 compliant by April 2016 and put in place the foundations of BIM and information delivery throughout its supply chain.

Environment Agency began building on this foundation with an object- and data-driven approach.

This data-driven approach aims to adopt the automated production, delivery and assurance of data and enable digital information to be captured at the earliest opportunity and integrated into existing and new Environment Agency enterprise systems. This is expected to remove mundane activities and increase the consistency of asset information delivery, in turn improving the efficiency and effectiveness of decisions for the Environment Agency and its delivery partners involved in capital delivery. For example, the Agency is targeting improvements in future data quality, minimising manual effort, and reducing the time required from its asset integration team to enter data into the Agency's asset management system from an average of 18 months to 24 hours post capital project handover. Improved data is also expected to enable greater use of visualisation tools, such as access to spatial data on new assets being constructed.

7.2.3 Implementation of DADI's Information Management Artefacts

In 2020/21, the DADI programme published its updated Exchange Information Requirements (EIR) which introduced several initiatives to support the Environment Agency's delivery of a data-driven approach (discussed above in Section 7.2.1). These include:

- Launch of the Environment Agency's Data Requirements Library (DRL) providing a detailed library of asset information requirements (described further in Section 7.2.5);
- Promotion of geoCOBie[49] as a data transmittal standard, providing consistent transfer of information on new and upgraded assets (described further in Section 7.2.6); and
- Development of an automated delivery verification service through a Datastore, Rules and Verification (DRV) project, to govern asset information as it transfers from capital programmes to the operational asset environment (expected to launch in 2021/22).

This marked a significant milestone for the Environment Agency in the shift from asset information stored in documents and drawings to information being stored as data which, once accepted, will be transferred into the Agency's DADI Azure Datastore for subsequent analysis, access and visualisation. This is expected to ultimately result in more reliable and consistent data available to the Environment Agency's enterprise asset information management systems.

7.2.3.1 The Data Requirements Library (DRL)

The DRL (extract in Figure 23) is a digital library of the Environment Agency's data requirements for each asset type. The DRL sits alongside the EIR and the Information Delivery Plan for a capital project. It defines the specific data required for each designed and installed asset, to be delivered at each gateway on a capital project, and eventually, each whole life intervention event. The DRL is a live register which will continue to expand over time, providing the mechanism to collate a broad range of data requirements, including

[49] COBie (Construction Operations Building Information Exchange), is a non-proprietary data format, defined in BS1192-4:2014, for the publication of a subset of building information models (BIM) focused on delivering asset and geometric data. GeoCOBie is a variant of BS1192-4:2014 to support infrastructure assets where, assets are dispersed over a geographical area, rather than contained in a single building structure. It provides a consistent format for the managed exchange of asset information allowing seamless integration in the asset information models.

environmental assets and performance attribution at an object level, such as cost and carbon.

The DRL is an important development for the Environment Agency, it's delivery partners and stakeholders, as it defines the data required at each lifecycle stage for each asset type and the elements to be delivered in a digital format. This provides the potential for improved information efficiency, reliability and consistency for all participants, as well as the opportunity to automate activities. It also provides a line of sight from the Environment Agency's Organisations Information Requirements (OIR), through to the point of creation on individual projects.

Figure 23: Screenshot of some of the defence asset types captured in the DRL

Defence

Asset that provide flood defence or coastal protection functions. These include both man-made and natural defences. Natural defences may include man-made elements to make them more effective or protect them from erosion.

Updated on 27-04-2021 | View history

Asset Type	Description	Asset Code	Uniclass 2015	Last Updated
Barrier Beach	A sand or shingle bar above high tide, parallel to the coastline and usually separated from it by a lagoon.	DA	En_32_85_06	Updated on 17-05-2021 | View history
Beach	A pebbly or sandy shore found at the coast.	DB	En_32_65_06	Updated on 17-05-2021 | View history
Bridge Abutment	A supporting structure at the end of a bridge span that also acts as a flood defence. It ties into other flood defences and completes the line of defence against high river levels.	DG	Ss_20_50_10	Updated on 17-05-2021 | View history
Cliff	A steep rock face, especially one that runs along the coast.	DC	Co_32_65_15	Updated on 17-05-2021 | View history
Demountable Defence	Sections of flood defence that are removable (e.g. for visual amenity or access reasons).	DM	Ss_25_95_30	Updated on 17-05-2021 | View history
Dunes	Wind-blown sand mounds found along the coast.	DD	En_32_65_75	Updated on 17-05-2021 | View history
Embankment	An artificially raised, earthen ridge used in the fluvial, tidal and coastal environments for flood defence, erosion protection, or channel containment.	DE	En_32_85_45	Updated on 17-05-2021 | View history

Source: Environment Agency, 2021

7.2.3.2 Adoption of GeoCOBie as the asset data delivery format

COBie has been adopted by the Environment Agency for several years, however the requirement has been limited to document submission. The GeoCOBie variant of COBie aims to support infrastructure, such as linear assets (flood walls, embankments, coastal defences), which are dispersed over a wide geographical area rather than contained in a single building structure. This establishes one of the first industry examples for delivering COBie for geospatial data and infrastructure assets.

GeoCOBie forms a standardised information model for each information exchange between the Environment Agency and its delivery partners. It provides a single, consistent way of transferring information and metadata generated during one stage of project delivery, onto the next, regardless of the number and type of parties involved.

7.2.4 The Environment Agency's collaboration with delivery partners: Digital Communities of Practice 'Task and Finish' project

The DADI programme seeks to improve the process of IM across capital programmes and into the onward asset phase. In 2019, the Environment Agency shifted towards their Next Generation Supplier Arrangements (NGSA) which focusses on the alignment of behaviours and ways of working across the Environment Agency's strategic supply chain. The Collaborative Delivery Framework (CDF) is a core component of the Environment Agency's NGSA, acting as the main vehicle for implementing capital schemes and supporting the Agency's commitment to invest £2.6 billion over the next six years to better protect 300,000 homes from flooding and coastal erosion.

In support of the Agency's regional approach to the CDF (Figure 24 below), national Communities of Practice have been established to encourage collaboration between the Environment Agency and its delivery partners in key areas, such as digital transformation, sustainability and health and safety. 'Task and Finish' funding is available to the Agency's delivery partners within its national Communities of Practice to help spearhead strategic change initiatives across the CDF and drive behaviours of collaboration and innovation at the heart of the NGSA.

The focus of this case study (see Section 7.2.5 below), is the Environment Agency's Digital Community of Practice, which was established to help ensure that the NGSA frameworks support ongoing digital, data and innovation developments and achieve the information requirements that support the Environment Agency in delivering its digital commitments under AMDIS. For example, focusing on delivering the objectives of a data-driven approach.

7.2.5 Case Study: Task and Finish project – Implementation of a detailed DRL / data-driven approach

In 2020, a partnership between the Environment Agency, Atkins and Capita Binnies (as part of the Digital Communities of Practice) applied for Task and Finish funding from the Environment Agency's capital delivery programme.

The Task & Finish project sought to explore the application of DADI's IM artefacts (DRL, GeoCOBie) for use on capital projects and establish, through a live project example, an exemplar approach to delivering asset data through adopting data-driven principles. This built upon an innovation developed during an asset data delivery hackathon which the

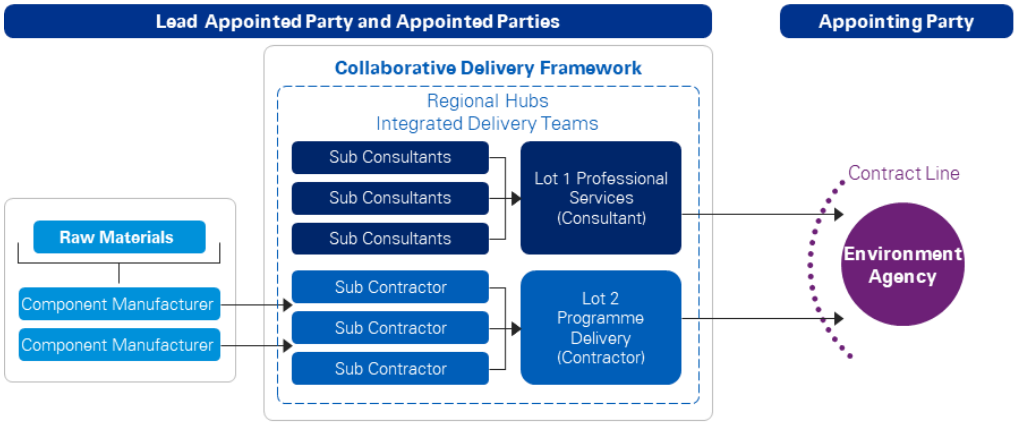
Environment Agency ran in 2019. The Task and Finish project set out to address three primary outcomes:

— Demonstrate a clear step by step example for how data can be integrated into a common design and construction processes;

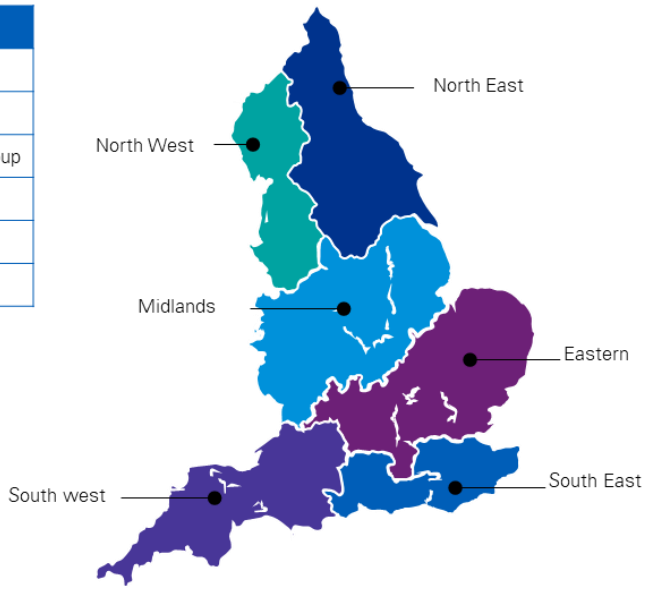
— Identify opportunities for using digital solutions, such as data automation, to improve project efficiencies while enhancing quality and rigor in creating asset data; and

— Establish the business case for investment in digital solutions and upskilling of staff across the Environment Agency and delivery partners in the newly established CDF.

Figure 24: Environment Agency Collaborative Delivery Framework (CDF) contractual arrangement and map of CDF delivery



Regional Hub	Integrated Delivery Team
North East	Ove Arup & Partners, BAM Nuttall
North West	Jacobs UK, VolkerStevin
Midland	Ove Arup, Jackson Civil Engineering Group
Eastern	Jacobs UK, BAM Nuttall
Southwest	Atkins, Keir
Southeast	Jeremy Benn Associates, VolkerStevin



Source: KPMG and Atkins presentation of information and evidence supplied by the Environment Agency, 2021

The group used real data from a previous Environment Agency project (River Rother Tidal Walls East scheme) and common delivery workflows/ processes to:

— Identify improvements to how suppliers collate and capture both graphical (3D model) and tabular attribution at an object level, in parallel to design and construction activities.

— Develop/reinforce the need for the creation of a model and data strategy at the start of each contract (strengthening the need for the project level BIM Execution Plan).

— Establish the importance of the role of the Information Manager in taking a holistic approach in the coordination of asset data from multiple sources, including engineers, contractors, and manufacturers, and to structure information in GeoCOBie in preparation for information exchange, validation and acceptance.

The Task and Finish project developed use cases for IM application (Section 7.2.6 below) and emphasised the importance of innovation funding in creating shared knowledge and clear guidance when dealing with the complexity of Environment Agency assets. Notably in tying together complex existing infrastructure and the natural environment, which limits the potential for automated design, particularly at the detailed design stage. The project also highlighted the need for delivery partners to consider their asset delivery approach and adopt leaner, more collaborative processes, as they move away from document production and require closer data integration and greater transfer of knowledge and skills with their supply chain.

7.2.6 Summary of the Environment Agency's use of Information Management

The Environment Agency's primary use case for IM in asset data delivery has been within the capital delivery programme in relation to its FCERM assets – see Figure 25 below. However at the organisation-level, the Environment Agency is seeking to apply its data-driven approach – underpinned by the DRL, GeoCOBie and further data sharing approaches[50] to enable early input of asset requirements to support handover, asset operations / maintenance, stakeholder engagement and de-risking of later governance gateways. These emerging use cases as part of the DADI programme are set out in Figure 26 below.

[50] Environment Agency (2021), Asset Management API Documentation, link

Figure 25: Summary of the Environment Agency's established use cases for Information Management

Function / sub-function	Information management use case
CapEX delivery (design & construction)	The use of integrated project models to achieve sign-off and decision processes at each stage gateways provides efficiencies to Environment Agency and the wider supply chain. Awareness and direct access to information delivered at previous stages via the CDE, through the Information Delivery Plan, providing an efficient and structured presentation of available information, de-risking the handover of information between parties and the likelihood of unnecessary re-work. Use of Defra Data Services Platform provides easy access to core information such as existing asset details, LiDAR, hydrology and the data requirements through an open licence, accessible via both web download and APIs enabling an efficient approach to information gathering. Requirement of a BIM Execution Plan to include a location, volume and modelling strategy to set out a clear approach for delivery of asset data start to set out a clear approach for de-risking the critical elements of asset data capture and transfer. Creation and development of the scheme design's asset and element objects in 3D, mapped against the Data Requirements Library used standard efficient workflows. Capture and collation of the Environment Agency's asset data requirements from all relevant parties (e.g. designers, contractors, suppliers, manufacturers) into a single data format at point of delivery, reducing the risk of asset information gaps at handover. Early Contractor Involvement in model environment to develop construction data and modelling requirements to create greater value from data creation and reduce re-work at a later stage. Adoption of GeoCOBie as the standard asset data transmittal format, ensuring asset data is provided at each stage in a consistent format at the appropriate level of detail required for that stage of development. Creation of a 'human readable' Supplier Asset Classification drawing, visualising the proposed intervention (e.g. creation of new asset, refurbishment or decommissioning of an existing asset) enabling clear Senior User understanding and sign-off.
Regulatory & compliance management	The centralisation of data records in the Environment Agency's CDE provides a standard reference location and process to support wider regulation/inspection on the programme and asset delivery.
Assurance, audit & reporting	The use of the Environment Agency's CDE and Information Delivery Plans across gateways to support the answering of plan language questions will reduce effort at the handover gateway for the Environment's teams. The centralisation of project data records in the Environment Agency's CDE provides a record of approvals and audits across project lifecycle and gateways.
Portfolio planning & resilience	The control of programme delivery information and scheme progression will decrease risk in achieving programme acceptance with key stakeholders and funding streams. The request for suppliers to share and issue survey information in the EIR will give Environment Agency the ability to manage and re-use survey data obtained through works for onward purposes.

Source: KPMG and Atkins analysis based on information and evidence supplied by the Environment Agency, 2021

Figure 26: Summary of the Environment Agency's emerging use cases for Information Management

Function / sub-function	Information management use case
Commercial management	The use of Environment Agency's CDE will allow teams to clearly visualise cost and carbon items associated across the scheme in development. The amalgamation of costed items to delivery items also supports onward data reuse in scheme delivery.*
CapEX delivery (design & construction)	Rule based automated validation of GeoCOBie ensuring asset data is accurate and complete.*
OpEX Delivery	The integration of Environment Agency's O&M data requirements in the data requirements library, allows the Environment Agency to embed asset information requirements into project at an earlier project stage.* Automated acceptable of asset data delivered through GeoCOBie will allow rapid transfer to the Environment Agency's Asset Information System (AIMS) within days not months.* Linking of information to a geographical location through GeoCOBie allows all information including documents to be geographically searchable within AIMS.*
Assurance, audit & reporting	The tracking of project risks, RFI's or change within the CDE will support the process for tracking of legacy issues and delivery tracking in detail.*
Portfolio planning & resilience	Use of a single CDE allows the Environment Agency to review project data delivery performance across the national and regional hub programme through the use of real-time dashboards.*

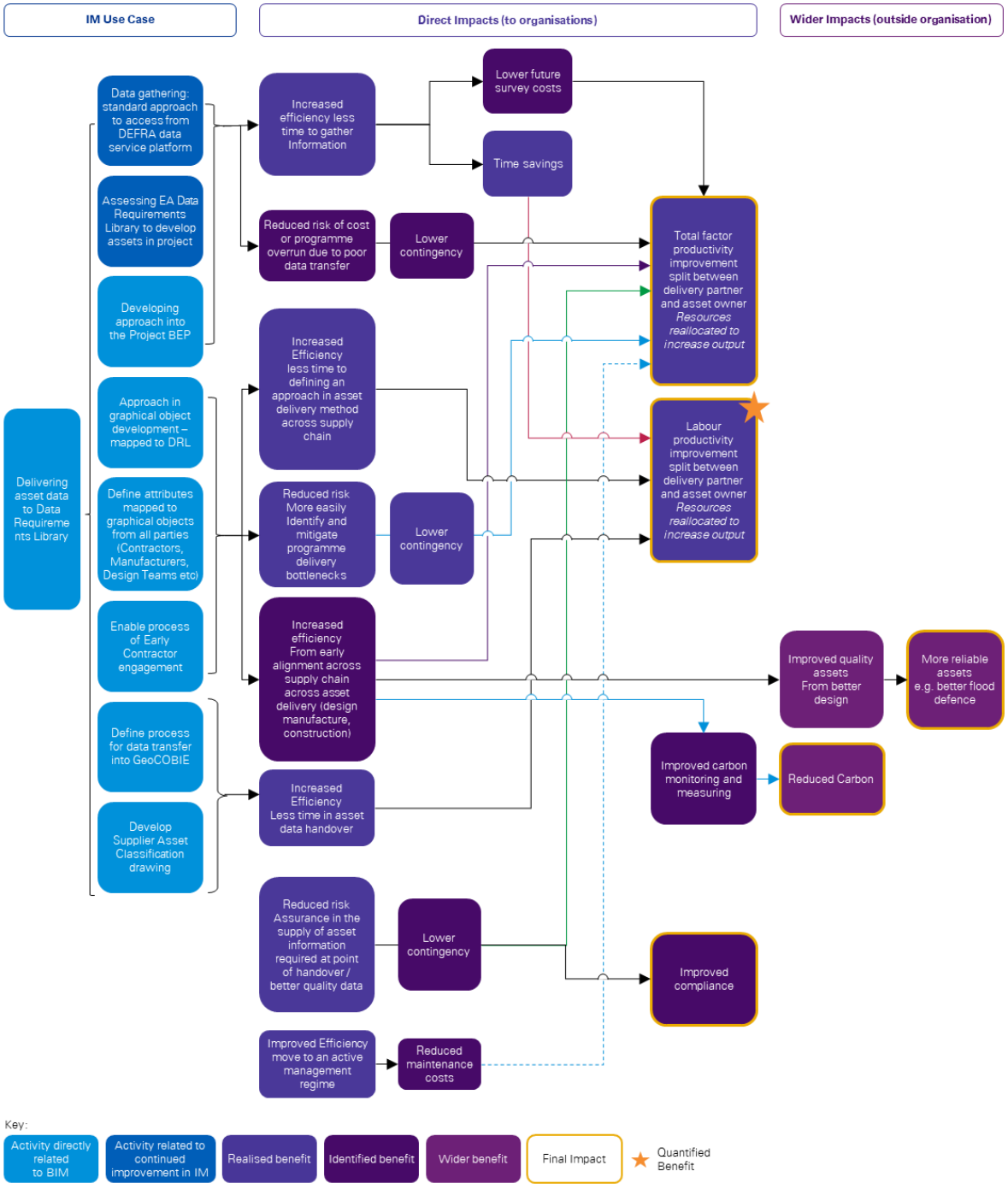
Notes: (*) Emerging use-case with some organisational elements in discovery or early implementation phase

Source: KPMG and Atkins analysis based on information and evidence supplied by the Environment Agency, 2021

7.3 Summary of the direct and wider benefits from the Environment Agency's use of Information Management

The Environment Agency's adoption of IM through implementation of its DRL across its capital programme is expected to unlock a broad range of direct benefits for the Environment Agency and its delivery partners (Section 7.4), as well as benefits for wider society (Section 7.5), as summarised in Figure 27.

Figure 27: Summary of the benefits from the Environment Agency's use of Information Management



Source: KPMG and Atkins analysis based on information and evidence supplied by the Environment Agency, 2021

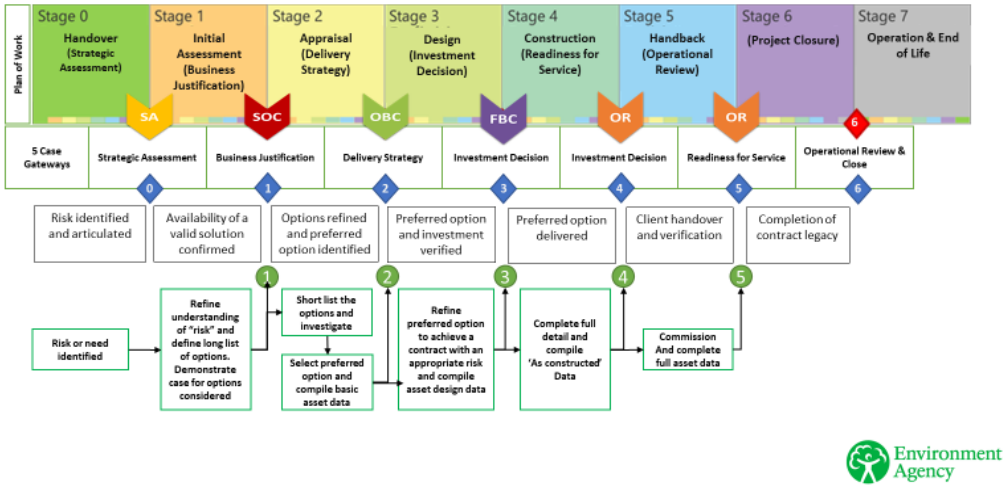
7.4 The direct benefits for the Environment Agency and its delivery partners

The Environment Agency's use of IM, including the DRL, promotion of GeoCOBie and the DRV project (described previously in Sections 7.2.3 and Section 7.2.5), is expected to deliver cost savings for the Environment Agency and its delivery partners through efficiencies and reduced risk, as well as benefits in terms of improved compliance with health, safety and ethical obligations and standards. The remainder of this section describes each source of benefit in more detail.

7.4.1 Cost savings from increased efficiency

Through the use of IM, both the Environment Agency and its delivery partners are expected to experience efficiencies across Stages 2 to 5 of the Environment Agency's plan of works across the asset lifecycle stages defined by the Environment Agency which are outlined in Figure 28.

Figure 28: Overview of Environment Agency's plan of works across the asset lifecycle



Source: Environment Agency, 2021

These efficiencies are expected to support cost savings and in turn productivity gains in two ways:

— Increased labour productivity if the efficiencies generated by the data/ information management approach specifically saves employee/contractor time; or

— Total factor productivity savings if the use of IM also makes the whole delivery process more efficient, meaning less need / use of equipment (e.g. computers and machinery) as well as less labour time.

These efficiencies are expected to arise in three potential ways:

1) The production and use of structured asset datasets, prerequisite information requirements and available survey data is expected to provide more easily accessible and understandable information to all parties. This is expected to result in less time required to gather information specific to each project and asset at the end of Stages 2-5 of the asset lifecycle. In certain situations, such as when a deteriorated wall or embankment is being renewed, upgraded, or replaced, there are also expected to be fewer onsite visits

and surveys required to collect asset and site information. This could lead to savings in time, cost, and overall programme schedules.

2) The DRL's definition of individual assets' specific attributes and the mapping of these to graphical objects means this information is accessible and available for all parties involved (e.g. Contractors, Manufacturers, and Design Teams etc). This is expected to reduce the time required to develop an approach to delivering the asset across various asset stages. For example, Stage 2 business case information would be available for the development of the outline design, asset type and footprint, and this information is then available to inform the Stage 3 detailed design process, and so on.

3) The handover process of information between delivery partners and the Environment Agency (between each Stage from 2 to 5) is expected to be simpler and quicker, and the quality assurance of this information by the Environment Agency is expected to be more efficient (as well as more comprehensive) as information is standardised (as well as potentially of better quality and more reliable – the benefits of which are covered in Section 7.4.2 below).

The labour productivity gains that could be unlocked by the Environment Agency's use of IM across its capital programme for the 'Collaborative Delivery Framework', and have been estimated by working with the Environment Agency to break down the relevant stages of the asset lifecycle into sub-tasks. The typical amount of staff time required to complete each task was identified (based on previously delivered projects using a manual/traditional approach) and compared with the estimated amount of time expected to be required with the use of IM and a digital, data-driven approach. Savings were derived using information from the River Rother Tidal Walls East pilot scheme, and stakeholders' professional judgment based on previously performed similar subtasks in past projects both with and without IM. Savings were then scaled up by multiplying the hours on an average project by the number projects across the Agency's capital delivery programme.

This was established in detail for Stage 3 (design – investment decision) with Stages 2, 4, and 5 being approximated as having a lower percentage of time savings. Savings were assumed to last 6 years to reflect the remaining life of the programme, and a three year ramp up period was applied to conservatively reflect learning and implementation constraints. Time savings were conservatively valued at the UK minimum wage.[51] Costs were estimated assuming a level of investment/labour cost across all partners to implement IM in each task as well as the initial investment/software fixed costs. To be conservative, factors were applied to costs and benefits to account for optimism bias. All benefits and costs were discounted in line with HMT's Green Book recommended 3.5% annual rate to compare them in present value terms.

Through this analysis, **it is estimated that the Environment Agency and its delivery partners could potentially achieve labour productivity gains worth £6.00 for every £1 spent on implementation of the Agency's data-driven IM approach, in present value terms.** Given the contractual gain / pain sharing arrangements between the Environment Agency and its delivery partners, it is expected that the costs and benefits of implementing IM would be shared evenly amongst the parties.

[51] This reflects the reservation wage of the employee/employer, which is lower than the market wage, indicating that labour time freed up may be spent on tasks of lesser importance. If freed up time is spent on relatively productive tasks, or it allows employees to reduce their labour requirements, the market wage should be used, and the expected savings would be greater.

7.4.2 Cost savings from reduced risk

Through the use of IM, both the Environment Agency and their delivery partners are expecting to reduce risks in the design and construction of the Environment Agency's future capital projects. Ultimately, this is expected to flow through into lower risk contingency costs, and/or fewer instances of programme or cost overruns. The use of IM is expected to lead to reduced risk in three main ways:

1) The risk of poor information handover and transfer at the end of each stage (2-5), and the risk of subsequent programme delays and cost overruns, is expected to be significantly reduced by having a standardised and consistent database and process (EIR and DRL). This information also informs the Agency's gateway review process.
2) An open and accessible approach to asset data management, with information on assets and their components being consistent and accessible across the supply chain, means potential bottlenecks or abortive work in the programme can potentially be more easily identified in the early stages, where these risks can be more easily be avoided or mitigated against. For instance, under a more traditional asset delivery process, there is a risk that the Stage 4 construction contractor would plan to procure site investigation data which should be completed earlier in the process to inform the detailed design stage (Stage 3). This might occur because project requirements and current information was not obviously accessible and/or useable to programme participants. With consistent data collection and hand-over, this risk, and the direct, knock-on time and costs implications for the programme, could be largely avoided.
3) The use of more comprehensive standards for IM means information is likely to be of better quality, and more reliable, enabling a more robust quality assurance process. This is expected to result in a reduced risk of re-works and programme timetable extension which can otherwise be the consequence of a poor assurance review rating.

7.4.3 Cost savings and improved safety in operations

The visualisation of design and construction through federated project models as part of the Environment Agency's implementation of IM is expected to create efficiencies in the maintenance/ operations of its assets, as well as improve operational safety.

For example, a typical challenge experienced by organisations with large and ageing physical asset portfolio, such as the Environment Agency, is that older physical records are incomplete or have not been correctly updated. This can also occur for new assets, albeit to a lesser extent, when IM is not embedded in the asset plan-of-works lifecycle.

Having up-to-date and visual information (e.g. condition, dimensions, materials) is deemed critical in allowing the Environment Agency to make the correct operation and maintenance decisions, and failure to do so can potentially lead to under investment. For instance, it was reported in 2021 that based on information available, more than 3,400 of England's "high consequence" flood assets, defined as those where there is a high risk to life and property if they fail, were judged by the Environment Agency to be in very bad condition.[52]

Moving towards a comprehensive, reliable and accessible digital information library could result in, for example, a better understanding of:

— the degradation and condition of an asset;

[52] The Guardian (2021), Swathes of England's vital flood defences 'almost useless', link

— whether it should be replaced or maintained;

— how it should be maintained; and

— the types of safety issues that need to be considered.

Improved decision-making on these issues is expected to result in reduced ongoing maintenance costs, potential increases in asset life where possible, and a lower likelihood of health and safety incidents.

The DADI programme also brings in elements of Electronic Data Interchange, which supports a preventative maintenance regime. This is because consistent and reliable information across the asset portfolio is critical to conducting maintenance in an efficient way i.e. scheduling maintenance when needed, as opposed to after the asset fails (reactive regime) or before it is required (planned regime). This is expected to lead to additional savings in asset maintenance costs and reliability, with less downtime for operational assets (e.g. pumps and gates, fish and eel passes).

The DRV project is also expected to create a 'common language' between the design and capital delivery programme and the operations and maintenance teams going forward. This means operating teams can better understand the asset and its various components in much greater detail, making them potentially more efficient in what they do and potentially reducing the costs of operations. In addition, the 'common language and understanding' could also mean that lessons learnt can be consistently fed back into the earlier design stages of future projects. In the medium term, this could lead to coordination and innovation synergies across the design process, potentially leading to further reductions in operational costs.

7.4.4 Improved compliance with health, safety and ethical obligations and standards

The improvement in information understanding, handling and assurance/review across the programme means the compliance with materials, health, safety and ethical obligations and standards are potentially more likely to be identified and planned for earlier in the design stage, minimising instances of non-compliance. It also provides an ongoing record for disclosure to the Health and Safety Executive, meaning information gathering for compliance or disputes could be more efficient to complete, potentially avoiding unwarranted investigation and legal costs. Further, updates of changes to compliance standards could be more easily communicated and integrated into the design and capital delivery process going forward.

7.5 The wider benefits to UK society

The integration of IM in the DADI programme is expected to unlock social value benefits for wider society and the environment, through improved decision-making by the Environment Agency and in turn more reliable assets, as well as through new opportunities to deliver on the Agency's sustainability and Net Zero agenda.

7.5.1 More reliable assets

As indicated in in Sections 7.4.1, 7.4.2, and 7.4.3, IM not only reduces the time, cost and risk associated with collecting, using and transferring asset information, but can also mean this information is more reliable and accessible. As a result, strategic decisions, design and

construction issues, and opportunities for improvement and innovation can be identified and addressed earlier in the asset planning process, and in turn potentially enable the Environment Agency to improve the reliability (and reduced failure) of its flood defence assets, and therefore potentially improve flood defence itself. Floods can have a catastrophic impact on the environment and on businesses and livelihoods (wider society). For instance, flooding in 2015/16 was estimated to cost the economy £1.6 billion, and whilst flooding in 2019/20 was estimated to cost £78 million, it would have cost an extra £2.1 billion without food defences.[53] This reflects loss of life and health and sanitary effects on people, the damage to houses and community infrastructure, the loss of economic activity, as well as the cost to restore and clean up the flood. This risk, and subsequent cost to wider society, is only expected to grow with the increasing threat and impact of climate change.[54] Examples of how this can come about include:

— The assets that the Environment Agency renews or constructs being better understood (e.g. condition, type, dimensions, materials). This could result in less or lower risk of downtime for operational assets (e.g. pumps and gates, fish and eel passes), and this can subsequently have a positive impact on local biodiversity.

— Larger assets (e.g. flood defences, such as walls, and embankments) can be better upgraded and maintained. This could arise as a result of the enhanced opportunity to share reliable and consistent information across the Environment Agency's many functions. For instance, strategic decisions are made using flood risk models, which require reliable data on the location and height of flood defences in place. If for instance, asset dimensions inputted into these models are incorrect, or the assets condition has deteriorated but this has not been properly addressed, the quality of the strategic decisions can be affected.

7.5.2 Improved sustainability

In alignment with overarching UK Government objectives, the Environment Agency is seeking to become Net Zero Carbon by 2030, including their direct operations and supply chain. The current strategy is seeking to achieve this objective through both reductions in emissions (45%) and as well as carbon offsets (55%).[55]

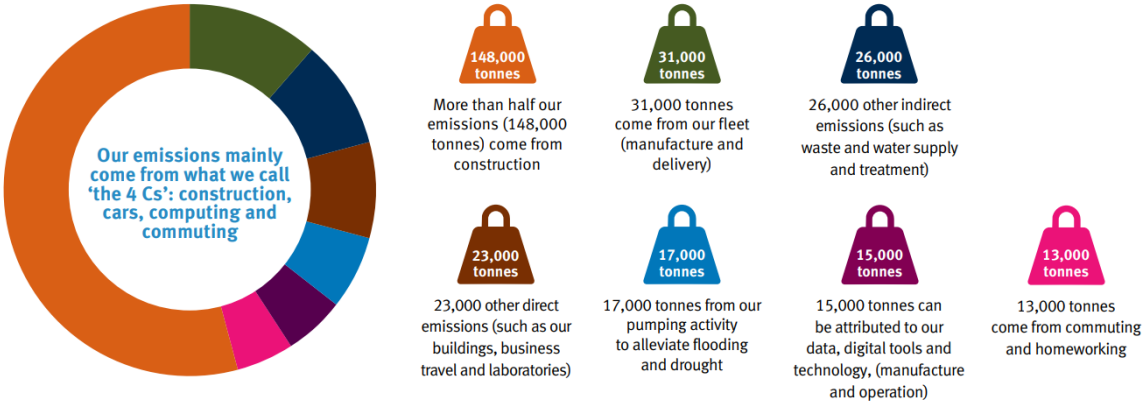
My being more efficient in the design and capital construction/delivery process, and reducing the likelihood of programme overrun and unrequired information gathering (e.g. travelling and conducting onsite visits and surveys), the Environment Agency is expecting to secure savings in CO2, by using less resources and emitting less carbon than required prior to the introduction of its data-driven approach.

Considering their objective of net zero by 2030, the Environment Agency's ambition is to extend the current use of IM through the DADI programme to incorporate relevant information on the emissions performance of their assets and their components. Figure 29 shows how significant the construction of buildings and infrastructure assets is to the Environment Agency's emissions performance, contributing to more than half (54%) of the Environment Agency's carbon footprint. Materials such as concrete, steel and cement make up the vast majority of this contribution.

[53] Environment Agency (2021), Counting the cost of flooding, link
[54] Office of Science and Technology (2004), Foresight Future Flooding, link
[55] Defra (2019), Environment Agency's 2030 net zero goal, link

Further developments in the Environment Agency's use of IM is expected to help drive both measurement of these important factors, as well provide the Environment Agency with a more accurate, detailed and holistic understanding of their current and changing carbon footprint in the construction of new assets. Further, it is expected to be a foundation to enable better decisions particularly in understanding the costs and benefits of future investment and design of assets (e.g. reducing use of concrete, utilising low carbon concrete and developing alternatives designs) as well as the sustainability of the supply chain.

Figure 29: Environment Agency's Direct and Indirect GHG Emissions (tC02e)



Source: Extract from the Environment Agency (2021), Reaching net zero by 2030, link

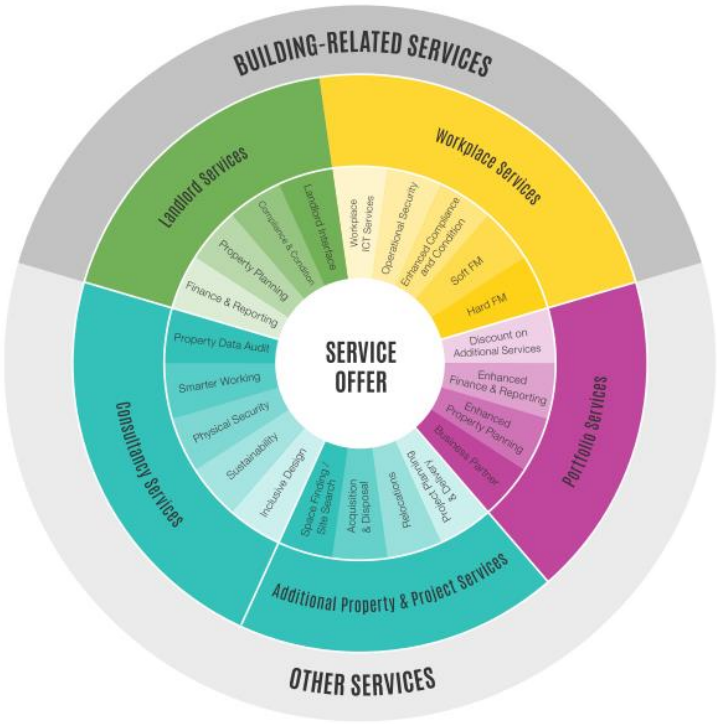
8 Government Property Agency

8.1 Context

8.1.1 Background to the Government Property Agency

The Government Property Agency (GPA) is an executive agency of the Cabinet Office, delivering property and workplace solutions for Government departments and local authorities in the UK. Established in 2018, the GPA provides landlord, workplace and portfolio services and additional property, project and consultancy services (see Figure 30), working closely with its Government clients to support them in delivering smarter property solutions for the Civil Service.

Figure 30: GPA's service offer



Source: GPA, 2021

GPA's mission is to "*create great places to work for civil servants, enabling them to deliver excellent public services, and to feel valued for the brilliant work they do on behalf of the public*". This mission is underpinned by five strategic objectives[56] which (as outlined in Figure 31) comprise:

— **People and places**: providing a modern and inclusive workplace for the Civil Service with client needs at the heart of decision-making.

— **Growth across the UK**: supporting the Government's levelling up agenda through the delivery of the Government Hubs and Whitehall Campus programmes, which will help to

[56] GPA (2020), Government Property Agency Business Plan 2020/21, link

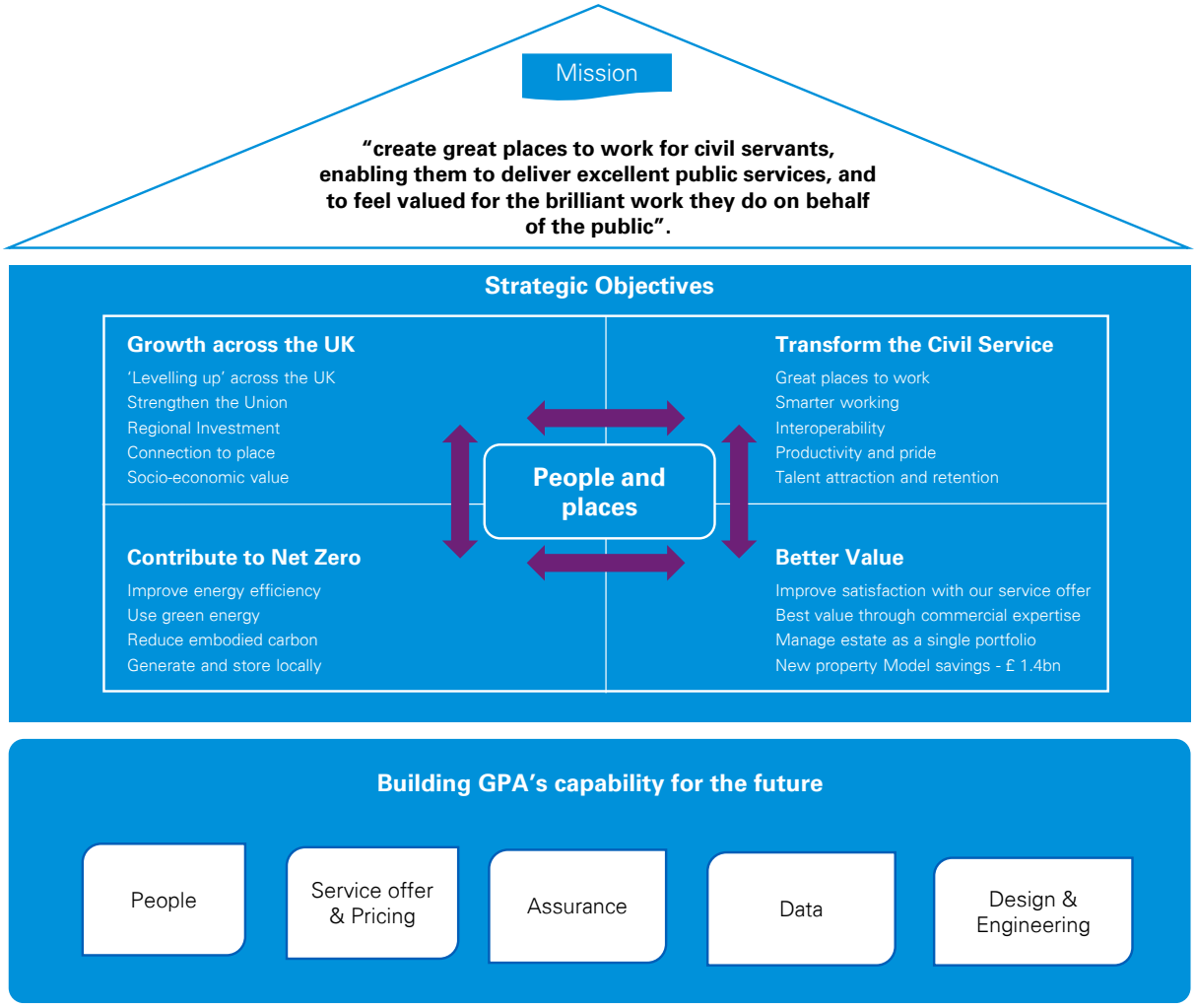
distribute Civil Service roles across the country and support local growth in the UK regions.

— **Contribute to Net Zero**: establishing targets and carbon reduction plans to provide an example for the UK property industry. The GPA are invested in targeted intervention plans which improve energy efficiency, utilise green energy, reduce embodied carbon and generate and store renewable energy. These interventions will ultimately help to achieve the UK Government's Net Zero carbon targets.

— **Better value**: Leveraging the benefits of managing the Government's property estate as a single portfolio and maximising value for money in the construction and maintenance of Government property.

— **Transform the Civil Service**: delivering more great places to work to help improve productivity and pride in the Civil Service, and to help departments attract and retain talent.

Figure 31: GPA's mission, strategic objectives and capabilities for the future



Source: GPA, 2021

Through their strategic objectives for 2020-21, the GPA is aiming to drive a 20% improvement in client satisfaction, establish 10% growth in its number of clients, reduce existing vacant space rate by 20% and improve space utilisation.

As outlined in Figure 31 above, 'Design and Engineering' and 'Data' have been identified as two of the five areas that are integral to building GPA's capability for the future and achieving its five strategic objectives. GPA aims to maximise the use of data and information models in the delivery and management of their property portfolio. In 2020, GPA established its B^{2}IM (Better Building Information Management) Strategy which outlines a proactive approach to IM and data requirements aligned to ISO 19650 standards. This B^{2}IM Strategy and its application to GPA's Government Hubs Programme (the focus of this case study) is further described in Section 8.2.

The B^{2}IM approach starts with putting the customer experience first; focusing on providing smart workplaces and a digitally connected estate that inspires the people involved throughout the entire property life cycle. To help achieve these aims, the approach uses established industry standards, methods, procedures and data schemas to capture and utilise data required by GPA's Workplace Services, Property Estate Management, Project Delivery, Data Engineering and Insights functions.

GPA has made three core commitments to drive their investments in IM, which links to the organisation's strategic objectives and capability plans (described above in Figure 31):

— Provide great customer experience by making best use of technology in Government buildings;

— Generate and utilise seamless data across the Government estate by utilising a common language across the building lifecycle; and

— Provide the right data to enable GPA and its supply chain to make the right decisions at the right time.

8.1.2 The GPA's Government Hubs Programme

Established in 2018, the Government Hubs Programme is a transformation project which aims to consolidate Government offices into fewer, more efficient regional Hubs and provide better quality workplace environments for the Civil Service, with the ultimate objective of providing better value. The programme comprises a focus on workplace transformation and promoting smarter, collaborative working, while optimising the use of Government property and releasing any underutilised assets. The Hubs Programme aims to reduce the Government estate from circa 800 buildings to less than 200 by 2030 and establish new Hubs in key locations in major cities across the UK. To date, 17 Hubs have been established across the UK in areas such as Belfast, Bristol, Croydon, Edinburgh, Peterborough and Leeds.

The Hub Programme was initially delivered through HMRC in delivering their regional centres[57] across key locations[58]. In 2019, GPA took over delivery responsibility for the Hub Programme. The GPA's remit for the Hubs programme includes the construction and refurbishment of Government Hub properties, as well as the operation, management and maintenance of the estate across the asset lifecycle. The projects within the Hubs Programme range from new build Hubs, CAT A / CAT B fit outs, minor refurbishments, operations and planned maintenance all the way through to end of use.

[57] NAO (2017), Progress on the Government Estate Strategy, link

[58] Government Digital Service (2017), Smarter Working in Government Hubs, link

8.2 GPA's use of Information Management on the Government Hubs Programme

8.2.1 The application of GPA's B²IM strategy to the Hubs Programme

Building on the 2016 Government BIM mandate and GPA's commitment to build future capability, GPA has established their B²IM strategy, underpinned by a suite of IM standards. The B²IM strategy builds on the achievements and learnings from HMRC's initial delivery of the Hubs Programme to embed the practical application of B²IM across their portfolio.

Implementation of the B²IM strategy focuses initially on the Hubs Programme with a view to paving the way for wider adoption across GPA's entire remit. The B²IM Strategy evolved in align to the ISO 19650 suite to ensure the Hubs Programme benefits from the advantages of cross-Government transition moving from PAS 1192 BIM standards to lifecycle IM, whilst adopting an internationally-aligned and established set of standards, which provide a consistent and coordinated approach to IM. The core principle of the GPA's B²IM approach is that everyone across the organisation uses a common language and set of data requirements; ensuring that data is gathered once and enables multiple reuse of data by different parties.

The B²IM strategy has been applied to all new build and refurbishment projects within the Hubs Programme from 2020, whilst information from previously completed projects will be aligned to the B²IM Strategy as far as practically possible. This aims to deliver robust IM across GPA's portfolio and drive benefits in capital delivery, operations / facilities management (FM) and inform future investment planning. To date, the B²IM strategy has been adopted on eight Government Hubs projects, listed in Figure 32.

GPA's Hub projects are being designed to comply and exceed the standards defined by the ISO 19650 suite, by taking a 'customer first' approach and majoring on the uses of technology to support GPA in its mission to have better building information throughout the entire life cycle. The B²IM standards are being set out in GPA's Exchange Information Requirements (EIR), Asset Information Requirements (AIR) and Asset Data Requirements (ADR) for each project. Application of GPA's B²IM strategy and ISO aligned suite of IM standards (EIR, AIR, ADR) is established at tender stage and is supported by internal GPA teams and external consulting partners (such as Faithful+Gould).

Figure 32: Government Hub projects that have adopted the B²IM strategy since 2020

Capital delivery
London – Croydon 2 (CAT B and beyond)
London – 55 & 3-8 Whitehall (CAT B and beyond)
Peterborough (CAT B and beyond)
Bristol Temple House (CAT B and beyond)
Birmingham 3 (CAT A and beyond)
Newcastle 2 (CAT A and beyond)
London – 36 Whitehall (CAT B and beyond)
Operations / facilities management
London – Old Admiralty Building

Source: GPA, 2021

8.2.2 B²IM functional standards - GPA's office model

GPA's B²IM functional standards for offices sets the technical asset data standards for how to define, deliver and assure 'Better Building Information Management' – not just for design and construction projects, but for each of the operational in use life cycle events.

As part of the B²IM strategy, the GPA functional standards (Office Model) is deployed to enable asset information to be exchanged in a technology-enabled environment that will support alignment of BIM information models and data with onward operational use cases, as well as enabling and supporting the Government Soft Landings approach.

The functional standards have unified industry data classification standards (Uniclass, NRM, SFG20 and CIBSE), to become the common language that links the GPA's asset information requirements across the design, construction, operation and maintenance of a facility, through to asset disposal or end of interest. Thereby bridging the capital and revenue stages and enabling more robust lifecycle costing to inform decision making.

Adopting the B²IM common language approach ensures that the same asset 'descriptors' are used consistently for space/location referencing, asset creation, renewal and operations and maintenance (O&M). This ensures that outcomes from the Project Information Model match the requirements and structure of the Asset Information Model. This is deemed pivotal to standardising and simplifying the integration and interoperability of data across GPA's functions and helping GPA's industry supply chain partners to deliver efficiencies and ultimately cost savings.

The B²IM functional model standards have been implemented to support the following activities:

— BIM to FM/Operations (at project handover);

— Lifecycle costing (during design, construction, renewal, O&M and end of life/disposal);

— Facility Management tendering, contract resource modelling and change control;

— Planned inspections and preventative maintenance (PPM) regimes (based on SFG20);

— Computer-aided facilities management (CAFM) alignment with common data environments;

— Condition surveying and development of lifecycle asset renewal investment plans;

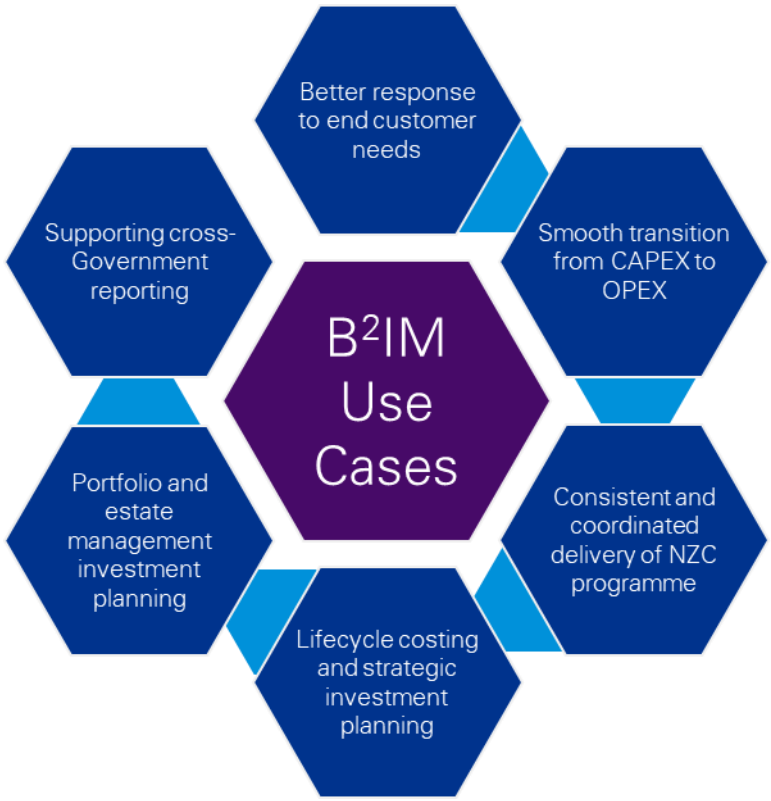
— Audits, assurance and benchmarking compliance with asset information requirements; and

— Extracting, transferring and loading of data from CAFM to estate management systems.

8.2.3 B²IM Use Cases

There are six key uses cases for GPA's B²IM approach, each of which are described below.

Figure 33: The key use cases for GPA's B²IM approach



Source: GPA, 2021

Better response to end-customer needs/customer satisfaction surveys

GPA's overarching mission is to create great places to work for Civil Servants which enable them to deliver excellent public services. Effective use of IM through the B²IM approach, together with new technology, is expected to help GPA to create a smarter working environment for their end-customers across the Hubs estate, increasing customer satisfaction and productivity. GPA is working in partnership with Leesman to roll-out customer experience surveys to customers moving into Government Hubs across the country. By collecting and analysing this data on how well the workplace supports smart working, wellness, community and collaboration, GPA will be in a position to make better informed decisions when designing future Hub projects.

Smooth transition from BIM Projects into FM / CAFM (Capex to Opex)

The core theme across the GPA's application of its B²IM strategy to the Hubs Programme is the standardisation of 'Better Building Information Management', along with methods and protocols, data standards and controlled information exchange functions, to support the delivery of a more productive workplace environment for end-customers and greater cost efficiency in construction and operations. The smooth transition from capital delivery to the in-use asset life phase is critical to enabling these outcomes.

The B²IM strategy provides the functional model standard for information requirements and formats that are to be delivered and assured from project initiation and followed through consistently in the handover to operations and CAFM deployment. This ensures the smooth transition from BIM-enabled capital delivery projects to operations and enables the digital automation of the CAFM set-up which is essential to maintaining consistency across a growing asset portfolio under GPA's asset management stewardship.

Across new Hub projects, data and information produced during the design and build stages (both geometric and non-geometric) will be reused in operations by ensuring the project handover data is digitally exchanged and by using the B²IM common language to ensure information does not need to be recreated at every lifecycle stage. This is expected to lead to increased efficiency and data quality in CAFM set-up and reduce operational expenditure in data collection and asset data verification, in turn bringing down the set-up costs of FM activities. These potential benefits are further discussed below in Section 8.3.

The B²IM standardised approach to information requirements, gathering and management processes across the Hubs Programme will also enable the use of interoperable data across Hub assets; providing GPA with higher data quality, more comprehensive and more timely information on which to make future strategic investment decisions across the Hub estate.

Utilising the project BIM data for setting up planned maintenance regimes and asset life cycle replacement plans, is expected to help drive down the whole life cycle costs of Hub assets and also help to monitor the performance of the estate and reduce its carbon footprint.

By enabling GPA's workplace services teams and FM suppliers to access and use the B²IM data via apps, mobiles and smart building technologies (sensors), this is expected to transform the delivery of operations and FM services and provide data insights, which in turn could enable GPA to drive further efficiencies and time/cost savings in managing the estate, and ultimately achieve better value for money and customer experiences.

More effective delivery of GPA's Net Zero Carbon Programme

The transformation of the Government estate is deemed vital to the Government's commitment to achieve Net Zero by 2050. Therefore, GPA has established a Net Zero Programme which is committed to reducing carbon emissions by optimising asset performance, reducing energy demand, heat decarbonisation and the use of onsite renewables. Changes to GPA's 'Design Guide' also enables GPA to minimise the amount of embodied carbon in future builds and refurbishment projects.

The use of B²IM will provide GPA with a consistent approach to measure, monitor and deliver informed carbon reduction interventions (such as LED lighting, use of BMS, HVAC improvements etc), whilst baselining and reporting the carbon performance of Government

offices. By having standardised data to measure, monitor and mitigate the effects of carbon performance of each building – such as particular asset characteristics and current energy consumption – GPA will be positioned to take decisions over future maintenance and investment activity which aim to reduce the carbon impacts of the estate.

Targeted carbon information gathered throughout the Net Zero Programme and beyond will support a structured approach to implementing and monitoring of GPA's Net Zero Carbon initiatives. The data will also enable accurate and effective reporting of metrics both within GPA and to relevant Government departments.

Life cycle costing and strategic investment planning

The GPA is developing a B^2IM set of information lifecycle costing models and associated data requirements to support lifecycle costing and strategic asset lifecycle investing planning. The allocation of resources and budgets to acquire, operate and maintain GPA's growing property portfolio, whilst optimising customer experience, is a critical success factor for GPA achieving its strategic objectives. The B^2IM approach will be coupled with GPA's portfolio-wide forward lifecycle replacement modelling, which uses existing asset information to refine the lifecycle investment planning process. This aims to capture portfolio asset performance, condition status and the remaining life data to optimise annualised maintenance programmes, and provide transparency of the site-specific asset condition, risks and performance. Thereby providing the evidence necessary for budgeting and prioritisation of forward replacement investments and optimising maintenance spend over the short and long term.

Taking a lifecycle approach to inform capex investment decisions is expected to enable GPA's B^2IM approach to more effectively measure and manage lifetime asset costs and lower operational spend, and in turn bring down the whole life costs of the estate.

GPA's large property portfolio requires ensuring the right level of investment is delivered on the right assets at the correct time. Strategic asset investment planning will allow GPA to optimise asset investment across their portfolio while balancing competing business drivers. The B^2IM approach is key in mandating these requirements through capital works phases to enable the effective handover of information and data related to lifecycle planning for reuse in operations.

Portfolio and estate management investment planning

The B^2IM approach lays the foundation to integrate more comprehensive and higher quality asset information with sensor technology across the Government Hubs Programme. The aim is to deliver interoperable data through the build and fit-out stages of new projects into the in-use and operational stages of the asset. This will provide GPA with asset performance data in relation to building occupancy and utilisation (as well as energy consumption, carbon emissions and waste generation, as noted above). This is expected to provide GPA with better information on which to make investment decisions across the existing Government estate, in light of end-customer requirements (e.g. in relation to refurbishments or enhancements). It will also inform strategic investment decisions on where to locate future Hubs and expand GPA's portfolio of offices, in support of its strategic objective 'Growth across the UK'.

Supporting cross-Government reporting

The alignment of the B²IM strategy with ISO 19650 standards will strongly position GPA and the Hubs Programme to contribute to the Government's ambitions to deliver a National Digital Twin. It also ensures GPA can embrace and benefit from the growing developments of the National Digital Twin programme as it evolves over the coming years. The information purposes and data requirements being specified within the B²IM approach incorporates the Government's Digital National Asset Register (d-NAR) reporting parameters, ensuring GPA can meet this obligation and align with this programme as it evolves.

As GPA works with numerous Government departments, aligning with this reporting standards will ensure a common language for information exchanges and in turn is expected to greatly reduce the time and effort required for data analysis and data cleansing across the Government estate.

8.2.4 Summary of GPA's use cases: Government Hubs Programmes B²IM Strategy

GPA's B2IM approach is delivering effective and digitally-enabled IM, through having interoperable functional standards for lifecycle applications across the six use cases described previously.

Focusing specifically on the B²IM use case of facilitating a smooth transition from BIM Projects into FM / CAFM, the GPA's use of IM comprises two forms of principle application:

— The structuring and management of graphical models (Project Information Models; 'PIM' and Asset Information Models; 'AIM') as defined by the GPA's EIR and AIR – providing consistency in capital project delivery through establishing and applying a project EIR on all Hub projects which are adopting the B²IM approach, thereby enabling the effective reuse of graphical models in the fit-out and operational stages of the project.

— A consistent and coordinated structure to information models through the use of common language across life cycle events which are captured in Asset Data Requirements (ADR) – establishing line of sight by utilising GPA's strategic objective to draw out information requirements driven by information purposes and an asset common language, thereby providing richer and more comprehensive asset information for use in operations.

Figure 34 below summarises GPA's use of IM on the Government Hubs Programme according to the categories within our Information Management Benefits Framework.

Figure 34: Summary of the GPA's use of Information Management on the Government Hub programme

Function / sub-function	Information management use case
CapEX delivery (design & construction)	**Graphical:** Onward design progression in CAT B (Fit out works). Increased clash detection/coordination efficiency between CAT A (Shell and core) & CAT B (fit out). Visual interrogatable models to aid design reviews. Visualisation and stakeholder engagement. **Non graphical:** Smooth transition of information and data from CAT A to CAT B phase.
OpEX delivery (renewals, maintenance & operation)	**Graphical:** Ability to reuse information models where future asset change of use is required. Foundation to integrate with wider digital tools to meet ambitious smart working, inclusion, wellbeing and sustainability standards. **Non graphical:** Smooth transition of data and information from CapEX to OpEX through a common language. Utilise structured digital asset register to efficiently set up CAFM. Structured data set to respond to helpdesk and reactive maintenance tasks. Reuse structured data to inform lifecycle planning. Reuse structured data to undertake condition surveys and progressively build on the structure data. Structured data to support renewal planning activities. Digital asset register to inform forward maintenance planning.
Portfolio planning & resilience	Supports estate wide portfolio planning services activities including analyzing and optimizing space utilisation.

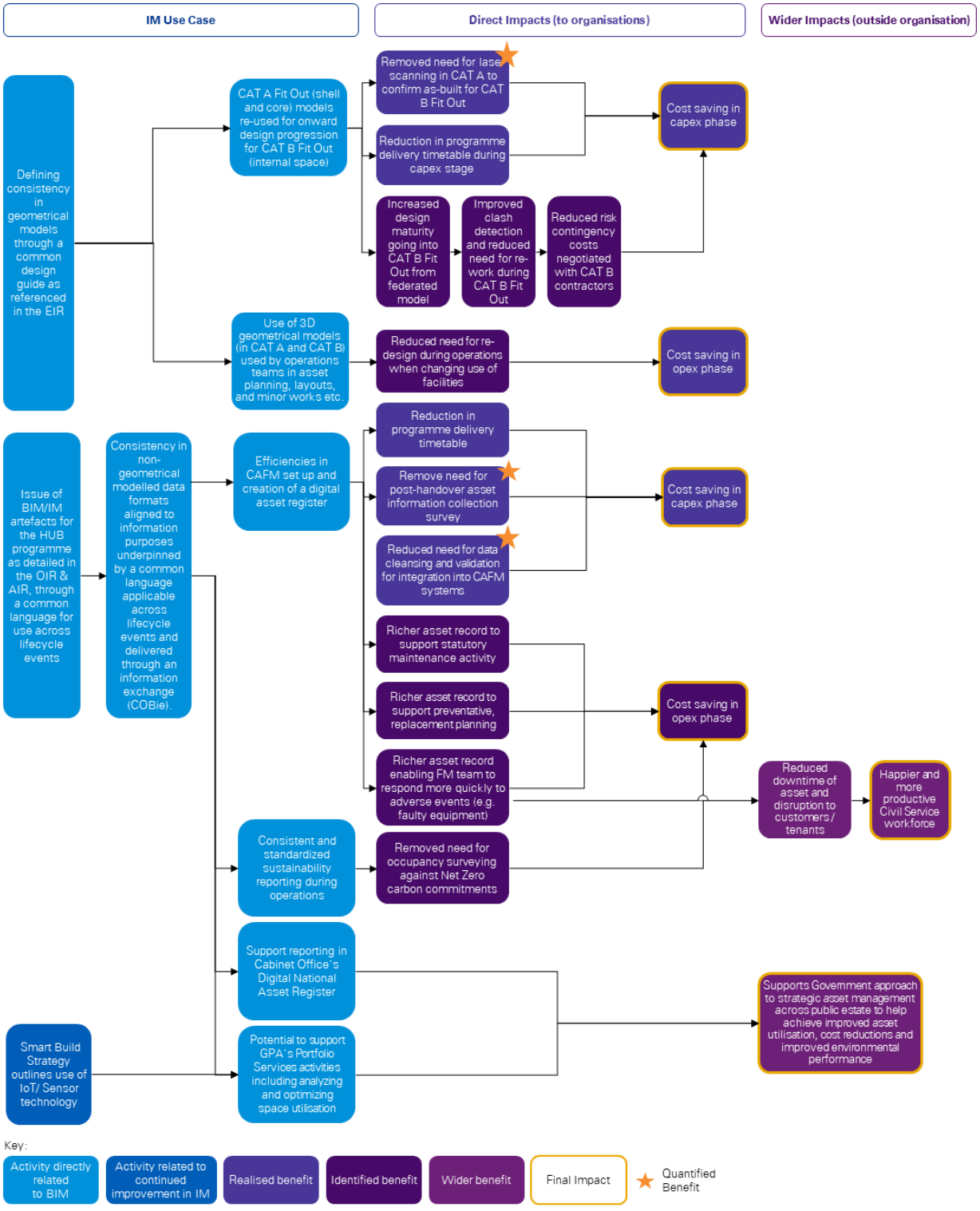
Source: KPMG and Atkins analysis based on information and evidence supplied by GPA and Faithful+Gould (SNC-Lavalin), 2021

8.3 Summary of the direct and wider benefits from the GPA's use of Information Management

In this section we focus on the expected benefits of GPA's use of IM in relation to their B^2IM strategy in supporting the smooth transition from BIM Projects into FM / CAFM on the Government Hubs Programme. These are summarised in Figure 35 below and further explained in the next section.

In summary, the GPA's use of IM is expected to enable time and cost savings across the asset lifecycle, with the potential for these to be realised across the Hubs Programme as the B^2IM approach is rolled out over time. The potential of B^2IM to bring down the costs of capital delivery and operations and maintenance activity for the Government estate would also mean reduced costs and better value for money for the UK taxpayer over the long term.

Figure 35: Summary of benefits from the GPA's use of Information Management on the Government Hubs Programme



Source: KPMG and Atkins analysis based on information and evidence supplied by GPA and Faithful+Gould (SNC-Lavalin), 2021

8.4 The direct benefits for GPA and its delivery partners

8.4.1 Cost savings from efficiencies in the capex phase

The application of the B²IM strategy provides efficiencies through the re-use of graphical and non-graphical data from CAT A (shell and core) to CAT B (fit out) capex delivery, which together are expected to enable time and cost savings for both refurbishments and new builds across the GPA's Hubs Programme and the future GPA office estate.

The definition of clear requirements in CAT A project EIRs and ADRs provides clarity to model structure and quality improvements in design progression for CAT B. Early clarity in the capital delivery process supports effective handover, management and onward re-use of models and data. The simple availability of structured information in CAT A capital delivery is enabling GPA to reduce re-survey costs (laser scanning to inform point cloud surveying and information models) and provides opportunities for programme time savings in CAT B (time saved from not having to conduct surveys).

In addition, under the B²IM strategy, consistent data formats are defined by the common language and supported by COBie exchange formats, which enables time and cost efficiencies in CAFM set up and the creation of a digital asset register pre-handover. This includes a reduced need for data cleansing and validation for integration into CAFM systems, as well as avoiding the costs associated with post-handover asset collection surveys.

Based on analysis of evidence provided by GPA, it has been possible to estimate the potential cost savings to GPA during the capex phase of Hub projects arising from these efficiencies (and as indicated in Figure 35 above). This is based on comparing the capital costs of two Hub projects which have adopted the B²IM strategy (in CAT A) against the capital costs incurred on a Hub project which has been delivered without B²IM in CAT A (and adjusting for the different size of projects).

Through this analysis, **it is estimated that the GPA's adoption of their B²IM approach could potentially enable a circa 3.2% cost saving in capital delivery through improved design integration between office base builds and end-user fit-outs,** in addition to further cost savings in capital delivery and operations from reduced risk and efficiencies (which are not included in this quantified cost saving).

8.4.2 Cost savings from reduced risks in the capex phase

Common risks occur in delivery of capital programmes when transitioning to downstream phases in capex delivery. The GPA's B²IM strategy provides structured graphical and non-graphical models from CAT A (shell and core), which is expected to mitigate risks and avoid costs in CAT B (fit out) as a result of:

— Robust CAT B design coordination and clash detection;

— A reduced need for re-surveying to establish the as-built status of the CAT A; and

— More realistic CAT B tender pricing based on assured as-built information, thereby enabling realistic quantification of CAT B delivery risk.

The use of the B²IM approach in CAT A further supports fit out activities, by enabling de-clashed federated models during CAT B. This removes significant effort and time in the post-occupancy acceptance of office space (fit for purpose) and allows the GPA to focus on reducing risk contingency in this vital stage.

8.4.3 Cost savings from efficiencies in the opex phase (facilities management)

The lack of accurate and trusted information is commonly cited as a limitation in the operational phase of assets. The B^2IM functional standard places emphasis on end-user needs and develops clear and understandable requirements with line of sight (OIR, AIR to EIR). The alignment of need, enabled by better available asset information and simple data transfer processes into CAFM systems, supports GPA in conducting effective planning and onward minor works without the need for costly and time consuming as-built surveys. Foresight and good planning mean that any redesign in the post-occupancy phase is easily accommodated.

The development of the common language allows the GPA to place core strategic requirements into capital projects. Through simple OIR, aligned to project deliverables (or model metadata), the GPA can support active reporting for key attributes like Net Zero carbon commitments.

8.4.4 Cost savings from better quality information in the opex phase (facilities management)

The acquisition of better quality, structured data from the B^2IM functional standard supports GPA in onward facilities management activities. As seen above, the definition of the CAFM model structure and application of common language and data transfer protocols offers a much more streamlined process in data transfer and reuse. Once in ownership, the GPA expected to realise additional benefits from CAFM service providers, again avoiding the costs of rework and surveys. The establishment of a richer asset record is expected to support:

— Statutory maintenance activity, whereby asset information models with clear data structures can be used to support daily planning;

— Preventative maintenance and replacement planning, whereby the availability of more complete and accurate information provides a much richer understanding of asset types, failure modes and their expected useful life; and

— More efficient and effective responses to adverse events (e.g. faulty equipment), with the B2IM functional standard and clear requirement mandating critical operations and maintenance data requirements.

— Together, these activities are expected to minimise downtime of the Hub estate – providing the GPA's end customers with a better user experience (e.g. minimising disruption during office hours from unplanned maintenance activity or facilities being out of use). And in turn, contributes to one of the GPA's key strategic objectives of providing a smarter workplace which supports a happier and more productive Civil Service.

9 Heathrow

9.1 Context

Heathrow Airport Limited ('Heathrow') is the sole operator/owner of Heathrow – the UK's only Hub airport. Heathrow is heavily invested in the role of digital transformation with a focus on a broad range of improvements, including IM, across its current functions in asset ownership, airport operations and future development. In 2011, Heathrow issued their strategy, Heathrow 2.0, which establishes the organisation's vision for achieving sustainable growth. Across the airport's operations, four priority areas and six values have been identified to support the vision: *'To give passengers the best airport service in the world'.*

Figure 36: Heathrow's strategic priorities and values

Priorities:	Values
— **Mojo** – making Heathrow a great place to work and placing people as priority to the ambition. — **Transforming Customer Service** – to deliver the world's best passenger service, we will work with the Heathrow community to transform the service we give to passengers and airlines, improving punctuality and resilience. — **Beat the Plan** – to secure future investment, we will beat the Q6 business plan and deliver a competitive return to shareholders by growing revenue, reducing costs and delivering investments efficiently. — **Sustainable Growth** – to grow and operate our airport sustainably, now and into the future.	1. **Keep everyone safe** 2. **Treating everyone with respect** 3. **Giving excellent service** 4. **Working together** 5. **Improving every day** 6. **Doing the right thing**

Source: Heathrow, 2021

In 2020/21, Heathrow aligned its investments in digital transformation; developing an 'umbrella strategy' which combines initiatives across its Service, Technology, Commercial, Security and Operational functions. The Digital Strategy maps upward to the Heathrow 2.0 priorities (see Figure 37 and Figure 38) and is underpinned by 'benefits profile' which include methods of measurement. All digital initiatives are considered through the lens of operational improvement from:

— Improved staff productivity;

— Reduced carbon footprint;

— Improved project efficiency;

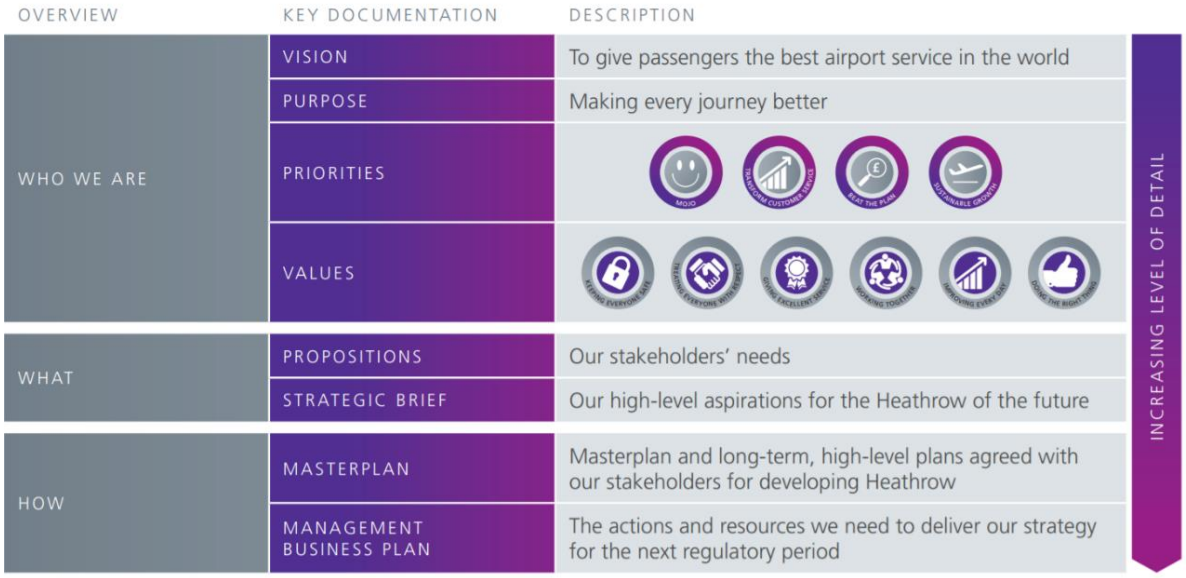
— Improved information transfers; and

— Improved operational efficiencies.

The development of the strategy was supported by a dedicated digital director and wider team from across Heathrow's functions.

Throughout 2020/21, Heathrow and the wider aviation sector has been drastically affected by the global COVID-19 pandemic, with an overall reduction in passenger numbers and reduced forecast expenditure across the organisation's capital infrastructure programme. Despite this scale of disruption, the organisation has maintained a focus on trialling new IM systems and procedures on capital projects, such as the Cargo Tunnel Project which is captured within this case study.

Figure 37: Extract from Heathrow's Strategic Brief



Source: Heathrow, 2021, link

Figure 38: Extract from Heathrow Digital Strategy aligning digital benefits and outcomes to Heathrow's four priorities

Source: Heathrow Digital Strategy, 2021

9.2 Heathrow's use of Information Management

9.2.1 Heathrow's journey of adopting Information Management

Heathrow is focused on increasing its productivity and end-benefits to customers through digital transformation across its capital assets and operational estate. In 2014-15, Ferrovial – one of Heathrow's Delivery Integrators – collaborated with IBM to undertake a study titled: 'Investigating the case for lifecycle asset information integration for infrastructure and building'. The pilot study explored the value of BIM in asset lifecycle information management for the T3IB baggage handling facility. The pilot demonstrated 3% to 7% savings in lifecycle costs for new infrastructure integration, improvements in end-to-end flow of asset information which enabled greater stakeholder collaboration, and a significant reduction in manual work eliminated by automating asset data management processes[59].

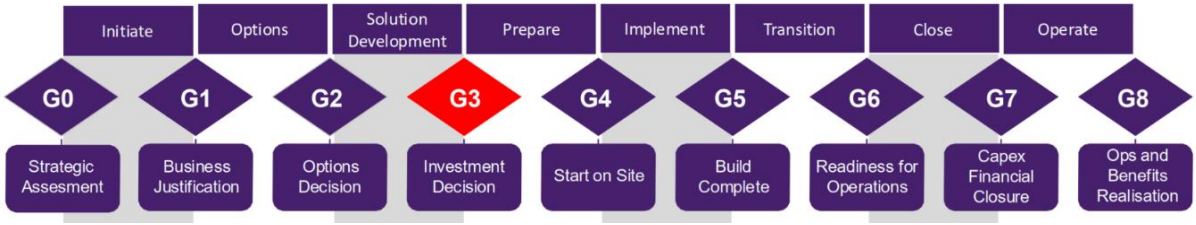
Building on the outcomes of the Ferrovial/IBM study, Heathrow invested in their BIM and wider IM capability through their IT and Asset Management portfolios to support the delivery of their now superseded Digital Asset Backbone Strategy. This included the procurement of a new Common Data Environment – the Heathrow CDE, in 2018/19. The Heathrow CDE replaces the organisation's existing Enterprise Content Management system, 'Documentum', and aligns processes of graphical and non-graphical data management. The organisation's investment in the Heathrow CDE aimed to deliver benefits across the design, build, handover and operations and maintenance phases, taking an integrated view of benefits that could be realised across the whole asset lifecycle.

Further to the benefits of the Heathrow CDE, the organisation has mapped wider IM benefits across Heathrow's 'Gateway Lifecycle'. This gateway process (Figure 39) models how a change initiative via a business case is planned, controlled and monitored from inception to completion. The most notable benefits identified by Heathrow from the use of IM across gateways are:

- **Increased Staff Productivity – measured as the improvement in staff time.** Firstly, by improving the effectiveness of colleagues' day-to-day activity through digitalising repetitive tasks and processes. Secondly, by ensuring colleagues have the right digital skills and information at their fingertips through integrated ways of working. And third, by supporting the sharing and management of supplier information resulting in efficiency savings in both the design and construction of capital projects through access to a central location for all capital information (the Heathrow CDE).
- **Improved Project Efficiency – measured as improvements in staff time.** Achieved by improving the efficiency of delivery across the project lifecycle, as well as through improved interaction and engagement with suppliers, and the continual flow of trusted data to support decision making**.**
- **Improved Information Transfer – measured as the improvement in staff time.** By supporting improvements in the transfer of information within projects and from project teams to central asset engineering teams.
- **Improved Health and Safety– measured as intangible benefits to colleagues and the organisation.** Achieved by supporting safer design through virtual representations of the estate and the use of digital rehearsals to test the safety of different activities.

[59] IBM (2016), Ferrovial: Investigating the Case for Lifecycle Asset Information Integration for Infrastructure and Buildings, link

Figure 39: Extract from Heathrow Gateway Lifecycle (HGL) guidance demonstrating overview of governance stages



Source: Heathrow Gateway Lifecycle Guidance, 2021

9.2.2 Case Study: Heathrow Cargo Tunnel Project

The Heathrow Cargo Tunnel Project aims to refurbish one of the main operational tunnels serving the airport's airside operations (freight, passengers and airport services). Built in the 1960s, the 890 metre long tunnel is one of the UK's only single bore tunnels which operates bi-directional traffic. The asset is critical to Heathrow's daily operations, with the refurbishment of all internal services programmed to be delivered at night to minimise disruption.

Figure 40: Heathrow Cargo Tunnel

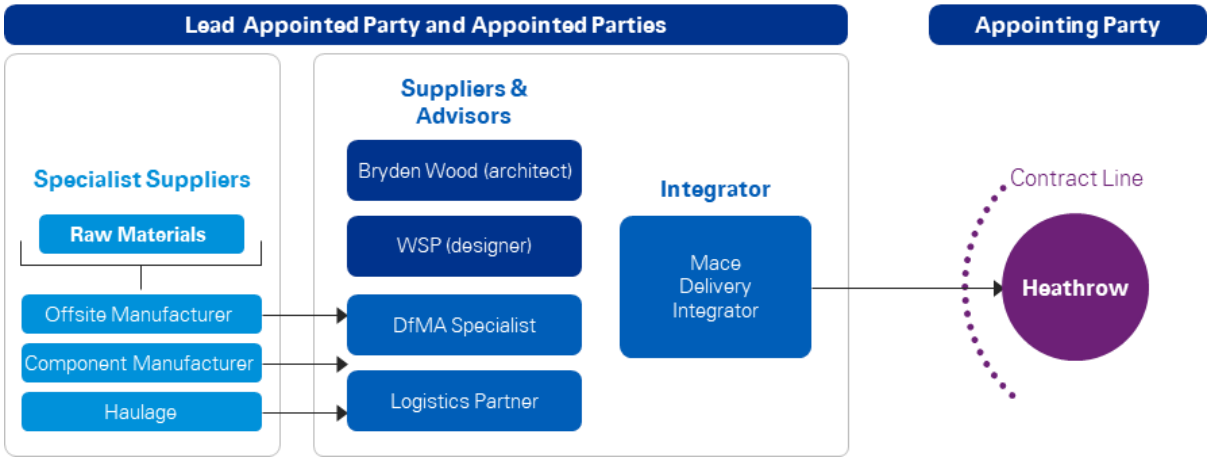
Source: Heathrow, 2021

A previous refurbishment project, based on more traditional design and delivery techniques, was planned to be mobilised on site in Heathrow's previous Capital Plan. Due to project complexity, budget and schedule challenges, it was paused in 2018 and reviewed. A new solution was developed which embedded the use of effective IM and BIM, and in turn critically enabled digital methods of delivery and modular and offsite construction principles; Design for Manufacture and Assembly (DfMA). A core aim of this digitally-focused, offsite construction methodology was to reduce the original programme timetable expectations

from four to three years to complete the construction phase of the tunnel refurbishment, and improve efficiencies and reduce clash errors, and in turn reduce overall project costs.

The Cargo Tunnel Project also aims to leverage benefits through new and more novel commercial arrangements proposed by the Institution of Civil Engineers (ICE) through the Project 13 enterprise approach. The P13 partnership model includes Heathrow as the Owner/Operator, Mace as Integrator and a wider supply chain including WSP (designer) and Bryden Wood (Architect and DfMA Specialist). There are no external investors identified in this project arrangement.

Figure 41 Extract from ICE P13 Commercial Handbook modelling Heathrow's application to Cargo Tunnel Project



Source: KPMG and Atkins presentation of information and evidence supplied by Heathrow, 2021

9.2.3 The role of Information Management on the Heathrow Cargo Tunnel Project

The Cargo Tunnel Project was identified as a prime candidate for the application of Heathrow's developing approach to IM (outlined above in Section 9.2.1). The project is currently in the Scheme Development Phase, equivalent to RIBA 2-3, with emphasis on early contractor engagement and planning under the P13 Integrator model.

IM artefacts, such as Exchange Information Requirements (EIR), supported by existing wider Asset Employer Requirements, have been leveraged by the Heathrow Procurement and Information Management teams into the procurement process for the Solutions Development gateway (G2 – G3 in Figure 39 above). The implementation and agreement of IM application on the project is managed in collaboration with Heathrow's Integrator (Mace) and the Heathrow Solutions Infrastructure team acting as the client project management function.

Enablers to the process of leveraging IM into the project include:

— The Heathrow gateway governance cycle (Figure 39) – acting as the formal process reference for project activity;

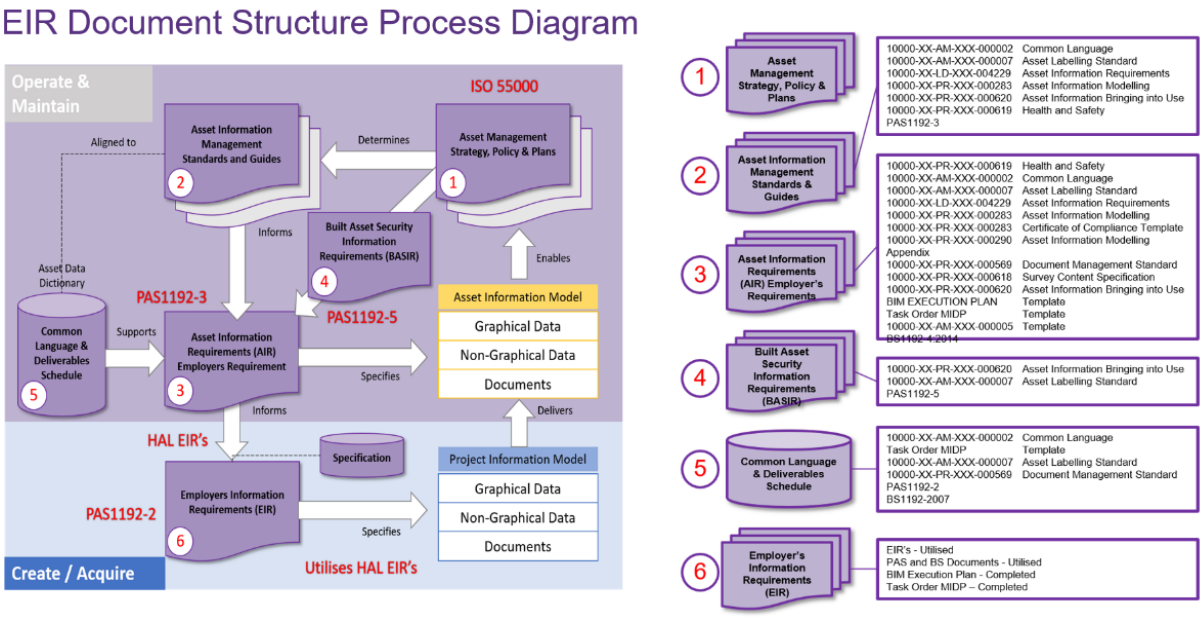
— The Heathrow CDE – acting as the common project data store;

— Alignment through Heathrow procurement – who established the contractual requirements for IM;

— The existing Heathrow in-house Information Management team – who support IM technical activities and clarifications for the Appointing Party; and

— The extent of existing asset integration, handover and operational standards (Heathrow's EIR) – including Heathrow Common Language; a spatially aligned asset nomenclature (see Figure 42 below).

Figure 42: Heathrow Information Management related standards



Source: Heathrow standards and procedures guidance, 2021

9.2.4 Summary of use cases: Heathrow Cargo Tunnel Project

The primary use case for IM on the Cargo Tunnel Project has been within the capital delivery phase. However, at the organisation-level, Heathrow is applying IM more broadly, such as the early input of asset requirements to support capital project handover, asset operations and maintenance, stakeholder engagement and de-risking later governance gateways. The breadth of these use cases are summarised in Figure 43.

Figure 43: Summary of Heathrow's use of Information Management

Function / sub-function	Information management use case
Commercial management	The use of Heathrow CDE allows Heathrow team members to clearly visualise cost items as associated across the scheme in development. The amalgamation of costed items to delivery items also supports onward data reuse in scheme delivery.
CapEX delivery (design & construction)	Use of integrated models to achieve sign-off across Heathrow's process gateways provides efficiencies to Heathrow and the wider supply chain. Use of integrated models and integrated ways of working through process standardisation supports a reduction in error and rework through scheme development. The use of IM allows Heathrow to track the approach and application of DfMA to achieve programme requirements. Developing a common federated project model gives the ability to visualise design, perform pre-emptive clash detection of components from suppliers and target improvements in construction to enable schedule and cost reductions. The use of Heathrow CDE and common data reference supports complex internal and external stakeholder engagement through the design development phases. The use of common workflows in Heathrow CDE supports the process of issue and delivery tracking through capital phase.
OpEX Delivery	The integration of Heathrow Asset O&M requirements allows Heathrow to embed asset information requirements into project at an earlier project stage.* The use of the Heathrow CDE and the validation of federated model across gateways will reduce effort at the handover gateway for the Client teams.* The use of the Heathrow CDE and the validation of federated model across gateways will save time/effort in achieving sign-off across process gateways with asset and operations teams.
Regulatory & compliance management	The centralisation of data records in the Heathrow CDE provides a standard reference location and process to support statutory tunnel inspections of the life of the asset.* The visualisation of design through federated project models has allowed for the development of a safety conscious design and safety information in alignment with PAS1192-6 which brings in elements of EDI to support all access operations and maintenance across the asset lifecycle.*
Assurance, audit & reporting	The centralisation of project data records in the Heathrow CDE provides a record of approvals and audits across project lifecycle and Heathrow gateways. The tracking of project risks, RFI's or change within the CDE will support the process for tracking of legacy issues and delivery tracking in detail.*
Portfolio planning & resilience	The control of programme delivery information and design progression will decrease risk in achieving programme acceptance with key stakeholders and investment parties. The use of IM in the project to evidence the application of DfMA supports the concept of offsite delivery into next regulatory period. The request for suppliers to share and issue survey information in the EIR will give Heathrow the ability to manage and re-use survey data obtained through works for onward purposes.

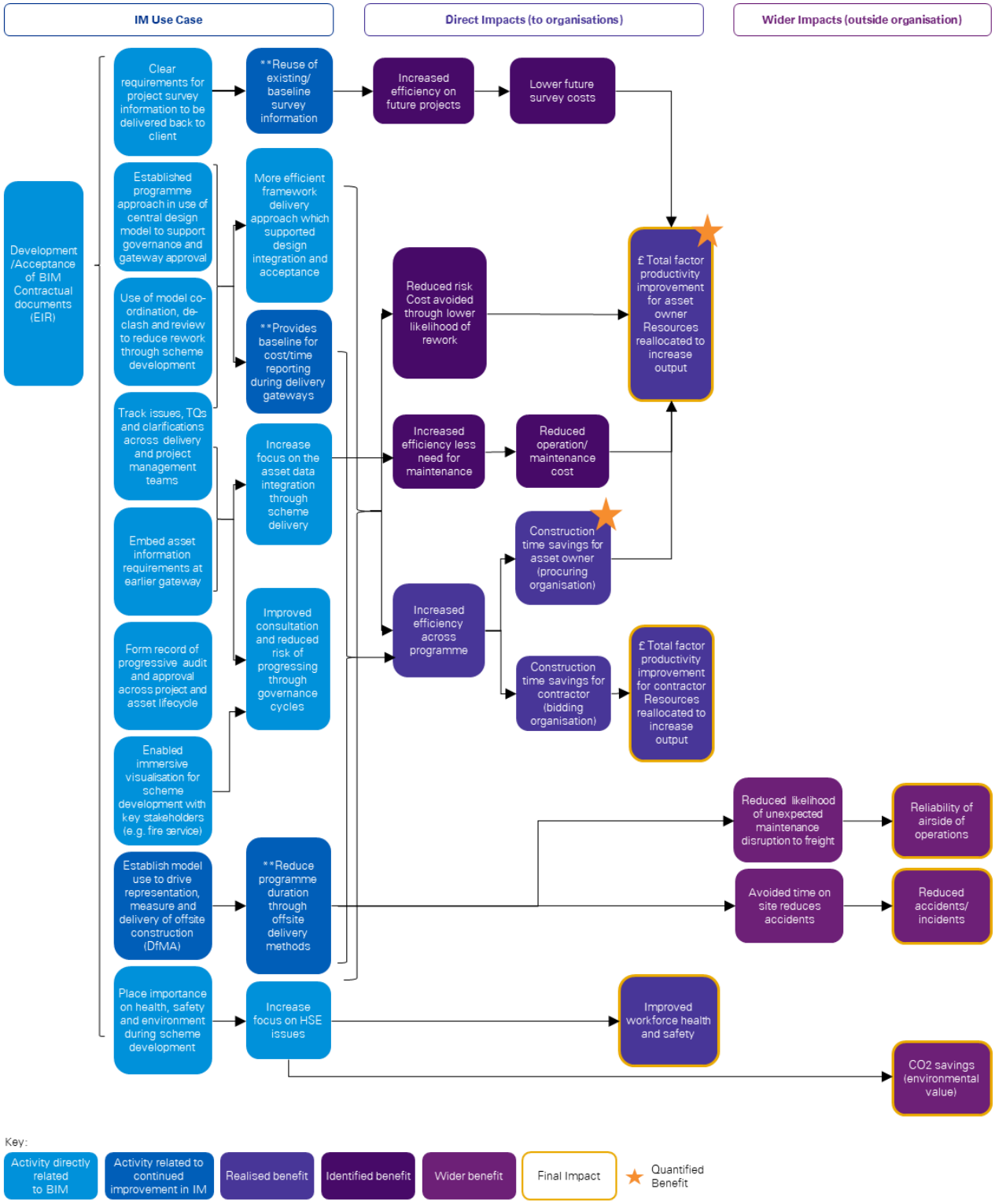
Notes: (*) Emerging use-case with some organisational elements in discovery or early implementation phase

Source: KPMG and Atkins analysis based on information and evidence supplied by Heathrow, 2021

9.3 Summary of the direct and wider benefits from Heathrow's use of Information Management

The integration of IM into the Cargo Tunnel Project is expected to unlock savings for Heathrow as an organisation and wider benefits for UK society as illustrated in Figure 44 below.

Figure 44: Summary of the benefits from Heathrow's use of Information Management on the Cargo Tunnel Project



Source: KPMG and Atkins analysis based on information and evidence supplied by the Heathrow, 2021

Overall, the use of IM is expected to enable a more efficient flow of information, improve engagement and collaboration between parties in the construction of the Cargo Tunnel, and critically, enable Heathrow's use of DfMA for the project.

Collectively, the use of IM and DfMA is expected to generate an 8% reduction in the design, construction and handover costs of the project and reduce the overall project delivery timetable by 25% (from four to three years). This has been calculated by comparing Heathrow's current estimates for the project with a previous 2018 budget and delivery schedule for the same Cargo Tunnel Project, which did not utilise the new Heathrow CDE or DfMA to the same extent. If the current budget and timetable for the Cargo Tunnel Project was compared against a traditional build that did not include any use of effective IM (rather than the 2018 budget for the Tunnel) Heathrow expects the savings estimated to be even larger. This reflects Heathrow's maturity in the use of IM, where it has been an early adopter in the industry, such as in Heathrow Terminal 5 project in 2004-08[60].

With respect to the benefits of IM specifically, the Heathrow CDE business case provides an indication of the typical savings in the Design, Construction and Handover of assets across Heathrow's current capital programme (of which the Cargo Tunnel is currently the largest of the programme). Through this business case, **Heathrow estimates that every £1 of additional cost associated with implementing the CDE across its capital delivery programme is expected to unlock cost savings of £7.40 (in present value terms, based on savings realised over a 13 year period).**[61] Heathrow is also expecting to realise further cost savings in construction from reduced errors, as well as savings in operating and maintenance costs, which would suggest the full benefits to Heathrow could be larger than the estimated £7.40 return.

The remainder of this section describes how the use of IM is expected to contribute to these cost savings for Heathrow. As the Cargo Tunnel Project is currently in the design stage, some of these IM processes or benefits are already being realised, while others are expected to arise at later stages of the project.

9.4 The direct benefits for Heathrow

9.4.1 Reduced costs in construction and operation from increased efficiency

By heavily integrating IM into the design and planning stages of the Cargo Tunnel Project, Heathrow is expecting to realise efficiencies across these stages and future stages of the project. Much of the benefits experienced are also expected to be felt by Heathrow's contractors. For instance, the procurement review process and the asset handover process described below not only saves time and costs for Heathrow, but could be somewhat mirrored on the side of the contractor.

9.4.1.1 Efficiencies in Heathrow's Gateway governance process

By integrating models and standards, Heathrow is expecting to reduce the time and effort required for assurance and sign-off across Gateway 2 onwards (Figure 39), and also improve the quality of engagement with its key stakeholders, especially across Gateways 2-6.

For example, the Project Information Model is used for high-level updates to senior stakeholders and the airline community, and also much more detailed design reviews in Heathrow's Engineering and Technical Services stage for every capital project, including the Cargo Tunnel. This review is now completed using 3D models; providing a 3D-visualisation of the scheme and more easily understood representation of the Cargo Tunnel, reducing the

[60] Whyte J, (2019), How Digital Information Transforms Project Delivery Models, link

[61] Note that the Tunnel itself has a 30-year life, and so maintenance/operational benefits for the Tunnel may be larger than for the capital programme on average

time required to review, comment and make design changes, as well as potentially allowing for a more in-depth and better-quality review overall.

Another example is the sign-off on the procurement contract between Heathrow and the design contractor, as well as various stages of the design itself. Procurement documents can be reviewed, edited and collaborated on in real time, improving the quality of the review process as well as shortening the time taken to complete it. This is expected to reduce the time required to complete such activities, and in turn improve labour productivity; freeing up staff time to work on other important tasks throughout the day.

In addition to the savings identified above, IM is currently enabling better coordination between Heathrow's capital and asset operations/maintenance divisions, giving them the ability to comment on, and influence, the design of assets before they are procured or constructed. This means that design changes can reflect asset requirements at earlier phases in the gateway process, driving whole-life cost and user-focused thinking, which could potentially save operating and maintenance costs for the tunnel in the longer term. Further, the process is not only expected to be more efficient, but also more reliable. Information can be more easily accessed, understood and documented. This means that the risk of an application rejection at any gateway (and the subsequent costs and time to rectify this) is also expected to reduce.

9.4.1.2 Efficiencies from the use of Design for Manufacture and Assembly (DfMA), enabled by the use of Information Management

Separate from the benefits directly associated with IM are the impacts that are critically enabled by it. A key driver of Heathrow's expected cost savings for the Cargo Tunnel Project is the extensive use of DfMA, allowing much of the manufacturing and prefabrication to occur offsite. These estimated cost savings are primarily driven by less time on site as well as lower costs in offsite manufacturing prefabrication (relative to onsite), and minimising the duration of the construction timetable. While DfMA is a standalone driver of efficiency in construction, the effectiveness and extent of its implementation is critically enabled by effective IM.

In the context of a complex capital project such as the Cargo Tunnel, Heathrow expects that it would only be cost-effective to deliver simpler DfMA approaches in the absence of the consistent collection and transfer of information between parties enabled by IM. For instance, the tunnel ceiling under the original design was a 'suspended ceiling design', which would have needed to be installed in-situ. The new design uses a longitudinal Duct (instead of a transversal). This unit draws on IM and design practices to be fully optimised for offsite construction and sized to suit the delivery vehicle to minimise material usage. Another example that relies heavily on IM is the project's South Plant Room fire suppression system pumps. Its development will involve an entirely new approach with the system being fabricated offsite, skid-mounted[62] and installed inside a prefabricated module complete with its electrical and building services infrastructure. It will be prepared and tested in a factory, avoiding the need for multiple trades on site, reducing both programme time and costs.

[62] A Skid mount is a popular method of distributing and storing machinery and usually-stationery equipment. Simply put, the machinery at point of manufacture is permanently mounted in a frame or onto rails or a metal Pallet. The equipment can then be easily and securely transported and used as a unit. A unit such as a fire-fighting Skid unit may also be temporarily placed onto a vehicle to equip it for a task.

9.4.2 Cost savings from reduced reworks and in turn reduced construction risk

In addition to the more 'certain' efficiencies outlined above, the use of IM on the Cargo Tunnel Project is currently enabling better coordination and sharing of information between various stakeholders. This is resulting in increased identification of 'rework risks' upfront in the design stage, and greater communication of information with the offsite manufacturer. For instance, by using the same BIM model and source of truth across the supply chain, Heathrow is spatially-coordinating multiple work packages from different suppliers and design disciplines (e.g. civil, mechanical, electrical) to avoid clashes. Doing this in the digital environment is expected to result in a reduction in errors/issues arising in the later construction stage. Heathrow deems the benefits in this area to be critical to the successful delivery of the Cargo Tunnel Project, and this is also suggested by industry analysis, which estimates the costs of errors can be between 5% (for direct costs) and 21% (when including indirect, waste and latent defects) of total project cost.[63] Technology implementation, specially IM and the introduction of BIM, is seen as a critical way of reducing these errors[64].

9.4.3 Improved workforce health and safety during construction and operations

IM is also expected to improve workforce health and safety during construction and operations through the use of 3D models to visualise construction risks and, in certain situations, replace onsite maintenance inspections with virtual inspections using mobile digital cameras with remote screens.

This is expected to lower the risk of injuries by reducing the volume of onsite inspections, as well as open up employment opportunities to colleagues with mobility impairments to perform roles they may have not been able to previously (e.g. where inspections or information gathering may have required climbing structures or reaching hard-to-access areas).

Moreover, the reduced time onsite in the construction process overall, enabled by the more extensive use of DfMA and in part by enabled by the use of IM, is also expected to reduce the risk of injury with prefabrication occurring in a safer and more controlled environment.

9.5 The wider benefits to UK society

Improving the end-quality of the Cargo Tunnel Project through the use of IM in design, construction and operations, as well as the expected reduction in construction delivery time by a year (relative to the 2018 business case) is expected to provide wider social value in three key ways:

— Improving the reliability of airside operations.

— Reducing accidents in construction and operation.

— Reducing CO2 through more informed investment decisions.

[63] Get it Right Initiative (2016), Research Report, Improving Value by Eliminating Error, pg. 56, link
[64] Get it Right Initiative (2016), Research Report: Harnessing Technology to Minimise Error, link

9.5.1 Improving the reliability of airside operations

Airlines, businesses and passengers all rely on the smooth running of Heathrow's airside operations, and any disruptions can have knock-on impacts to the goods and services they are transporting, or to their individual travel plans. The Cargo Tunnel is a critical asset for the smooth running of Heathrow's airside operations, as it provides an important link between Heathrow's Central Terminal Area and the T4/Cargo area, and facilitates the transportation of cargo and passenger baggage.

While the risk of downtime caused by unexpected tunnel maintenance issues is generally low, its impact could be significant for Heathrow's operations, and subsequently for businesses and passengers. If downtime of the Cargo Tunnel did occur, the next best alternative route for cargo transportation would add an additional 20 mins of travel time from Heathrow's Central Terminal Area to the T4/Cargo area. This could negative have knock-on impacts, particularly for passengers travelling between connecting flights (which is typical of a Hub airport) who are time sensitive and rely on baggage to be transported quickly. It could also impact airlines or businesses transporting time-sensitive and high-value cargo, such as time-critical inputs used in businesses' final products, or goods that are at greater risk of spoil if they are not transported quickly (e.g. pharmaceuticals, perishable food, etc).

The risk of one of these unexpected failures in the tunnel increases as the asset deteriorates with age, reducing significantly once it is renewed. Since the use of IM and DfMA is expected to reduce the project time by one year (compared to the 2018 budget where IM and DfMA was not employed to the same extent), this means the final 'high risk year for unexpected instances' of the Cargo Tunnel's life is avoided, and therefore is expected to improve the reliability of the tunnel one year earlier.

9.5.2 Reducing accidents in construction and operation

As already highlighted in Section 9.4.3, the use of IM is expected to reduce the number of accidents and health and safety-related incidents during construction and operation of the tunnel, as well as provide inclusivity benefits. While these impacts are valued by Heathrow as an organisation internally, they also provide value to individuals and wider society. Accidents and, worse still, fatalities, pose costs to individuals, their friends and families through lost income, pain, grief and suffering, and intrinsic loss of enjoyment of life. They also pose costs to society through additional healthcare costs, police costs, and insurance administration costs, as well as tax revenue foregone. The Government typically appraises and values the social costs and benefits of public investment in infrastructure by taking estimates of these costs into account e.g. DfT Appraisal for road schemes consider impacts on road accidents.[65]

9.5.3 Reducing CO2 through more informed investment decisions

While not currently being implemented on the Cargo Tunnel Project, Heathrow's aspiration is to use its CDE to help measure and record the embedded and operational carbon it produces in the construction and operation of its built assets. This will enable Heathrow's carbon footprint to be more accurately measured and understood, and in turn, equip the organisation to better integrate carbon reduction targets into the optioneering and design process. This is expected to help Heathrow to make investment decisions which drive down the environmental impacts of building, renewing and operating its assets. This is considered

[65] DfT (2020), TAG UNIT A4.1 Social Impact Appraisal, pg. 2, link

an important enabler for Heathrow in meeting its Net Zero mid 2030 commitments[66], which are key to its current organisational strategy, Heathrow 2.0.

[66] Heathrow (2020), TARGET NET ZERO – Heathrow's Plan for the Critical Decade Ahead, link

10 The Met Office

10.1 Context

The Met Office is the national meteorological service for the UK and since it's foundation in 1854[67], it has led on the science of meteorology and its application. Its services include a Public Weather Service (PWS), which is primarily funded by the Government Department for Business, Energy and Industrial Strategy (BEIS), alongside contributions from the Civil Aviation Authority and ad-hoc UK and European grants. The PWS provides the UK Government, emergency responders, businesses and the general public with:

— Weather forecasts to help with day-to-day decisions;

— Advance warning of extreme weather;

— Weather and climate predictions; and

— Access to historic weather information.

The purpose of the PWS is '*to help protect lives, property and infrastructure from weather impacts, and to contribute to UK economic growth through the effective use of weather information*'[68]. This underlines the importance that the Met Office places on ensuring that its weather forecasts are reliable and informed by high quality meteorological data. The process of collecting meteorological data is delivered using a diverse built estate, including over 450 weather reporting stations, 6 balloon sheds, 16 weather radar stations and 14 manned sites across the UK[69]. The estate is managed by the Met Office's Property Services Team, which reports to the organisation's Chief Financial Officer.

The Met Office's need to drive efficiencies in the cost of managing its estate has led to an increased focus on commercial decisions in recent years. To meet this requirement, the Met Office's Property Services Team has initiated a strategy to use BIM to realise efficiencies for operations, maintenance and renewal of its existing estate, building on the BIM standards used for its Exeter Data Centre project, which was completed in 2016.

10.2 The Met Office's use of Information Management on Camborne and Lerwick Balloon Shed Projects

The Met Office has two existing weather balloon sheds which are of strategic importance due to their crucial role in collecting upper air measurement data used in its weather models to produce analysis for a variety of purposes, including aviation navigation and climate change monitoring. One of these sheds is located near Lerwick in the Shetland Islands (first constructed in the 1970's and refurbished every 10 years or so) and the second is located near Camborne in rural southern Cornwall (last renewed in 2007).

Balloon launches occur a minimum of four times per day per shed. Having the sheds fully functional, and capable of operating safely and reliably in all-weather conditions is critical to

[67] Met Office (2021), Our History, link
[68] Met Office (2021), How Valuable is the Met Office?, link
[69] Skanksa (2020), Why Innovation and Trust are the Essentials of Delivering a Great Project, link

the Met Office's function of guaranteeing data for complex weather prediction models that inform the day-to-day decisions of citizens and businesses.

The two sheds are large (approximately 7.5m long x 6m wide x 7.5m high and 30 m^2 in area) and are designed to operate in a harsh environment. They also include a 360▪ rail track (which the shed is designed to rotate on) and are supplied by a gas pipeline. This makes them the only balloon sheds in the UK that have the capabilities necessary to launch the types of balloons and monitoring equipment required to collecting upper air measurement data.

Figure 45: Camborne Balloon Shed real life (physical) and digital twin

Source: Skanska, 2021

In 2019, the Met Office identified the need to renew the Lerwick facility. After initial optioneering, instead of a full redesign, the Met Office decided to use the Camborne Shed design as a basis for a renewed/new facility at Lerwick. The decision was made largely because the design had served the Met Office well over the past 30+ years.

In June 2019, the Met Office engaged Skanska in a professional services agreement to create a digital replica of the balloon shed at Camborne for onward use in the renewal of the Lerwick shed. This involved laser scanning the building, production of a BIM model in Revit and publishing it in a Revizto collaboration platform. This scan-to-BIM project was completed over an 8-week period and served the dual purpose of providing an Asset Information Model for the Camborne facility and the design prototype for a new build at Lerwick.

At the time of writing, the Met Office has engaged Capita to:

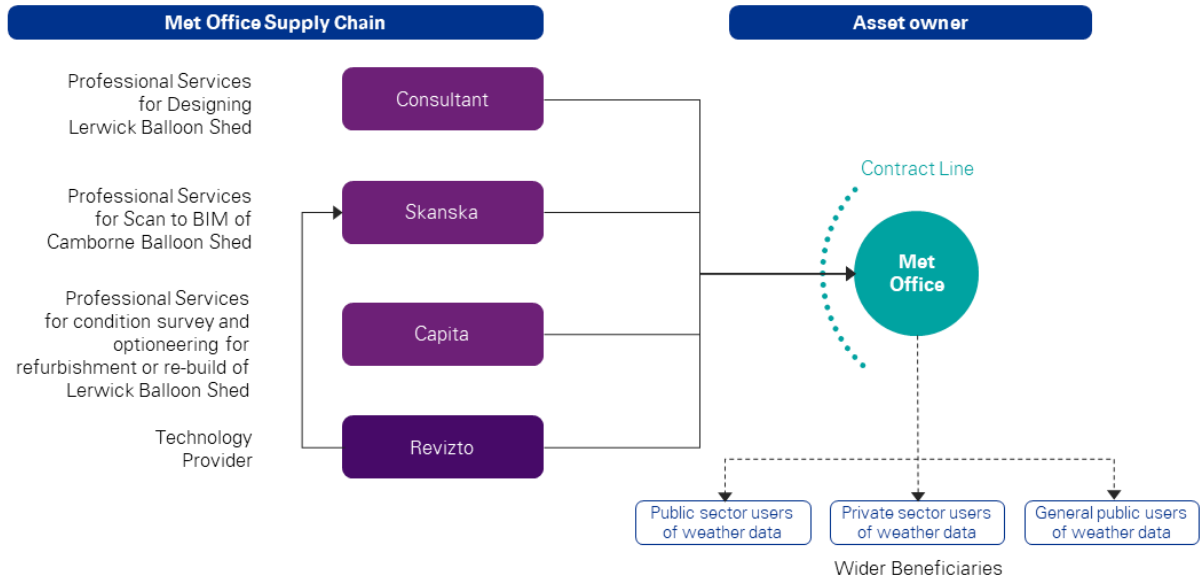
— carry out a condition survey of the existing facility at Lerwick;

— develop a programme of either refurbishments or rebuild based on their assessment of the various systems and components; and

— The outcome of this work could be either a completely new build based on the Camborne prototype or a significant refurbishment of the existing building, both requiring significant design and procurement costs. If a new build scenario is selected it is

expected to reuse elements of the current structure that meet the Met Office's durability and compliance criteria. A competitive tender process to deliver the design and procurement process for the Lerwick project is currently underway.

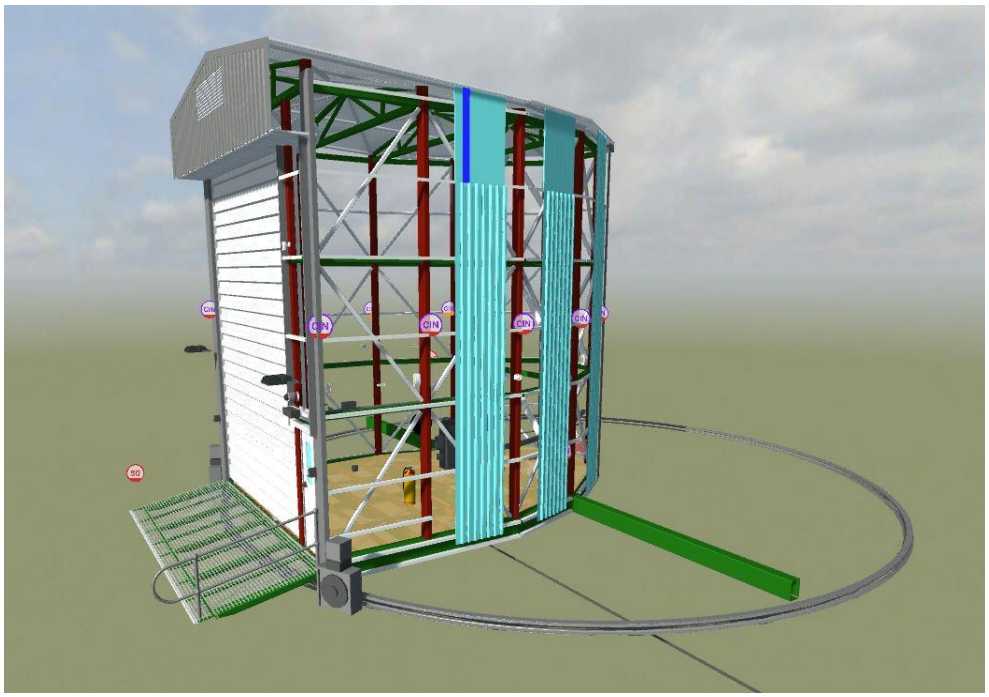
Figure 46: Stakeholder relationships for the Met Office's Lerwick Balloon Shed project



Source: KPMG and Atkins presentation of information and evidence supplied by EDAROTH, 2021

In the past, the Met Office has treated the Camborne facility as a single asset. The availability of the Asset Information Model has enabled the Met Office to adopt a PPM (planned preventative maintenance) regime at a more granular level in the asset hierarchy using SFG20, the industry standard for building maintenance specifications.

Figure 47: BIM model of Camborne Balloon Shed



Source: Skanska, 2021

Figure 48 below summarises the Met Office's use of IM across the two balloon shed projects.

Figure 48: Summary of the Met Office's established use cases for Information Management on the Camborne and Lerwick Balloon Sheds

Function / sub-function	Information management use case
CapEX delivery (design & construction)	Laser scanning the Camborne facility, production of a BIM model in Revit and publishing it in a Revizto collaboration platform.
OpEx delivery (Renewals, Operations & Maintenance)	Asset Information Model used as a basis to develop a PPM (planned preventative maintenance) regime using SFG20, the industry standard for building maintenance specifications.

Source: KPMG and Atkins analysis based on information and evidence supplied by the Met Office, 2021

Figure 49 below also highlights future use cases for IM that have been identified by the Met Office as a result of the scan-to-BIM project.

Figure 49: Summary of the Met Office's emerging use cases for Information Management as a result of the scan-to-BIM project

Function / sub-function	Information management use case
Estimating, Planning & Whole-life Costing	Monitoring and reporting of regulatory compliance (e.g. fire, electrical safety) at an individual asset level.
CapEX delivery (design & construction)	Using the BIM model as a basis for the design of future schemes
Regulatory & compliance management	Monitoring and reporting of regulatory compliance (e.g. fire, electrical safety) at an individual asset level.
Incident Management & Business Continuity	Advancing the BIM model by introducing IIoT (Industrial Internet of Things) sensors that facilitate real-time data exchange and remote operations during severe weather.

Source: KPMG and Atkins analysis based on information and evidence supplied by the Met Office, 2021

10.3 Summary of the direct and wider benefits from the Met Office's use of Information Management

The scan-to-BIM project and the resulting Asset Information Model are expected to unlock a range of benefits for the Met Office, Skanska and wider society as illustrated in Figure 50 below. This includes savings specific to the maintenance and ongoing operation of the

balloon sheds at Camborne and Lerwick, as well as potential benefits linked to the future design and construction of a replacement/renewed balloon shed at Lerwick.

Figure 50: Summary of the benefits from the Met Office's use of Information Management

Source: KPMG and Atkins analysis based on information and evidence supplied by the Met Office, 2021

10.4 The direct benefits for the Met Office and its delivery partners

The Met Office's use of scan-to-BIM and wider IM activities is expected to unlock a range of direct benefits across the lifecycle of the balloon sheds, for both the Met Office and its delivery partners. These include:

— Cost savings from increased efficiencies and resilience across both sheds;

— Improved compliance with safety, environmental and ethical/legal standards at Lerwick; and Camborne balloon sheds during operations;

— Reduced risk and improve resilience during operations;

— Improved workforce health and safety during operations; and

— Innovation and increased output for the Met Office's delivery partners.

Each of these impacts is explained below.

10.4.1 Cost savings from increased efficiency and resilience

The Met Office's is expected to unlock enhanced resilience and efficiencies across the lifecycle of the balloon sheds and in turn to a range of different cost savings (and thus productivity improvements) from use of scan-to-BIM and wider IM activities. These cost savings include:

— Whole life cost savings for both the Lerwick balloon shed (from its renewal / capital delivery through to operations and maintenance) and Camborne balloon shed (in operations and maintenance, and any future renewal activities);

— Cost savings in the design and procurement process for the Lerwick balloon shed; and

— Lerwick balloon shed construction cost savings through enabling more effective and efficient DfMA.

The remaining sections expand on each of these sources of benefit.

10.4.1.1 Whole Life Cost savings for the Lerwick and Camborne balloon sheds

The scan-to-BIM project at the Camborne balloon shed (completed in summer 2019) has provided the Met Office with more comprehensive asset information, which in turn has enabled them to better understand, and plan future investment in, operations, maintenance, repair and renewals over the life of the asset. The same savings are expected to be unlocked on the Lerwick shed once its asset information is incorporated into the Asset Information Model.

Prior to the use of BIM, the make, model and condition of many elements within the balloon shed were not held in a central database. Maintenance therefore followed a more 'reactive' regime. When elements required repair, an immediate in-person investigation (requiring time and travel to remote sites) would be needed, leading to unexpected costs in identifying and procuring new parts as well as in repairing or replacing elements. In some instances, failure of some critical elements of the balloon shed could result in alternate, less efficient ways of carrying out its function (e.g. manual balloon launches) requiring more personnel, increased manual effort and potentially an increased risk of accidents.

The Asset Information Model (within the Revizto platform) has allowed for greater and more accurate information about each element within the balloon shed including;

— The elements individual condition and useful life;

— Exactly where the element is located within the shed and what it is connected to;

— Relevant alternatives in the market for procurement and replacement;

— When it should be replaced; and

— Who it should be replaced by (the skilled engineer required).

This has resulted in the Met Office transitioning towards a more a PPM-based regime, which is seen amongst industry as a lower cost, more mature approach to maintenance[70], which is anticipated to increase the expected useful life of the asset. As with most preventative maintenance regimes, the Met Office expects this to result in increased replacement costs in the near term, but drive down costs over the life of the asset and reduce operating effort (through less instances of additional people and staff hours), as well as reduce the risk of asset downtime (covered in more detail in Section 10.4.3). It is also expected to mean that when unplanned maintenance is still required, it can be undertaken more quickly and efficiently, as the Met office will have immediate access to all of the information required.

By having the new Lerwick balloon shed in a digital scan within the Revizto platform, the Met Office is also likely to experience similar maintenance and asset life savings to those identified for the Camborne shed. For example, by having ongoing and up to date information on the make and condition of the steel beams, these and other items could be re-used in in future renewals of the balloon shed in a way that is less cost prohibitive and risky than it would be if this information was not available (which is the case today). Material re-use also has environmental benefits for wider society, due to waste and embedded CO2 considerations that come from using new materials.

Having the Lerwick digital scan is also expected to enable consistencies and synergies in maintenance and investment planning activity across the two sheds. These synergies arise if future procurement of parts and replacement scheduling can be coordinated in tandem.

10.4.1.2 Cost savings in the design and procurement process for the renewal of the Lerwick balloon shed

The balloon shed at Lerwick has been identified as requiring replacement or major renewal having reached the end of its useful life. The Camborne 'digital twin' produced through scan-to-BIM has provided the Met Office with an 'off the shelf' design (satisfying RIBA stage 2/3) that can be easily updated and adapted to the conditions and requirements at Lerwick. As a result, the Met Office is expecting to procure the design and administration of the procurement process for the renewal of the Lerwick shed at a lower cost, as well as reduce the overall timetable required to complete the design and construction of the project.

The expected cost saving as a result IM has been estimated by comparing two scenarios: the contract value of the Met Office's latest design and procurement support proposal for the Lerwick shed, which has been informed by the Camborne digital twin, against an earlier

[70] Institute of Asset Management Subject Specific Guidance Note Capital Investment, Operations and Maintenance Decision Making (v1.1) page 33

proposal which did not have this information available. Comparing these proposals, **the Met Office is expecting to achieve an estimated 18% cost saving in the design and administration of the procurement for the renewal of the Lerwick balloon shed**[71]. This saving reflects a reduction in the costs of the design and administration of the procurement process for the renewal/ construction stage (owing to the readily available digital twin of the Camborne shed) and is primarily driven by:

— The reduced need, and therefore costs incurred, for frequent travel to the Lerwick site to survey and inspect the asset and site conditions; and

— The lower level of risk contingency costs in the design stage for the Lerwick facility owing (as all identified components and their attributes are already known and defined).

10.4.1.3 Lerwick balloon shed construction cost savings through enabling more effective and efficient DfMA

The digital twin of the Camborne shed provides the Met Office with the opportunity to further drive down the costs of the immediate renewal of the Lerwick shed, as well as future renewal activity, through the role in IM in enabling the adoption of modern methods of construction (MMC) and offsite manufacturing (DfMA).

Offsite manufacturing and prefabrication are expected to play a key role in the construction process for the Met Office's Lerwick facility, regardless of the use of BIM, due to the remote nature of the site which typically makes traditional, majority onsite construction activity cost prohibitive. However, through the use of IM, the Met Office expects the DfMA process to be more efficient and cost-effective to deliver. For instance, having information stored in a digital 3D model allows for 'express press to print' individual or multiple parts of the design, making information transfer for the manufactures easier, as well as reducing risk of manufacturing errors, which could in turn avoid costly reworks and knock-on delays to onsite construction.

10.4.2 Improved compliance with safety, environmental and ethical/legal standards at Lerwick and Camborne balloon sheds during operations

Managing compliance at the Lerwick and Camborne balloons sheds are of critical importance for the Met Office, particularly in ensuring the safety of employees as well as protecting against the legal and reputational damage that might arise should an incident occur. The balloon sheds have a range of different compliance considerations, these include:

— Environmental and biodiversity considerations, such as the flood lighting used on the sheds, and its impact on local wildlife;

— Employee health and safety, such as the safety concerns specific to the gas pipelines and both helium and flammable hydrogen gas; and

— Regulations on ethical sourcing of products such as eliminating modern slavery in the supply chain, including the reporting requirements associated with these.

Meeting and remaining up-to-date with these regulations has historically been difficult for the Met Office to achieve, considering that most elements comprising the shed assets were

[71] Note that the actual construction cost is not part of this specific calculation/saving, instead this a change in the design and procurement costs only. Also note, that even though costs associated with the Camborne digital scan were already 'sunk', to be conservative 50% of these costs were included in these calculations to fairly and conservatively reflect the actual savings associated with IM.

of unknown make. The Asset Information Model will enable the Met Office to capture and monitor the compliance of its shed assets with current and future safety, environmental and ethical/legal standards. This information will enable the Met Office to consider compliance in future maintenance and renewal investment planning, and in turn potentially avoid the costs (financial and/or reputational) of non-compliance, as well as reduce the need for (and subsequent costs of) on-site surveys that have been previously required to ensure compliance is upheld .

10.4.3 Reduced risk and improve resilience during operations

The use of effective IM, particularly through the scan-to-BIM project and use of the Asset Information Model enabling an efficient planned maintenance regime, is expected to reduce risk and improve the resilience of the weather balloon shed in operations, as well drive efficiencies through reduced the need for data collection.

For instance, during COVID-19 restrictions the gas pipeline feeding the shed in Camborne failed. The existence of the digital twin and Asset Information Model meant that an initial assessment, plan and procurement of replacement materials was devised without the need for multiple and lengthy site visits. This not only saved on costs, but meant delays due to restrictions on all but essential travel were minimised, and decisions could be made remotely, promoting employee safety and wellbeing. IM was critical in this situation as even if a more traditional *physical* record keeping process was in place, the sharing and discussion of this information required to make this plan across the Met Office and its stakeholders would have been very difficult as they would not have been able to meet in person.

The resilience of the assets can also have a knock-on impact on the data collected. The Met Office's obligations under the Global Observation System (GOS), a part of the World Meteorological Organisation (WMO) as well as EUMETNET agreements, means it must launch its measurement balloons at the same time as others across the globe with a minimum of four per day per shed. The Met Office has an acknowledged global reputation as a world leader in Climate and Weather services[72]. Balloon data from these sites is relied upon in Global Weather forecast models. This requires an extremely reliable launching shed that can ensure accurate and frequent measurement of upper air measurement data to be used in complex weather prediction models. The sheds at Lerwick and Camborne are the only two in the UK large enough to accommodate the balloons that can make these types of upper air measurements.

While the current sheds are already designed with a sufficient amount of resilience and reliability in mind, in tough weather conditions and continued use there have still been on average two breakdown incidents per year. These failures can result in significant downtime of the asset. When these have occurred, the employees and maintenance contractors have had to ensure that manual launches have continued to take place and emergency maintenance is quickly addressed. However, the risk of more extreme breakdowns as the asset continues to age increases, and any prolonged downtime would affect the Met Office's ability to meet its obligations to the WMO.

Not only is breakdown less likely to occur as a result of better planned maintenance enabled by the use of IM (see Section 10.4.1.1 above), when it does occur the maintenance can be

[72] Met Office, Who are we, link, Global accuracy at a local level, link

carried out more quickly and efficiently. This results in better resilience and reliability of the supporting data that the Met Office relies on to keep the balloon shed fully operational.

10.4.4 Improved workforce health and safety during operations

With better safety compliance, and more informed maintenance investment decisions, the Met Office's use of IM is expected to improve the general health and safety of its workforce (including contractor staff).

The workforce's health and safety is an impact driven by many factors discussed in this case study, including:

— Improved compliance (Section 10.4.2 above), where the Asset Information Model is expected to enable the Met Office to capture and monitor the compliance of its shed assets against current and future safety, environmental and ethical/legal standards;

— Improved risk and resilience (Section 10.4.3 above), meaning there are expected to be lower instances of breakage and emergency repair (which sometimes must occur in risky conditions such as poor lighting or inclement weather), and a reduced need for manual operation of the balloon shed which can increase health and safety risks (see Section 10.4.1.1 for more details on manual operation); and

— The use of offsite prefabrication and construction (Section 10.4.1.3 above), which is expected to reduce the time onsite, and therefore overall risks of incidents onsite.

10.4.5 Innovation and increased output for the Met Office's delivery partners

The Camborne balloon shed project has enabled Skanska to rapidly establish a proof-of-concept for a new end-to-end 'Digital Estates' service offering, which it plans to take to other asset owners across the sector. This service builds on the idea of a scan-to-BIM and Asset Information Model developed for existing assets, and uses these techniques to collect and store consistent and accessible information, with the ambition to create a digital twin for an entire organisation's existing asset portfolio.

This new Digital Estates service line represents an innovation within Skanska; providing the opportunity to engage with new clients and develop new products and digital solutions that would not otherwise be possible in the absence of IM and digitalisation. For Skanska's clients, it is expected to unlock similar benefits to those generated for the Met Office, such as renewal and whole life cost savings, improved asset reliability and resilience and improved compliance. In addition, there are expected to be further synergies from digitising an entire asset portfolio, including: bulk purchase of parts and coordinated scheduling of maintenance; understanding asset regulatory compliance across an organisation's portfolio; and more straight forward application of updates to regulatory requirements.

10.5 The wider benefits to UK society

The Met Office's use of IM is expected to provide benefits to wider society through:

— Improved reliability of services to users of the Met Office's Public Weather Service – which spans UK Government, emergency responders, businesses and the general public; and

— Reducing CO2 emissions across the Met Office's balloon shed assets and wider estate, as well as reducing negative impacts on biodiversity and natural capital ecosystem services.

The rest of this section expands on each of these impacts in more detail.

10.5.1 Improved reliability for users of the Met Office's Public Weather Service

The upper atmospheric data collected by the Lerwick and Camborne balloon sheds is used in various UK and European Weather models, climate models and specialist upper air forecast products for aviation. Data is also gathered to measure atmospheric Ozone. Simply put, this source data is used multiple times in multiple applications across the globe.

For instance, thousands of aircraft rely on the 'trans-Atlantic jet stream' every year and require reliable and timely data from the Met Office and global counterparts to maintain their planned journey times, fuel consumption and CO2 emissions. Without such information, airlines could incur additional operational costs, passengers could experience longer journeys, and in turn this could increase CO2 emissions in the environment.

The reliability of the balloon sheds has a direct effect on the availability of data collected by the Met Office and their global counterparts, and this has a knock-on impact on the consistency and reliability of wider weather analysis. Because of their importance, the system and the sheds themselves have a sufficient level of resilience built in. It would be an incredibly rare event that would cause prolonged downtime that would be significant enough to reduce the reliability of this data (e.g. very severe weather events across the UK, or potentially serious but unconnected events across different sheds at the same time). However, given the stakeholder reliance on reliability of this information, the wider impact could potentially be significant in the event asset downtime / reduced reliability was to occur. Therefore, any improvement in the reliance and reliability in the launching shed, and the speed with which the sheds could be repaired in the case of emergency maintenance requirements, would generate positive benefits for society.

10.5.2 Reduction in CO2 and negative impacts on natural capital and biodiversity

The Met Office, as with most public sector organisations, is striving to achieve the Net Zero Carbon objectives by 2030[73]. So far it has concentrated its effort on minimising operational carbon through reduced travel and efficient energy usage. IM has a direct impact on travel through several mechanisms. With respect to the reconstruction of the Lerwick shed alone, the existing scan-to-BIM means the need to perform multiple surveys and site trips from Glasgow to the Shetland Islands by air is expected to be reduced by two thirds; equivalent to 400kg of CO2 calculated using the ICAO Carbon Emissions Calculator.

Incorporation of DfMA (enabled by IM) and the reduction of multiple site visits for construction, as well as reduced frequency of travel for ongoing maintenance (see Section 10.4.1.1) could potentially further increase the magnitude of this saving. Given this is the expected way forward for the Met Office's entire capital and renewal programme, the overall saving could be larger and ongoing across the asset portfolio. The Met Office expects

[73] Met Office (2021), Journey to Net Zero, Link

such CO2 savings to outweigh any *increased* CO2 impacts (from additional energy) of running the asset management database (however, this has not been calculated).

Further, the Met Office's ambition is to incorporate embodied carbon information into the Asset Information Model across these two balloons sheds, and in the future across its wider asset portfolio. This would transform the way the Met Office understands and measures its carbon footprint, beyond the day-to-day operational impact from energy usage and travel, incorporating the significant embodied carbon of its capital assets. This is expected to assist the Met Office in making future decisions in the design, construction and maintenance, incorporating both cost and environmental information when procuring new products, replacing or reusing items. For instance, the potential re-use of steel in its Lerwick shed (enabled by IM – see Section 10.4.1.2) is expected to save carbon, and the Met Office's decisions on the materials used in the cladding of the shed will also incorporate CO2 considerations in the final design and build.

Beyond carbon savings, the Met Office is also using IM to support other environmental considerations relating to natural capital and biodiversity impacts. Having consistent and comprehensive information readily accessible means the design and ongoing maintenance of the balloon shed assets can incorporate the Met Office's biodiversity benchmarks, for instance the type of fittings required for design, build and replacement of flood lights at balloon shed locations to reduce negative impacts on surrounding habitats.

11 Transport for Greater Manchester

11.1 Context

11.1.1 Background to Transport for Greater Manchester

Transport for Greater Manchester (TfGM) is the local transport authority with statutory responsibility for developing and delivering the transport strategy and policy priorities for the Greater Manchester (GM) city region, which is home to 2.8m people and over 90,000 businesses.

The Greater Manchester Transport Strategy 2040 - developed by TfGM on behalf of the Greater Manchester Combined Authority (GMCA) and Greater Manchester Local Enterprise Partnership (LEP) - focuses on creating an integrated, sustainable and coordinated multi-modal transport system. The Greater Manchester Transport Strategy 2040 sets out a commitment to provide a transport system which:

— Supports sustainable economic growth and the efficient and effective movement of people and goods;

— Improves the quality of life for all by being integrated, affordable and reliable;

— Protects the environment and supports GM's target to be net zero carbon by 2038 as well as improving air quality; and

— Capitalises on new technology and innovation.

Meeting the transport needs of GM's residents, visitors and businesses is considered central to this strategy, with TfGM adopting seven key principles for improving GM's transport network for its customers. These are outlined in the figure below.

Figure 51: TfGM's Customer Principles

Source: TfGM, 2021

To deliver its long-term strategy, TfGM produces a 5 Year Transport Delivery Plan which sets out a medium term programme of interventions and infrastructure projects that it will either

deliver, complete a business case for, or develop in more detail prior to progressing through the business process. In 2019, TfGM also established "Our Network", a ten-year plan to create an integrated, modern and accessible public transport system[74].

Alongside the Greater Manchester Transport Strategy 2040 and 5 Year Transport Delivery Plan TfGM has been developing its IM capabilities over a number of years. This has included:

— Production of a BIM Strategy;

— Deploying BIM to deliver the Metrolink Trafford Park Line extension (the focus of this case study) and new transport interchange facilities at Ashton, Stockport and Wigan;

— Implementing a new Asset Management Information System;

— Development of Asset Information Requirements for Facilities Management; and

— Restructuring of the asset data structures for Metrolink.

11.1.2 Background to the Manchester Metrolink network

Manchester Metrolink is a light rail system in Greater Manchester (GM), owned by TfGM and operated by KeolisAmey Metrolink (KAM). It consists of 99 stops along 65 route miles (105 km), served by 121 trams (147 by mid-2022) carrying over 45 million passengers annually (and growing) up until the start of the pandemic, making it the most extensive light rail system in the United Kingdom and second only to the Docklands Light Railway for the number of passengers it carries. Metrolink is also the most accessible form of public transport in GM (versus bus and heavy rail), providing step free access to all tram stops.

Within the city centre, it also operates at more demanding headways than National Rail and London Underground. The system represents the largest local-central government partnership local transport investment programme in the UK. Since 2008, £2 billion investment (including a £1 billion local contribution) has secured a trebling of the system, providing new extensions through key commuter and regeneration corridors, linking a series of key regional town centres to Manchester city centre and enhancing city centre capacity that helped secure major commercial development growth and anchor large scale town centre regeneration programmes.

There are eight Metrolink lines which radiate from Manchester city centre to termini at Altrincham, Ashton-under-Lyne, Bury, East Didsbury, Eccles, Manchester Airport, Rochdale and the Trafford Centre. The network has been delivered in three key phases over the last 25+ years:

— Phase 1 – opened in 1992 comprising of 31 km route (serviced by 26 stops and 26 trams) across two converted heavy rail commuter lines to Altrincham and Bury connected by an on-street tramway with a branch to Piccadilly Station. The depot, Control room and HQ were located at a single site.

— Phase 2 – The system was extended to Eccles in 2000, consisting of 6.5 km route operated by 6 additional trams across 10 stops.

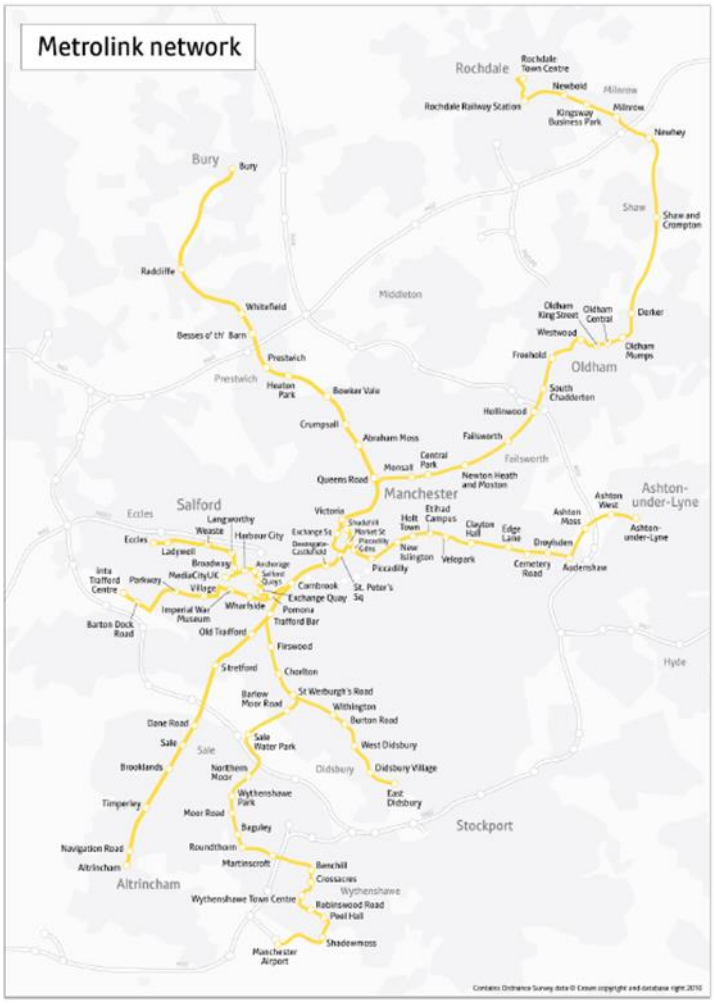
[74] TfGM (2021), Our Network, link

— Phase 3 – The system was expanded through a number of extensions delivered in stages, adding a total 57 km of route, 55 stops, 120 M5000 trams (some of which were to replace the original 32 Phase 1 and Phase 2 trams). This included:

  - Conversion of previous heavy rail lines to Oldham / Rochdale and to East Didsbury.
  - Construction of partial street running sections to Ashton-Under-Lyne and Manchester Airport;
  - Construction of a second line through Manchester City Centre (the Second City Crossing); and
  - A new purpose-built Network Management Centre (NMC) and a second, larger, depot, the Trafford Park Line (TPL) extension which opened in March 2020, and was the first Metrolink extension in which TfGM used BIM in the design and construction of the project.

Phase 3 of Metrolink was delivered via a single contract with MPact Thales (MPT) as the main contractor under a Joint Venture arrangement between Laing O'Rourke, Thales and VolkerRail.

Figure 52: TfGM's Metrolink Network



Source: TfGM, 2021

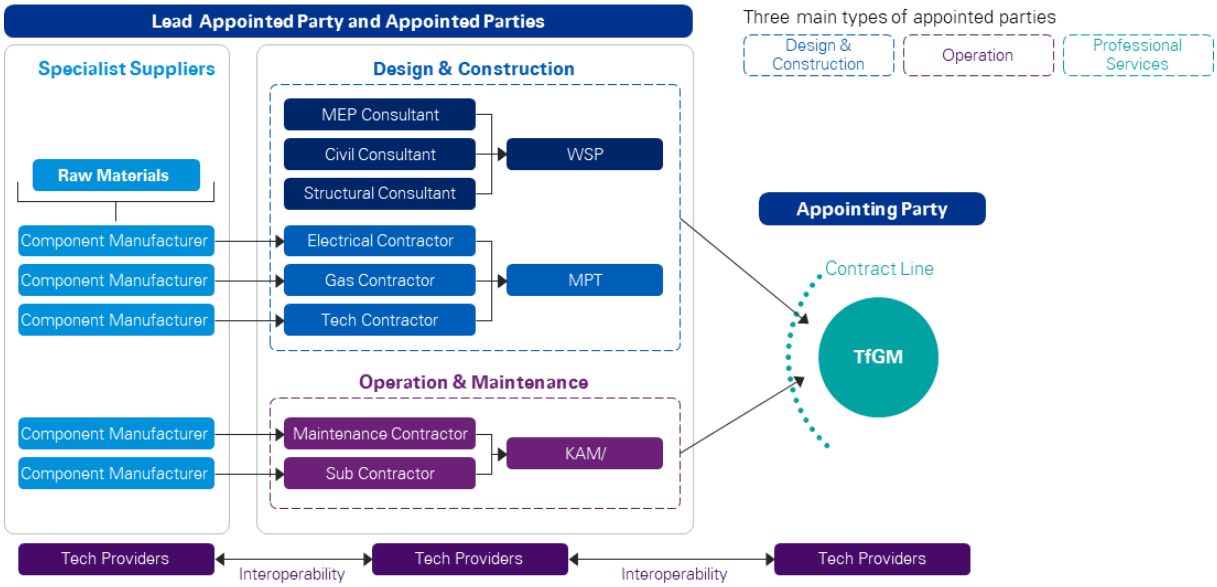
11.2 TfGM's use of Information Management on the Metrolink Trafford Park Line extension

The Metrolink TPL involved the construction of a 5.5 km extension which commenced in 2017 and completed in 2020, seven months ahead of schedule. The line connects the Trafford Centre (a major retail and leisure venue) to Manchester city centre via Trafford Park, one of the largest industrial parks in Europe.

The TPL extension cost c£350m and was funded as part of a wider £900m, 30-year "Earn Back" funding deal with central government, which built on the GM Transport Fund (which included Metrolink Phase 3 described above) which was funded through a combination of local contributions from the 10 GM district authorities and central government grant funding, and over the last decade has delivered the largest transport capital programme outside London.

The design and construction of the TPL project was delivered under TfGM's contract with MPT, building on the 10+ years of working together to deliver previous phases of the Metrolink network, and with WSP appointed as TfGM's Delivery Partner.

Figure 53: Organisations involved in the use of IM in the design and construction of the Metrolink Trafford Park Line



Notes: As demonstrated by this diagram, the 'reach' of the construction industry is broader than the international definition of construction (see Annex) in the Standard Industrial Classification (SIC) codes (2007) which only covers the non-design aspects of construction and the operation and maintenance of assets. Based on KPMG analysis, Department for Business, Innovation & Skills (2013), 'UK Construction: An Economic Analysis of the Sector', Figure 3.6, pg 27.

Source: KPMG and Atkins presentation of information and evidence supplied by TfGM, 2021

The project was the first Metrolink line that TfGM delivered using BIM. The decision to use BIM was made by TfGM in recognition of the importance of BIM for the purposes of asset management and in consideration of the need to align with the UK Government's BIM Mandate. As a pathfinder project, the TPL project provided opportunities for TfGM to build and develop the organisation's BIM capabilities. Notably, lessons from the TPL project have served as an opportunity for TfGM to enhance its approach to developing its Employer's and Asset Information Requirements, which are now being applied across TfGM's Interchange programme.

The investment in BIM on the TPL was taken up by TfGM's supply chain (MPT), building on the c10+ years of knowledge sharing and collaborative working with TfGM, combined with their experience in using BIM to deliver other schemes in the UK. Notwithstanding this, a journey of learning was required by all parties given the limited examples of using BIM to deliver a linear transport scheme in the UK at that time.

The BIM approach implemented collaboratively by TfGM, WSP and MPT on the TPL project can be summarised as follows:

- Identification of opportunities to add value through the adoption of BIM processes and technology to enhance TfGM's approach to capital delivery.
- Integration of BIM processes and technology within TfGM's capital delivery processes.
- Building and maintaining a collaborative and integrated 'one-team' ethos among TfGM, WSP and MPT throughout the entire lifecycle of the project.
- Co-developing the Exchange Information Requirements and BIM Execution Plan.
- Appointing a BIM Digital Engineer capable of overseeing and co-ordinating data-drops and model federation.
- Competency assessments supported by training to upskill staff and transfer knowledge on BIM technology and processes.
- Establishing an ecosystem of BIM technology comprising:
  - BIM authoring tools and federation software.
  - A-site deployed as the Common Data Environment with cost data and documentation aligned to the top five levels of the work breakdown structures (the hierarchy of the work to be executed by the project team).
  - Using the BIMcollab platform to fully digitise the design assurance process and enable real-time management of design issues.
  - Using the JIRA platform for tracking responses and closure of snagging issues.

Figure 54 below summarises TfGM's use of IM on the Metrolink TPL project.

Figure 54: Summary of TfGM's use of Information Management on the Metrolink Trafford Park Line project

Function / sub-function	Information management use case
CapEX delivery (design & construction)	Alignment of the work breakdown structure (WBS) and cost breakdown structure (CBS) to drive cost and programme reporting. Alignment of WBS to risk register (Predict!) for risk quantification and management. Electronic document management system folders and naming conventions linked to the WBS. Progressive design assurance database allowing real time exchanging of design comments. Design coordination with third parties and utility companies. Utility data incorporated within a federated model as an enabler for Joint Utility Trenching design, co-ordination and mitigation. 3D visualisations for design consultations with stakeholders including Disability and Cycle Reference Groups. Database for digital mark-ups and logging comments on drawings. Database for tracking responses and closure of snagging issues. Asset integration, validation and acceptance process. Phased handover of health and safety files for quality acceptance.

Source: KPMG and Atkins analysis based on information and evidence supplied by TfGM, 2021

Figure 55 below also highlights a future use case for IM identified by TfGM involving in the costing of future Metrolink schemes as part of its future investment planning activity, having reflected on the lessons from its TPL experience.

Figure 55: Summary of TfGM's emerging use case for Information Management

Function / sub-function	Information management use case
Portfolio planning & resilience*	Costing of TfGM's future schemes using unit rates extrapolated from WBS data to support early-stage prioritisation and decision-making on scheme and business case development activity.

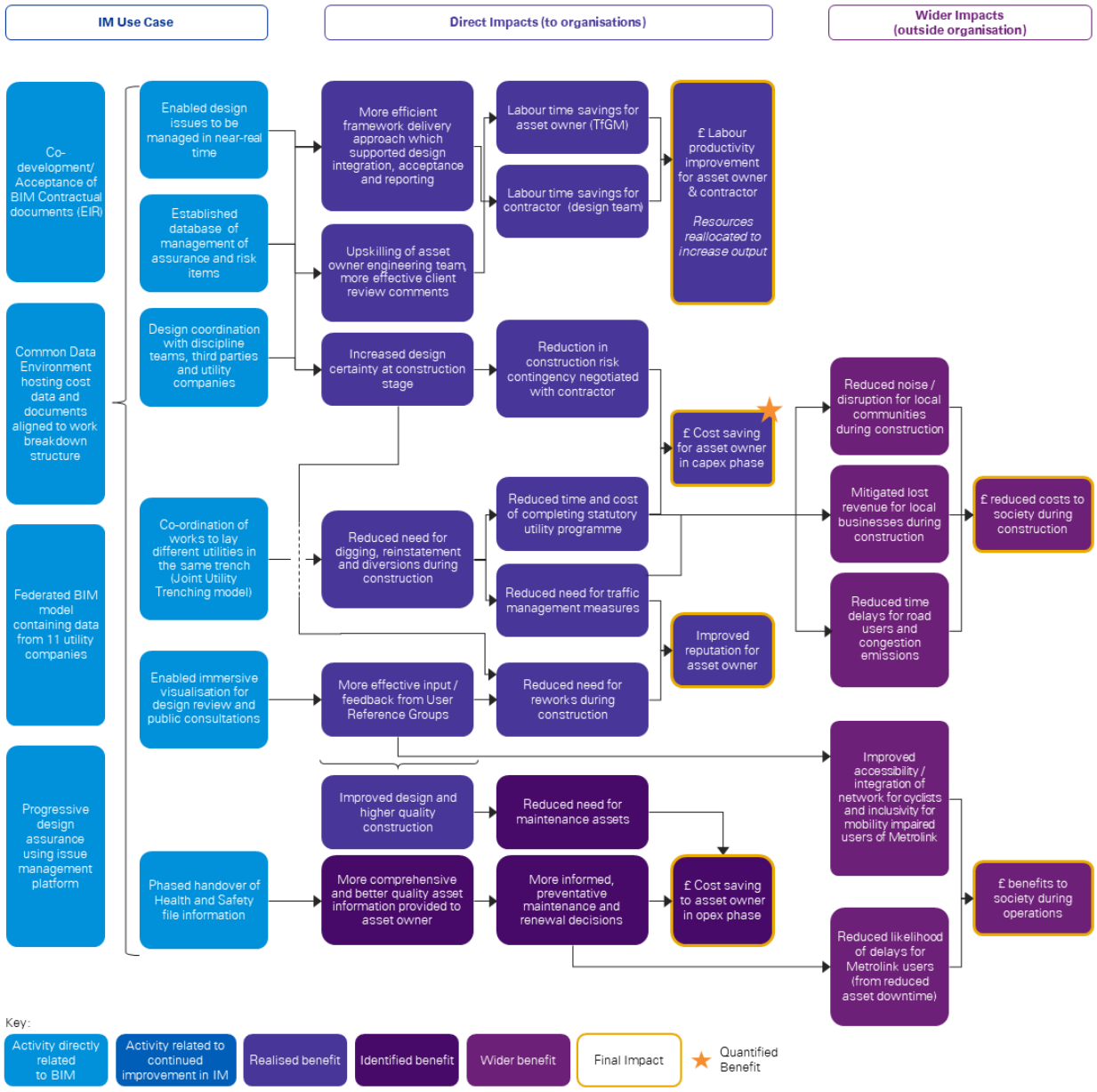
Source: KPMG and Atkins analysis based on information and evidence supplied by TfGM, 2021

11.3 Summary of the direct and wider benefits from TfGM's use of Information Management on the Metrolink Trafford Park Line

The adoption of IM as part of the TPL extension is estimated to have unlocked a broad range of direct benefits for TfGM as an organisation, as well as wider benefits for its customers and society which align with TfGM's corporate objectives and customer principles. These direct and wider benefits are summarised in Figure 56.

Some of the benefits set out in the following sections were identified by TfGM prior to this study as part of a lessons learnt exercise carried out in 2020, which was conducted as part of on-going continuous improvement of TfGM's BIM capabilities, which has included using BIM to deliver its Interchange programme (as noted above).

Figure 56: Summary of the benefits from TfGM's use of Information Management on the Metrolink Trafford Park Line project



Source: KPMG and Atkins analysis based on information and evidence supplied by TfGM, 2021

11.4 The direct benefits to TfGM and its delivery partners

The use of IM in the design and construction of the Metrolink TPL project has delivered benefits to TfGM in terms of:

— **Improved labour productivity for TfGM's engineering team** from more progressive, collaborative and less time-intensive design review periods, enabled by better co-ordination and collaborative working between TfGM's engineers, design consultants and third-party utility providers; and

— **Cost savings during the capex phase** from reductions in risk contingency costs owing to a more mature scheme design at construction stage, and more efficient utilities planning and delivery activity leading to a reduction in utility diversion costs.

It is also is expected to deliver benefits in terms of:

— **Cost savings during the opex phase** from:

  - Reduced maintenance costs for TfGM and its delivery partners pricing for TfGM and its delivery partners as a result of better construction quality enabled by better design; and
  - More informed maintenance and renewal decisions as a result of better quality and more granular asset information provided when the TPL assets was handed over.

— **An improved reputation** with TfGM's customers, as well as helping to strengthen relationships with wider stakeholders, including local businesses and residents from reduced disruption during construction and ultimately the delivery of a higher quality scheme.

Based on analysis of evidence from TfGM, it has been possible to estimate the potential cost savings to TfGM during the capex phase of TPL (as indicated in Figure 56 above). This is based on comparing the time and costs incurred on the TPL project against the time and costs incurred on comparable Metrolink extensions which have not used IM.

Through this analysis, **it is estimated that the lower level of risk contingency costs and utility diversion costs enabled by TfGM's use of IM resulted in the capital costs of the TPL project being some 1.6% lower than would have otherwise been the case (had they not used IM).**

The remainder of this section describes the range of direct benefits to TfGM in more detail.

11.4.1 Cost savings in construction

11.4.1.1 Cost savings for TfGM from reduced risk in construction

At the point at which TfGM initiated the procurement process for a build contractor, the progressive design assurance process and the use of a collaborative issue management platform (BIMcollab) provided TfGM and the contractor with greater design certainty relative to other Metrolink schemes. BIM also enabled TfGM to co-ordinate a design that was better integrated both in terms of different engineering disciplines (e.g. track, drainage, signalling) and the surrounding infrastructure (e.g. highways, utilities), avoiding the costs of reworks during construction.

This enabled TfGM to negotiate a lower level of risk allowance with the contractor; amounting to 2.9% for the TPL design and build contract, compared to an average margin of 4.8% on other schemes (a reduction of 1.9 percentage points).

This lower level of risk allowance is estimated to have resulted in the total capital cost of the TPL project being some 0.9% lower than would have been the case if TfGM had not used BIM on the project.

11.4.1.2 Cost savings for TfGM from reduced utility diversion costs

Capturing of trial hole data and as built utility company datasets into the 3D model allowed TfGM, WSP, MPT and utility companies to identify opportunities to minimise the number of utility diversions that were required during the construction of the TPL project. Combined with the implementation of a Joint Utility Trenching model which enabled effective contractual arrangements among the parties, the use of BIM contributed to a 25% reduction in the time required to complete the statutory diversion programme. It also reduced utility

diversion costs for the scheme by around 10%. **This is estimated to have resulted in the total capital cost of the TPL project being some 0.7% lower than would have been the case if TfGM had not used BIM on the project.**

11.4.1.3 Labour time savings for TfGM and its design contractors from a more efficient design process

Design reviews for previous Metrolink schemes were conducted using a lengthy feedback loop of design comments being collated, tracked and managed using spreadsheets. However, the digitisation of the design assurance process and the development of a progressive design assurance process utilising regularly updated federated models and the BIMcollab platform meant that design issues between TfGM and MPT could be addressed in near-real time. This led to fewer issues needing to be addressed at the detailed design stage and a 4 week (19%) reduction in the timetable for the design phase for the TPL scheme.

This time saving also had a positive knock-on effect of enabling TfGM's Metrolink teams to better apportion and dedicate their time to the running of the Operating and Maintenance Agreement with the operator for the existing Metrolink network.

11.4.1.4 Cost savings for TfGM from reduced need for reworks

The progressive design process and supported by the BIMcollab platform helped to ensure that potential issues and conflicting requirements in the design were identified and addressed progressively and as early as possible rather than being discovered at formal design gateways or during the construction phase. This reduced the risk and schedule and requirement for resources of any re-works during the final stages of construction.

11.4.2 Cost savings in operations

The benefits of TfGM's use on the TPL project are not limited to the capex phase. It is expected that 'downstream' benefits will be realised during the operation of the TPL. These are as result of both better asset information and better quality construction, which are explained below.

11.4.2.1 Cost savings from better asset information and preventative maintenance decisions

Historically on other Metrolink schemes, health and safety files had been handed over at the end of construction in the form of DVDs which would often contain circa 2,500 documents. In-line with the terms of the contract, TfGM would typically have 28 days to check the files for omissions or errors (e.g. gaps in drawings). Time and resource constraints meant that TfGM would typically conduct 10% spot checks on the health and safety files.

However, the phased handover of health and safety files on the TPL project, combined with the use of Common Data Environment workflows, live mark-ups of drawings and a comments database meant that TfGM's Metrolink Engineering Team were able to review the information earlier and over a longer time frame with full audit trails. This led to 100% of health and safety files subject to assurance checks.

The availability of more complete and accurate information in operations is expected to provide TfGM with a much richer understanding of what assets it has, their failure modes and their expected useful life. This is expected to result in much more informed asset

maintenance, replacement and renewal decisions – enabling more of a preventative rather than reactive approach, which in turn is expected to enable reductions in the whole life cost of the project.

11.4.2.2 Cost savings from a better quality design

Changes made during the construction phase can have significant knock-on impacts during the operational phase of an asset. The impacts may include factors such as the ease of accessing an asset for maintenance or the selection of lower specification materials with a shorter life expectancy. On this basis, it is expected that a better quality design required fewer changes being made during the construction phase of the TPL project and therefore resulted in the quality of the construction being higher compared to previous schemes. As a result, costs to operate and maintain the TPL assets are expected to be lower over the life of the project.

11.4.3 Improved reputation for TfGM

The use of 3D visualisations as part of the design process enabled TfGM to produce designs that had taken consideration of potential accessibility and integration issues, such as sight lines or kerb heights, before construction had started. The design was then enhanced further following consultations with stakeholders, including Disability Reference Groups and Cycle Reference Groups. This resulted in TfGM being able to deliver a design that more closely aligned with the needs and expectations of its customers, which translated into an improved design quality compared with previous schemes and therefore enabled TfGM to deliver against its Customer Principles.

However, the use of 3D visualisations was not limited to the design phase. They were also used during the construction phase. In this case it was to develop, consult and communicate the projects construction phasing and traffic plans to local businesses, such as the Trafford Centre, demonstrating and updating the proposed plans in alignment with stakeholders' requirements.

11.5 The wider benefits to UK society

Beyond the benefits to TfGM and its contractors, the reduced disruption during construction and higher quality design enabled by BIM on the TPL scheme is expected to generate wider benefits for Metrolink users as well as local residents and businesses along the route.

These wider benefits will make an important contribution to TfGM's 2040 Strategy objectives and Customer Principles. This wider social value includes:

— **Reduced costs to society during construction**. As outlined in Section 11.2, the use of BIM enabled TfGM/its partners to more effectively engage with stakeholders on the TPL construction timetable and secure input from major local businesses and residents on the scheduling of construction works. It also enabled TfGM to work with WSP, MPT and the utility companies to identify opportunities to minimise the number of required utility diversions. Together, this this expected to have reduced the extent of nuisance impacts and construction blight for local communities along the route, such as **reducing exposure to noise** from construction/utility works, **reducing disruption to the operations of local businesses**, and **reducing journey time delays** for local road users from fewer road diversions.

— **Benefits to society during operations:**

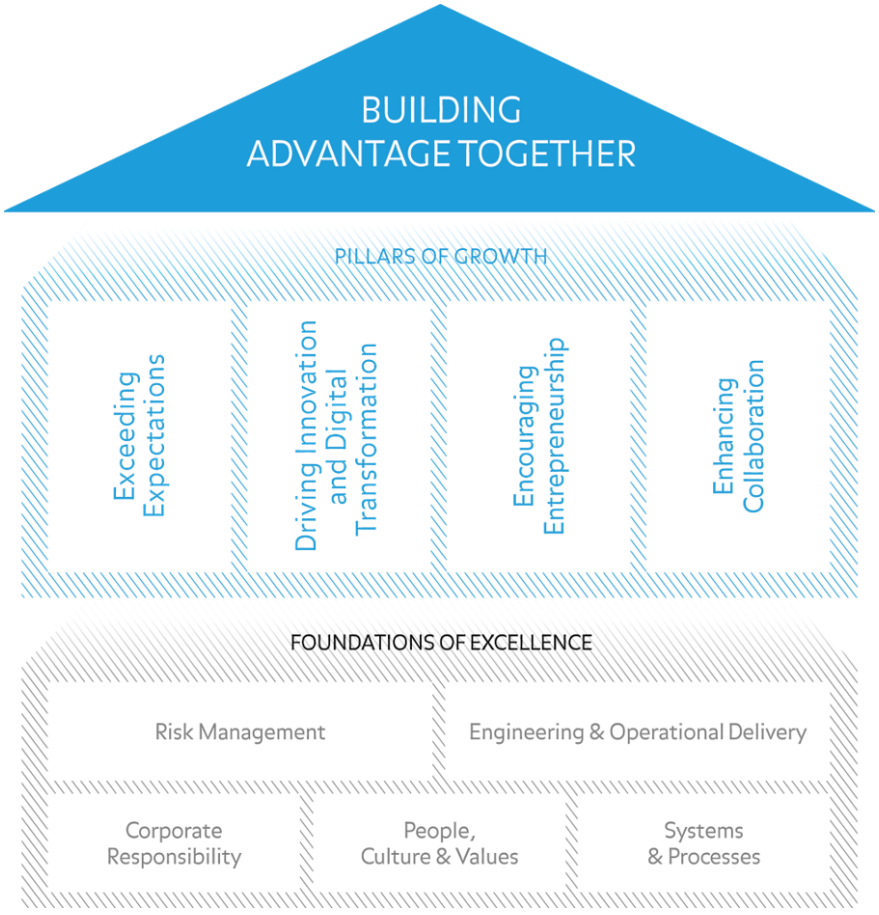
- The use of 3D visualisations facilitated more effective input from key Reference Groups – enabling previously unforeseen design issues to be addressed and leading to a **more accessible and inclusive design for mobility-impaired users** of Metrolink and **better integration with users accessing the network via active modes**. For example, through consideration of sight lines at crossing points.
- The digitisation of phased handover of health and safety files used on TPL is also expected to provide TfGM and KAM (Metrolink's operator) with more timely and better quality information for operation and maintenance of the TPL, which is expected to enable both parties to mitigate downtime and disruption on the network. **This in turn is expected to benefit Metrolink users; resulting in less disruption to their journeys and thus fewer journey time delays** (compared to a situation where BIM had not been used)**.**

12 VolkerWessels UK

12.1 Context

VolkerWessels UK is a multi-disciplinary contractor that delivers innovative solutions across the civil engineering and construction sectors, including rail, highways, airports, marine, energy, water, and environmental infrastructure. It operates through five separate but complementary business units – VolkerFitzpatrick, VolkerRail, VolkerStevin, VolkerHighways and VolkerLaser, and has a turnover of £1,180 million (2019) and circa 3,000 employees nationally. VolkerWessels UK's strategy for growth is set out in its Vantage Business Model, as set out in Figure 57 below.

Figure 57: VolkerWessels UK's Vantage Model



Source: Extract from VolkerWessels UK's Vision for the Future, 2021 – link

12.2 Background to VolkerWessels UK's digital agenda

In 2018, the group launched its 'Tomorrow Now' digital transformation strategy through a newly established group Chief Digital Officer, operating across the groups' five business units. The group has established a vision to be "*Powered by Data and Driven by People*" (see Figure 58) as part of its Tomorrow Now strategy. The strategy was enabled by C-suite sponsorship and investment in developing new, or supporting growing, digital initiatives and competencies across the group.

Tomorrow Now outlines a people-focused strategy for embedding digital technology across the group; providing an awareness, knowledge and commitment to digital transformation with the leaders of its businesses, flowing through to its delivery teams for individual projects and programmes. The strategy is supported by Digital Champions and Disruptors acting as part of a national disruption network. The network has been established across VolkerWessels UK's five business units to support colleagues in the use of technology; encouraging the open sharing of experiences and promotion of disruption which makes a positive difference.

Figure 58: VolkerWessels UK's 'Tomorrow Now' vision statement

Source: VolkerWessels UK, 2021

Over the last three years, VolkerWessels UK has been implementing its Tomorrow Now strategy through:

— Development of a group-wide vision, implementation plan and team culture around the use of digital tools to drive operational efficiency in 2019;

— Development of specific business plans and performance targets for each of the group's business units in 2020, including embedding strategic initiatives in core areas of digital competence, such as IM, through tailored training for leadership, project management and technical teams; and

— Establishing a common "Digital Toolbox" and outcome metrics for embedding digital technology on individual client projects, which are held on a central platform. The Toolbox is now in use across VolkerFitzpatrick, with a programme in place to expand to VolkerWessels UK's other business units during 2021.

Central to VolkerWessels UK's Digital Toolbox approach in capital delivery is the use of three outcomes against which the impact of digital transformation is measured and evaluated for individual client projects. These are:

— **Reduction in failure cost – measured as the £ value of costs avoided** through the use of risk management approaches which are closer to real time, and more accurate site records, which enables more automated reporting and change management. This is represented through negotiation of unforeseen change events, sub-contractor and project disputes.

— **Improved performance – measured as the £ improvement in the firm's efficiency margin**, through the use of group level technology (the Digital Toolbox) and wider point solutions, such as focused application development, which automate processes both onsite and between the site and the construction office.

— **Improved staff productivity – measured as the saving in staff time (hours)** from replacing more traditional ways of working with more digital approaches, enabled by the use of IM (such as a Common Data Environment and BIM Execution Plans), enabling employees to spend more time on more value-adding tasks.

For each outcome metric, a target is identified and agreed with project delivery teams at the early opportunity appraisal and tender phases, and then tracked and monitored through management information dashboards on a quarterly basis. This creates a 'leader board' of performance across all projects which have employed the Digital Toolbox, encouraging a culture of continuous learning and improvement across each business's delivery teams.

The VolkerFitzpatrick business has so far employed the approach on five projects across the rail, infrastructure and civils sectors, with an average capex value of £20 million, and a further twenty projects commencing during 2021 with a capex value ranging from £5 million to in excess of £100 million.

12.3 VolkerWessels UK's use of Information Management

12.3.1 The role of Information Management in capital delivery

IM has been a strategic focus for VolkerWessels UK in 2020 and 2021, with central funding and support being allocated to establish an enterprise-level Common Data Environment alongside an Information Management Academy.

IM forms a core part of the group's capability, which provides a foundation for digital adoption and targeting increased productivity on projects. At a group level, the exposure to the UK Government's BIM mandate was a catalyst for embedding IM within capital delivery. Around two thirds of all VolkerFitzpatrick's and VolkerRail's current projects, and a further two thirds of its future four-year pipeline, are subject to the mandate, compared to three years ago where none of the businesses' projects required BIM.

The wider application of IM on individual projects varies, with examples of best practice in the VolkerRail and VolkerFitzpatrick businesses, where clients' requirements through project BIM artefacts (e.g. Exchange Information Requirements) are now well established.

Figure 59: VolkerWessels UK's Digital Toolbox

VolkerWessels UK 's Digital Toolbox	
Tools	**Purpose**
— BIM and Common Data Environment	— Supporting project teams in establishing common processes and methods of integration
— Microsoft 365 Suite – including Teams and SharePoint	— Development of specific automation functions to support process improvements for site-based and office-based colleagues
— Microsoft Power Apps Platform	— Empowering citizen development where non-IT-trained employees become software developers
— LetsBuild	

VolkerWessels UK 's Digital Toolbox

- VolkerVisuals: Augmented/mixed and virtual reality experience
- 360 degree imagery/photogrammetry
- of Apps and specific automation functions to support process improvements for site-based and office-based colleagues
- Tracking near real-time site-based activities and providing clarity in relation to productivity, teamwork, decision-making and the wider site records process
- Supporting project visualisation, development, logistics and planning, as well as stakeholder engagement
- Providing site visualisations to support communications between project teams, minimise reworks and support site-to-office-based collaboration

Source: VolkerWessels UK, 2021

Through 2019/20, the group focused on developing its IM capability, establishing and growing an internal technical team and further identifying its preferred Common Data Environment. Across each of VolkerWessels UK's core business units, established heads of IM have been employed to support projects and colleagues to implement the Digital Toolbox approach. In 2019/20, the group launched the *VolkerWessels UK's Information Management Academy,* with the completion of 1,200 modules across 11 core modules by colleagues.

IM is now a core requirement for all strategic projects and is embedded within project delivery teams, rather than being provided by separate BIM and digital teams which have a removed culture from a central function.

12.3.2 The role of wider digital transformation and Information Management

The *Tomorrow Now* strategy builds upon the principles of IM in data standardisation and develops its wider use beyond capital programme delivery to enable innovation through workflow automation, digital tools and product development, which are collected within the Digital Toolbox.

At a group level, capabilities exist in immersive experience (VolkerVisuals), visualisation of construction logistics and virtual reality collaboration with the development of the in-house tool VolkerSpectator, alongside other visualisation technologies. There is a clear and strategic focus on governance and site intelligence (LetsBuild). VolkerWessels UK also has a clear vision to support and adopt tech start-ups where suitable. The application of the Digital Toolbox to individual projects is supported by the group's experienced Digital Disruption Network (described previously), which supports continued adoption, development and active application measures.

12.3.3 Summary of VolkerWessels UK's use of Information Management

The primary use case for IM is focused on improvements in capital delivery programmes across the group. The group's Digital Challenge process targets the use of IM in design and construction delivery activities, however, at the organisation-level, the adoption of IM at scale provides use cases for IM in the functions of commercial management,

assurance/audit and reporting, and portfolio planning and resilience, as outlined Figure 60 below.

Figure 60: Summary of VolkerWessels UK's use of Information Management

Function / sub-function	Information management use case
Commercial management	The use of the LetsBuild platform has allowed for the centralisation of key site records, including sub-contractors' activities and progress reporting for site activities in near real time. The use of a platform approach has provided efficiencies for site-based teams in reporting and issue of commercial invoices.
CapEX delivery (design and construction)	Leveraging standard IM artefacts and ways of working to support project team mobilisation and delivery (e.g. BEP development) with extended supply chains (global). Promoting standardisation in project protocols through the use of VolkerWessels UK's preferred CDE where possible to support major projects. Use of CDE to support design coordination and onsite use of project documents. Improvements through leveraging Microsoft suite tools to support project communications and collaboration sessions across site teams. Development and use of site-based Apps to support plant operations, piling and paving activities. Leveraging reality capture approaches to support planning, logistics and site performance measurement. Improvements in site records management and co-ordination of activity using latest technology platform - LetsBuild. More efficient resolution of claims disputes through central site records tool - LetsBuild. Use of IOT sensor technology to support concrete site pour activities and improvements in schedule.
Assurance, audit & reporting	The use of the Microsoft PowerApps platform alongside a strategy to encourage citizen development enabled bespoke applications focussed on fast and stable data structure to capture site records. This approach has led to more efficient resolution of claims disputes through central site records, detailing site disruption due to unforeseen conditions (weather), as well as tracking and management of sub-contractor activities to support claims and disputes.
Portfolio planning & resilience*	A data centric approach to portfolio performance developed across capital projects has allowed the group to leverage KPIs to support supply chain assessments for onward portfolio planning and delivery activities. Without core data performance metrics this activity was not plausible.*

Notes: (*) Emerging use-case with some organisational elements in discovery or early implementation phase

Source: KPMG and Atkins analysis based on information and evidence supplied by VolkerWessels, 2021

12.4 The direct benefits for VolkerWessels UK from the use of Information Management

Across the VolkerFitzpatrick's five projects that have employed the Digital Toolbox, the business unit is expecting to realise:

— **An estimated reduction in site staff time of around 3.7%,** with this labour productivity improvement enabling staff to better focus on delivery and strategic activities such as management of the supply chain, risk management and reducing failure costs.

— **An estimated circa 1% project margin improvement** from a combination of both an improved efficiency margin and costs avoided (very broadly split 50/50 in terms of the benefit attributable to each).

— Based on the cost to deliver and support these efficiencies (including staff time associated with selecting, and rolling out, chosen technologies to the 5 projects as well as training/upskilling costs and direct technology costs), **an estimated project-level financial return of £6.90 for every £1 of the project-specific costs incurred in applying the Digital Toolbox approach.**

VolkerWessels UK is currently scaling the approach used on these five pilot projects within its VolkerFitzpatrick business in 2021. This is commencing with the application of a business-wide digital benefits selection and monitoring system on over 20+ construction projects with a capital value ranging from £5 million to in excess of £100 million (as set out previously). Following confirmation of the value and economic returns that IM can unlock on these projects, VolkerWessels UK plans to expand this approach across the group to all major construction projects from 2022 onwards.

13 Yorkshire Water – BIM4Water: Gouthwaite Reservoir Spillway Improvement Works

13.1 Context

This short-form case study provides extracts from case study developed by Mott MacDonald Bentley (the supplier) with acceptance by Yorkshire Water (the asset owner) and issued by the BIM4Water network: see https://www.britishwater.co.uk/bim.aspx. BIM4Water is a cross-industry technical group involved in providing information across digitisation initiatives open to all organisations involved in the management and delivery of water and wastewater assets.

The information provided in this short-form case study is taken directly from the publicly available BIM4Water case study: https://www.britishwater.co.uk/media/download.aspx?MediaId=2151, rather than being based on primary research and analysis (as has been the case with all other case studies presented in this report).

13.2 Yorkshire Water's use of Information Management on the Gouthwaite Reservoir Spillway Improvements Works Project

The Gouthwaite Reservoir has the largest dammed catchment in Yorkshire at 115km2, with the greatest flows of any spillway in the region. In response to flooding in 2015, the Gouthwaite Reservoir Spillway Improvements Works aimed to re-build the water retaining spillway structure and install siphon pipework prior to the onset of winter floods in subsequent years.

The project commenced in 2016 had an agreed target cost of £8.5m and was awarded to Mott MacDonald Bentley (MMB). The project was completed in July 2018. The Project was set up to PAS1192:2 standards with a BIM Execution Plan (BEP). At the time of award, the Client - Yorkshire Water did not mandate the use of BIM, and did not provide an EIR, therefore the (BIM) strategies were developed by MMB on behalf of the client in the case of reservoir projects. A BIM Execution Plan was developed and ProjectWise was used as the CDE set up in line with company standards.

Due to nature of project and its complex geometry, various different software systems were used to create a federated model for use on site. The existing structure was re-created using a laser scan point cloud in Autodesk ReCap, and Civil 3D was used to generate longitudinal sections, setting-out points and ground surfaces for the site. Revit was used to model individual concrete pours and the mechanical pipework. The federated model was produced in Navisworks, and the project program in MS project. Without the use of BIM, it would have been very difficult to manage these processes.

To enable increases in time and cost benefits, the project team utilised an integrated process of laser scanning to produce accurate models of the dam and surroundings, tying this model into the complex hydraulic modelling for the channel using physical and

Computational Fluid Dynamics (CFD) models. The federated model was produced in Navisworks, and the project program in MS Project, the two were attached via a manual process in the software. Revit modelling changes were managed via the unique IDs of the individual parts in the software (GUIDs), which meant that the model did not require "re-attaching" to the programme each time the geometry was updated.

13.2.1 Summary of Yorkshire Water's use of Information Management

Mapping this case study to our framework, the use of IM on the Gouthwaite Reservoir Spillway Improvements Works is summarised in Figure 61.

Figure 61: Summary of Yorkshire Water's use of Information Management on the Gouthwaite Reservoir Spillway Improvements Project

Function / sub-function	Information management use case
CapEX delivery (design & construction)	The federated model produced in Navisworks was aligned to project program in MS Project, the two were attached via a manual process in the software. Early input considering buildability helped to reduce the completion date by six months, finishing on site in December and more importantly avoiding inclement weather. The project team utilised an integrated process of laser scanning to produce accurate models of the dam and surroundings, tying this model into the complex hydraulic modelling for the channel using physical and Computational Fluid Dynamics (CFD) models. The as-built model was able to provide carbon calculation for 6D sustainability take-offs. Supports process for tracking of legacy issues and delivery tracking in detail.

Source: KPMG and Atkins analysis based on information and evidence supplied by Yorkshire Water, 2021

13.3 The direct benefits for Yorkshire Water and its contractors

The resulting outcome of the IM process has been to create a very efficient channel to reduce visual impact during the construction process to dam refurbishment, improve cost, programme and size of the structure.

13.3.1 Cost savings from increased efficiency

Close collaboration between the design and construction teams is estimated by Mott MacDonald Bentley to have generated significant time and cost savings for the project.

With the use of CFD modelling, the early adoption of digital construction, PAS1192 and a Common Data Environment helped achieve savings of over £300,000 efficiency savings for the Contractor on the project. Early input from the construction team in the design phase to consider buildability helped to reduce the original construction programme by 6 months, which was anticipated as a 'best case' scenario during planning and confirmed at handover. Importantly, the early completion date also avoided inclement weather (and the associated time and cost delays to the programme). For the contractor and Yorkshire Water, this generated a £601,000 gain share, with works completed 18 months prior to the contract's compliance date.

13.3.2 Improved workforce health and safety

There were additional benefits to health and safety briefings to site operatives and visitors, engaging the supply chain with the use of the model on site where any potential hazards or areas of significance could be highlighted in the 3D model, prior to visiting the working area. During construction, the site team were able to use the model for briefings on site (over 700

persons inducted), giving a virtual view of health and safety risks as the reservoir remained operational throughout construction. In over 46,000 hours worked over two years, two minor injuries, a minor cut and a bruised eye were reported.

13.3.3 Improve carbon compliance in operations

The as-built model was further used to provide carbon calculation for 6D sustainability take-offs. Whereby materials used in the construction process could be attributed with embedded carbon to facilitate carbon measure. The measure of carbon within operational and capital schemes is becoming an increasingly important element for water market clients as they look to set their strategies in achieving NetZero targets - https://www.yorkshirewater.com/environment/climate-change-and-carbon/

A1: List of contributors

— Atkins and Faithful+Gould (SNC-Lavalin)

— Babcock

— Balfour Beatty plc

— BDP

— BIM4Water

— The Cabinet Office

— Connect Plus Services

— EDAROTH Ltd (a wholly owned subsidiary of Atkins - part of the SNC-Lavalin Group)

— Environment Agency

— Government Property Agency (GPA)

— Heathrow Airport Ltd (Heathrow)

— Her Majesty's Revenue and Customs (HMRC)

— Mott MacDonald

— The Met Office

— Skanska UK plc

— Transport for Greater Manchester (TfGM)

— UK BIM Alliance Wales

— VolkerWessels UK

— Yorkshire Water

A2: Scope of work from CDBB

Background

The implementation of BIM across the built environment has been designed to increase efficiency and reduce cost in the construction of new assets. There is increasing awareness that the principles of BIM can be applied across the entire lifecycle of an asset to increase efficiency and reduce cost across the entire lifecycle of the built environment – both existing and new. Research undertaken to date, including that commissioned by CDBB, indicates that managing information about the built environment can enable us to get more out of existing and new assets. Whilst this concept is becoming increasingly understood, the quantification of benefits from information management in the built environment is not yet well developed. The recent and ongoing Covid-19 pandemic has suggested that organisations with a higher degree of information management experience a higher level of organisational resilience, however this link has not yet been empirically demonstrated.

CDBB has engaged KPMG to undertake a further study to better understand and quantify the benefits of Information Management in the construction and infrastructure sector.

Purpose and scope of the study

The purpose of the study is to:

— Identify the broad range of potential benefits of investing in Information Management throughout the lifecycle of assets in the built environment and how that investment can potentially support economic recovery and increased economic resilience in the future, considering: (i) the benefits of BIM adoption between 2011 and 2020; and (ii) the benefits of wider Information Management practices at the organisation-level.

— Provide economic analysis of the potential scale of these benefits, where possible, to add to the existing empirical evidence on the effectiveness of BIM and Information Management in providing benefits to construction organisations and asset owners, the multiplier effects for the whole UK economy, and wider society.

— Understand to what extent the BIM mandate has contributed to the benefits that have been realised in the sector.

Deliverables

The deliverables from the study will comprise:

— A full report outlining the context for the study, the analytical approach employed and the results of the analysis;

— An Executive Summary of the full report; and

— A 1-page summary of the key messages from the report.

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