

Driving transformation, delivering value: Output from Government Discovery research

July 2020



About the Construction Innovation Hub

The Construction Innovation Hub brings together world-class expertise from the Manufacturing Technology Centre (MTC), BRE and the Centre for Digital Built Britain (CDBB) to transform the UK construction industry.

With £72 million from UK Research and Innovation's Industrial Strategy Challenge Fund, and working around the four core themes of **Value, Manufacturing, Assurance and Digital**, we are changing the way buildings and infrastructure are designed, manufactured, integrated and connected within our built environment.

We are a catalyst for change. We are driving collaboration to develop, commercialise and promote digital and manufacturing technologies for the construction sector. We are helping build smarter, greener and more efficient buildings much faster and cheaper than we currently do.

Research is helping us understand how the industry needs to change in terms of skills, product standards, capacity and innovation. This is combined with an academic programme to create the security-minded frameworks and rules that will underpin the future digital built environment and grow exports for UK know-how.

We are working closely with other initiatives as part of the Government's Transforming Construction challenge programme. Through collaboration across the sector, we can provide a better-built environment for future generations.

Further information

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Executive Summary

In 2019, the Construction Innovation Hub carried out comprehensive research to understand how strategic government intervention can boost productivity and improve performance in the UK construction sector. This research included a systematic literature review, supported by targeted interviews with a number of government departments.

In 2019, the Construction Innovation Hub carried out comprehensive research to understand how strategic government intervention can boost productivity and improve performance in the UK construction sector. This research included a systematic literature review, supported by targeted interviews with a number of government departments.

The outputs from this research helped shape the Hub's forward programme to ensure our projects, interventions and priorities could maximise impact. Our programme is now structured around four linked themes – Value, Manufacturing, Assurance and Digital. Moreover, to deliver the impacts from these four themes, we have transitioned to a co-delivery model, undertaking more of our work in partnership with industry and our key stakeholders.

Since this research was completed, the economy and our whole society have been impacted by Covid-19. The Hub's programme has responded, ensuring that our activities support not only the long term transformation of the sector, but also are able to play a key role in the recovery from Covid-19. In practice, this translates to elements of our programme being accelerated and receiving new focus to support earlier delivery of outputs and impacts that can help drive a faster and more sustainable recovery.

This report summarises the outputs from this research process, and sets out nine key recommendations for government to action in collaboration with industry, building both on the research findings and reflecting the current context. Covid-19 has not influenced the analysis, nor does it fundamentally change the recommendations. It does, however, increase the need to implement these recommendations at pace to ensure that all opportunities are taken to drive a faster recovery and the sustainable, long-term transformation the sector needs.

Nine key recommendations



Business Model & Strategy

Commissioning bodies should assess value in a different way, shifting from cost-of-construction to broader approaches based on whole-life value, performance, social impact and carbon reduction.



Labour & Capability

Government investment in up-skilling internal staff, equipping them with the skills and knowledge – both from a technical and commercial perspective - to implement digital technologies, innovative processes and advanced materials in-step with wider industrial training schemes that build industry capability.



Collaboration

Industry and government must work together to create the conditions for construction supply chains to thrive by addressing access to finance and payment practices, and improve financing opportunities for projects that support innovative approaches to construction (both on and offsite).



Process & Operations

Government should seek to plan all projects and programmes in an integrated way, across departments and tiers of government, within a sufficiently detailed pipeline that enables strategic resource management for the development and implementation of portfolio solutions.



Commissioning

Government to drive long-term objectives in productivity, sustainability and carbon reduction through intelligent commissioning behaviours, either requiring or favouring measurable performance-enhancing solutions in business cases and procurement and mirroring this behaviour across all departments and tiers of government.



Regulation, Policy & Standards

Implement smart regulations, harmonised and efficient building codes and standards that rewards innovative approaches that demonstrate measurable improvements in performance, safety and quality while anticipating emerging needs.

Nine key recommendations



Culture & Leadership

Government stakeholders to work with industry to promote the development of new, collaborative business models and to incentivise their industrial partners, driving a culture of trust and alignment.



Technology, Materials & Tools

Develop and introduce standards for a common data environment and digital framework to incentivise industry adoption of digital technologies and enable the collection, management and sharing of data throughout the value chain.



Industry Image & Outreach

Government commitment to a recognised industry accredited assurance framework and quality scheme for construction to build consumer trust and confidence, supporting measurable safe delivery and operation of the built environment.

Systematic Literature Review

To inform the development of our programme and priorities, comprehensive research was undertaken to understand both the scope of the issues facing construction today and the key role that the UK Government plays.

The overarching methodology of our research was to undertake a detailed literature review and analysis to understand the linkages between root causes and potential solutions for the construction sector. Following this, we undertook a series of structured interviews with government clients to corroborate problems and solutions, contextualised for UK infrastructure. Together these findings were put through a transformational change model to identify strategic requirements and produce a series of recommendations.

Scope

Extensive literature has been produced that analyses the problems within the construction industry. These reports are typically written from a specific stakeholder perspective, each identifying problems and proposing solutions that are aligned with their specific focus. The integration of the insights from all stakeholder opinions provides a holistic picture of the issues facing the industry. Focusing on recent publications provided a contemporary viewpoint.

Seventeen reports were selected from the volume of literature available. Together they formed the source list ([see Table 1](#)) for the Systematic Literature Review, which was the foundation for the subsequent research and analysis that informed this report.

The literature was drawn from those published after the 2013 release of Construction 2025 [1] and were narrowed down to provide a broad array of stakeholder viewpoints and objectives. As such, this research contains the potential for expansion later as change is implemented and new analysis made available.

Category	Report Title	Author	Year
Industry Analysis: Strategy Consultants	Shaping the future of construction: A breakthrough in mindset and technology [2]	World Economic Forum & Boston Consulting Group	2015
	UK construction: Consolidation ahead, counterparty risk [3]	Ernst & Young LLP	2016
	Reinventing construction: A route to higher productivity [4]	McKinsey & Company	2017
	Industry insights, construction skills network forecasts 2018-2022 [5]	CITB Research & Experian Construction Futures	2018
	International Construction Market Survey 2018 [6]	Turner & Townsend	2018
Industry Analysis: Industry Consultancies or Stakeholder	Moving to Industry 4.0: A skills revolution [7]	Steve Hughes / Mace	2017
	The Farmer review of the UK construction labour model: Modernise or die [8]	Mark Farmer / Construction Leadership Council	2016
	From transactions to enterprises: A new approach to delivering high performing infrastructure (Project 13) [9]	Infrastructure Client Group	2017
	Unlocking construction's digital future: A skills plan for industry [10]	CITB Research & Revealing Reality	2018
Government: Policy Papers	Construction 2025 [1]	UK Government	2013
	Industrial strategy: Building a Britain fit for the future [11]	Department for Business, Energy and Industrial Strategy	2017
	Government construction strategy: 2016-2020 [12]	Infrastructure and Projects Authority	2016
	National infrastructure delivery plan 2016-2021 [13]	Infrastructure and Projects Authority	2016
	Transforming infrastructure performance [14]	Infrastructure and Projects Authority	2017
	Building our industrial strategy [15]	UK Government	2017
	Best practice in benchmarking [16]	Infrastructure and Projects Authority	2019
	Transport infrastructure efficiency strategy, v1.0 [17]	Department for Transport	2017

Table 1. Systematic literature review source list

Method

An initial review of the literature proved broad agreement among industry experts on the primary problems facing construction; they are best summarised by Mark Farmer [8] (see Figure 1). There were differing perspectives, however, as to the root causes of these problems. The variety of these root causes then drove an even wider array of proposed solutions.

The focus of this research was the methodical cataloguing and clustering of these root cause/ solution pairs using the World Economic Forum report [2] as the baseline because of its broad approach and comprehensive analysis.

The recommended solutions were categorised into three primary tiers: Tier I addressed what kind of changes were being proposed; Tier II addressed at what level the changes should be implemented; Tier III sub-divided the data into nine key areas that have subsequently been used throughout this work. These are detailed in Table 2.



Figure 1 - Key problems plaguing construction, adapted from [8]

Tier	Category	Definition
I	 Strategic	Long-term actions to why, when, where and under what conditions work is carried out.
	 Operational	Changes to how work is done, focusing on short-term processes or frameworks in place.
	 Technical	Recommended changes about which tools are used.
	 Cultural	Changes to who is responsible for, does the work, communicates needs, recruits or trains the right people.
II	 Company	Action to be taken within individual companies or their supply chains.
	 Industry	Actions targeting the entire industry, from leadership councils and training boards to large corporations to SMEs.
	 Government	Actions aimed at Government both as a policy maker and funding body.
	 Client	Actions to be taken by clients, commissioning bodies, owners, project sponsors, Senior Responsible Owners (SROs), etc.
III	 Business Model & Strategy	High level business strategy, contracting models, risk and value assessments.
	 Collaboration	Commercial relationships, funding methods, best practice sharing, supply chain fragmentation and management.
	 Commissioning	Life cycle cost modelling, strategic pipeline, and cost/benefit calculations.
	 Culture & Leadership	Aligned leadership, communication, organisational structure, cultural shift and problem solving.
	 Industry Image & Outreach	Recruitment, marketing, and community engagement.
	 Labour & Capability	Aligned education and training, knowledge base, strategic resource management, and retention.
	 Process & Operations	Project planning, program management, value engineering, forecasting, lean methodology, data collection and analysis.
	 Regulation, Policy & Standards	Benchmarking, performance measures, quality schemes, technological standards, and building codes.
	 Technology, Materials & Tools	Innovative tools or materials, research and development, digitalisation, BIM and offsite construction.

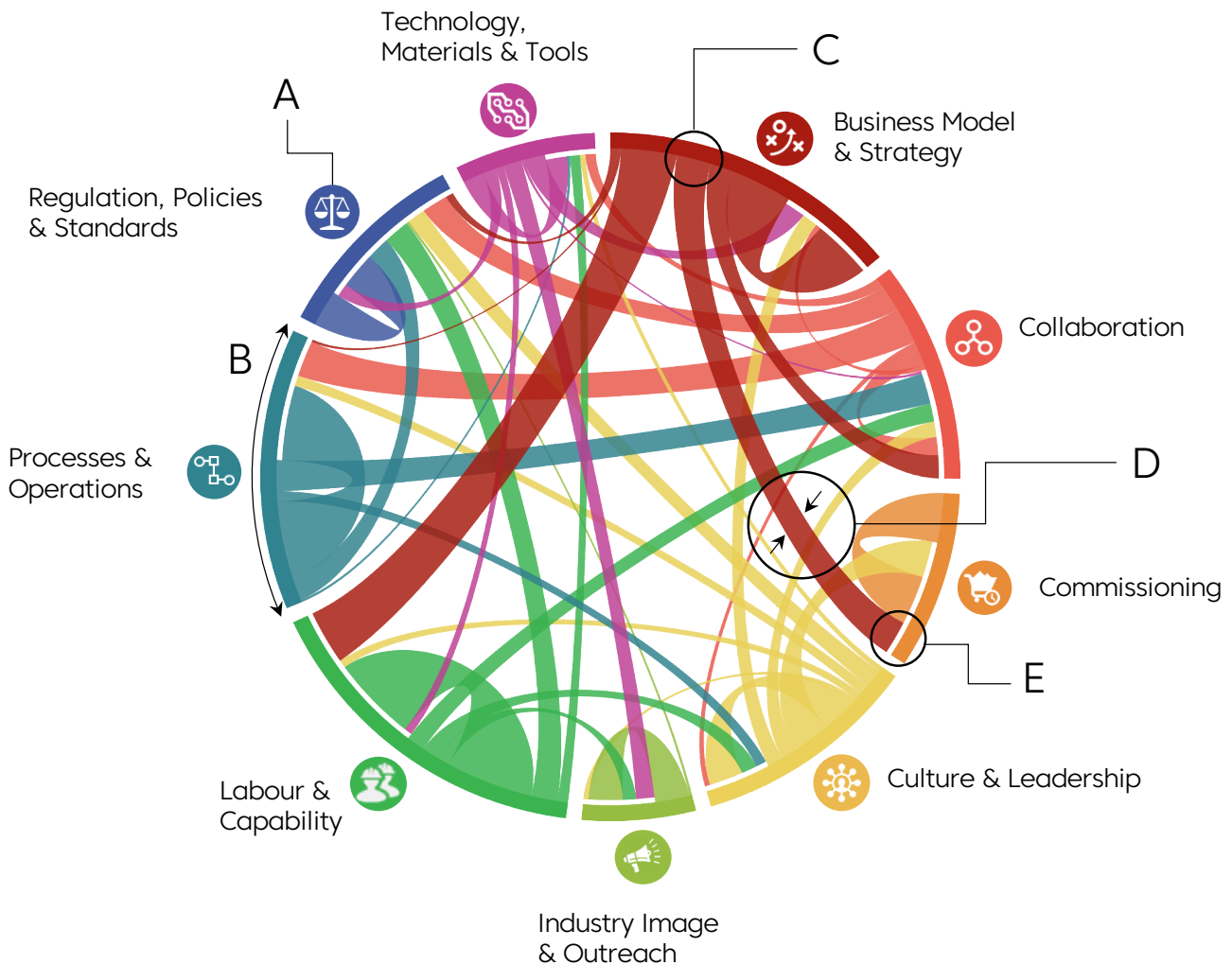
Table 2. Tier I, II and III category breakdown

Findings

The Systematic Literature Review Matrix, as shown in [Table 4 \(see in Annex\)](#), provides a visual representation of over 1,100 pages of literature released over the last three to seven years. It highlights the insights of experts from around the world as well as those within various UK government departments. It illustrates 67 root causes, (either explicitly or implicitly stated), of established problems plaguing the construction industry and aligns them with 72 solution strategies put forth by the various stakeholders in order to illustrate a portfolio of options.

The output, represented in the chord diagram shown in [Figure 2](#), provides insight into the complexity of the inter-relationships between these root causes and their solutions. Given the complexity, many categories may require measures to be taken not only within their limited scope, but also across a variety of others, to bring about the requisite change.

Figure 2. Construction industry chord diagram



How to read the Chord Diagram:

- A - The **main ring** includes nine **chords** that represent each of the nine categories common to both root causes and solutions.
- B - The **arc length** of each **chord** represents the relative contribution of root causes and solutions generated by a given category.
- C - The **ribbons** begin at (and take their colour from) their **root cause**.
- D - The **thickness** of each ribbon represents the magnitude of the correlation between the two categories in question.
- E - The **ribbons** end at (but do not touch) the category of their associated **solution**.

For example: The wide red ribbon going from the red arc of Business Model and Strategy to the green arc of Labour & Capability represents a high correlation between root causes arising from Business Model & Strategy and possible solutions relating to Labour & Capability.

Government Interviews

Scope

For the second part of the research process, the Hub conducted a series of in-person ‘discovery’ interviews with a cross-section of key government departments (and their arm’s-length bodies where appropriate). The focus of the interviews was to understand the current processes used throughout a built asset’s lifecycle (from identification of need through to disposal), in order to document commonalities and differences between departments, highlight best practice, and corroborate or refute the assertions identified in the systematic literature review.

The combined research facilitated understanding of how both government and industry can collaborate to drive transformation in the sector.

The final question set focused on ascertaining the following:

- A general layout of each department and their organisational structure
- How they manage their existing estate and their future pipelines
- How they fund new projects
- How they manage risk
- How they collect data
- How they collaborate with their supply chain
- How they plan projects and track performance
- How they maintain built assets throughout their entire lifecycle

Method

Six key government departments were selected in partnership with the Infrastructure and Projects Authority (IPA) which together are responsible for the majority of the government’s capital expenditure on construction – across both economic and social infrastructure.

Face-to-face interviews were conducted where possible, in preference to online or written surveys, because they offered the interviewer a more comprehensive understanding of the material whilst facilitating relationship building within the individual departments. Twenty-six in-person interviews were conducted and four interview responses were submitted in writing by the departments.

A series of forty-seven questions were developed to provide both context to, and potential corroboration of, the systematic literature review data. The questions primarily focused on eight of the nine Tier III categories as well as a range of sub-categories taken from that research (see Table 3).

(The category that was not as extensively covered was ‘Labour and Capability’ as it was recognised that government employees within commissioning bodies were not necessarily sufficiently expert to determine the skills available and/or needed within the construction industry).

Notes from all of the interviews were transcribed into a master database, with the responses to each question categorised on a scale from 1 (critical) to 5 (optimal). The resultant data was then reviewed and analysed for trends and used to inform the analysis and recommendations made in this report.









	Tier III Category	Tier IV Sub-Category
	Business Model & Strategy	Risk Management
		Value Assessment
	Collaboration	Conflict Resolution
		Knowledge Transfer
		Supply Chain
	Commissioning	Funding Models
		Pipeline
	Culture & Leadership	Team / Organisation
	Industry Image & Outreach	Communication
		Industry Image
	Labour & Capability	N/A
	Process & Operations	Data Collection
		Design
		Initial Project Definition
		Onsite Operations
		Project Management
		Project Monitoring
		Quality
	Regulation, Policy & Standards	Benchmarking / Cost Estimation
		Data Management
		Intellectual Property (IP)
		Performance Measures
	Technology, Materials & Tools	Digital / Building Information Modelling (BIM)

Table 3. Interview question categorisation

Findings

The literature review demonstrated trends of challenges facing construction on a global scale. The discovery interview responses provided general agreement on those challenges, whilst also providing context to UK infrastructure delivery.

The interview data demonstrated the breadth of experience and capabilities across departments and tiers of government, but with all departments recognising the need for improvements in some areas. The evidence also highlighted the potential for cross-departmental collaboration through sharing lessons learnt and best practices to support and accelerate the identified improvement areas.

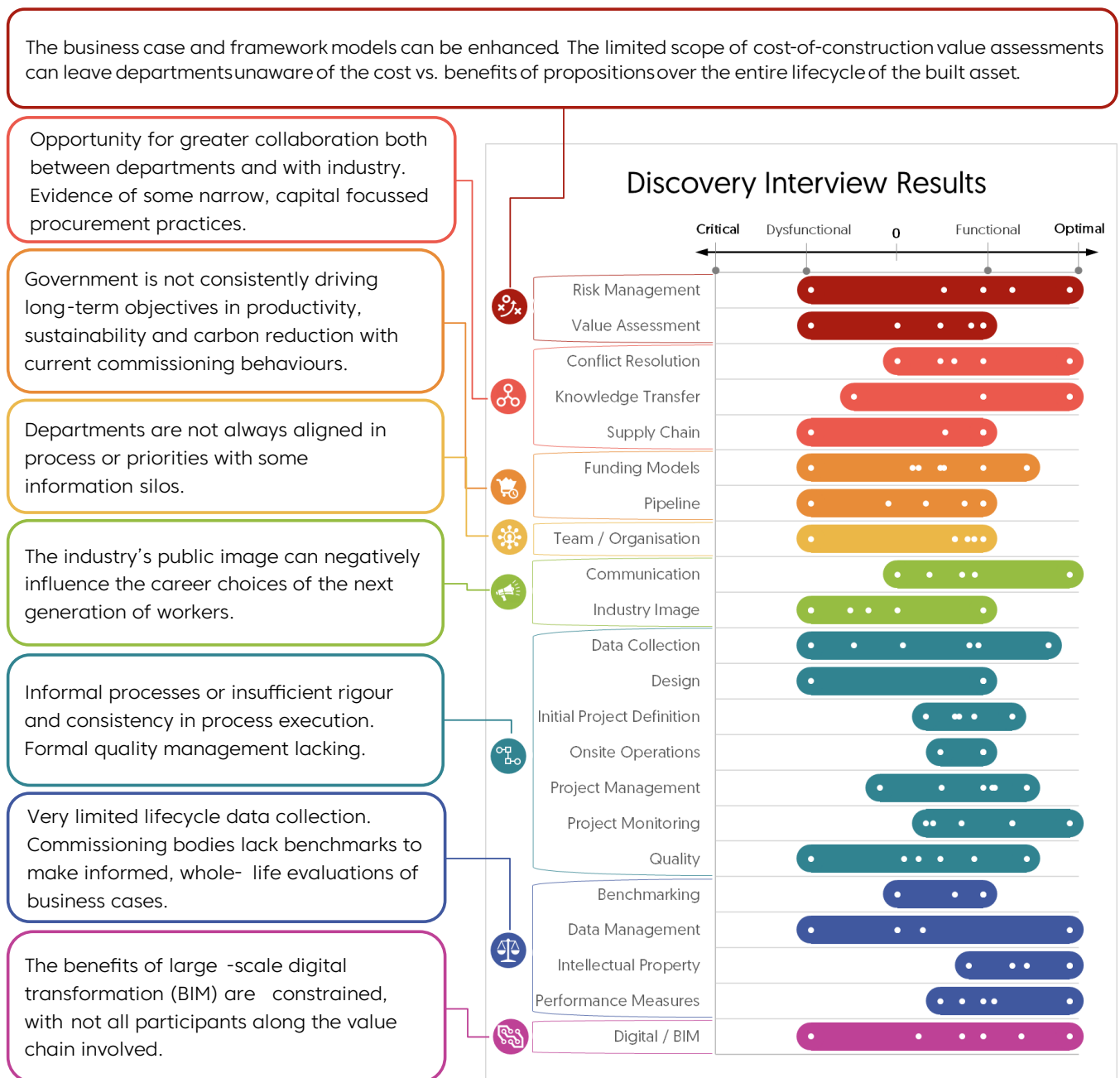


Figure 3. Government Discovery findings summary

Analysis

The data obtained from the systematic literature review highlighted a complex system of inter-related root causes to the construction industry's key problems. The Government Discovery interview process provided sufficient corroboration of these issues to merit deeper analysis of the combined research.

A transformational change model (see Figure 6 in Annex) was built upon the Systematic Literature Review data and informed by the Government Discovery interviews to organise and quantify the impact of the potential solutions put forward in the data.

The transformational change model identified opportunities for both government and industry to work together to drive sector transformation. Alongside the leadership role of government the model identifies strategic transformation themes for each of the other Tier III categories. These are summarised in Figure 4 below along with expected benefits to Government and industry, and form the basis of the specific recommendations of this report.

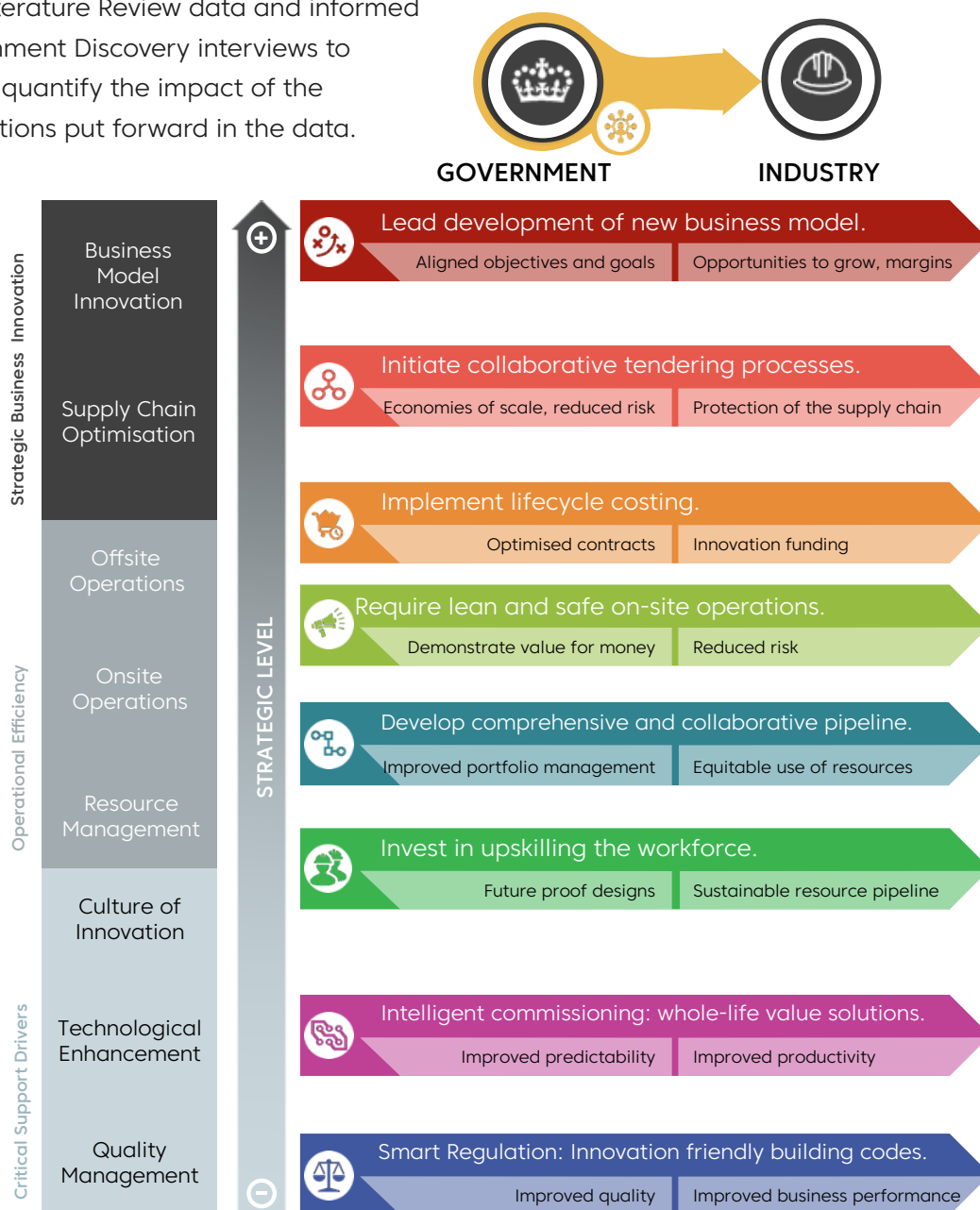


Figure 4. High-level strategic transformation themes

Recommendations



Business Model & Strategy

Commissioning bodies must assess value in a different way, shift from cost-of-construction to broader approaches based on whole-life value, performance, social impact and carbon reduction.



Collaboration

Industry and government must work together to create the conditions for construction supply chains to thrive by addressing access to finance and payment practices, and improve financing opportunities for projects that support innovative approaches to construction (both on and offsite).



Commissioning

Government to drive long-term objectives in productivity, sustainability and carbon reduction through intelligent commissioning behaviours, either requiring or favouring measurable performance-enhancing solutions in business cases and procurement and mirroring this behaviour across all departments and tiers of government.



Culture & Leadership

Government stakeholders to work with industry to promote the development of new, collaborative business models and to incentivise their industrial partners, driving a culture of trust and alignment.



Industry Image & Outreach

Government commitment to a recognised industry accredited assurance framework and quality scheme for construction to build consumer trust and confidence, supporting measurable safe delivery and operation of the built environment.

Recommendations



Labour & Capability

Government investment in upskilling internal staff, equipping them with the skills and knowledge to implement digital technologies, innovative processes and advanced materials in-step with wider industrial training schemes that build industry capability.



Process & Operations

Government to plan all projects and programmes in an integrated way, across departments and tiers of government, within a sufficiently detailed pipeline that enables industry-wide strategic resource management for the development and implementation of portfolio solutions.



Regulation, Policy & Standards

implement smart regulation, harmonised and efficient building codes and standards that rewards innovative approaches that demonstrate measurable improvements in performance, safety, and quality while anticipating emerging needs.



Technology, Materials & Tools

Introduction of construction-wide standards for a common data environment and digital framework to incentivise industry adoption of digital technologies and enable the collection, management and sharing of data throughout the value chain.

Conclusion

The ultimate finding of this research is that a web of inter-related behaviours reinforces the status quo. Breaking the cycle will require building capability in both government and industry. It will require an approach that does not focus on producing more of the same, but delivers a new blend of skills that can enable smarter commercial solutions that deliver value to users and society across the entire lifecycle of the built environment.

From the perspective of the Hub's programme, this will mean establishing a clearly articulated value framework and suite of tools that focus on reducing environmental impact, unlocking productive economic growth and improving social outcomes. It will mean developing and implementing an assurance framework that can demonstrate compliance with building regulations as well as wider safety and quality requirements, providing confidence not only to consumers and users, but also to investors and insurers to unlock finance opportunities. It will require a clear digital framework where data is used to measure performance and inform decisions, not only at the project level, but across the whole estate. Together the value, assurance, and digital frameworks will drive modern productive delivery and improved operational performance, unlocking the opportunities that can be achieved through manufacturing-led platform-based approaches.

Covid-19 has brought increasing focus on the need for transformation in the sector. Construction has a vital role to support a broader economic recovery, but itself needs a structured approach to recovery. Government has a key role to work with industry and to support and enable the sector's recovery.

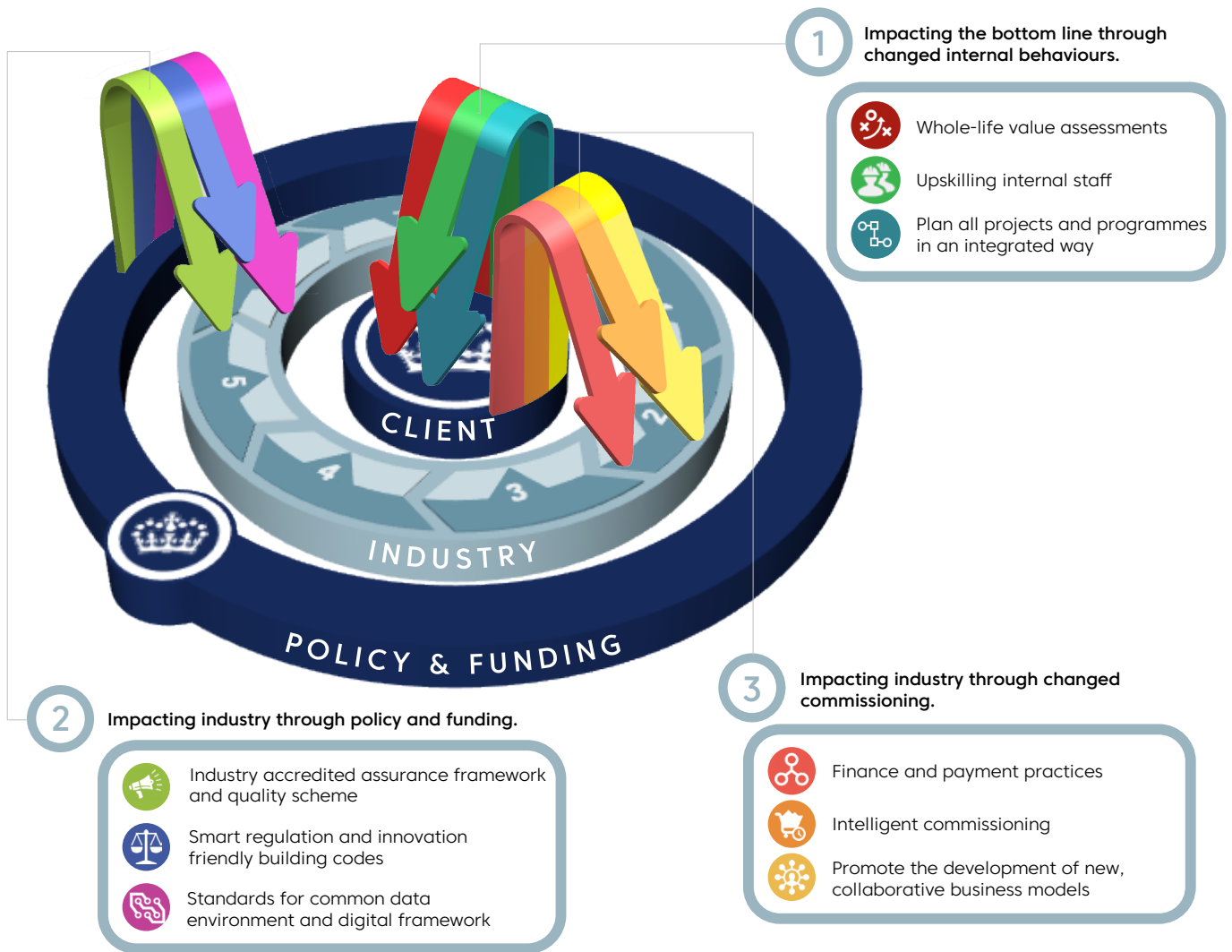


Figure 5. Routes to impact

Government is in a position to drive these changes on multiple fronts (as shown in Figure 5), acting in concert as both a client and an institution of funding and policy, by embracing the recommendations. These nine action areas are complex and inter-related in a manner similar to the root causes that the industry is facing. They are designed to work in concert, as a complete transformation portfolio, and only as a portfolio will they have the necessary force to break the existing cycle.

Government can deliver these recommendations through leveraging its position to:

- impacting the bottom line through changed internal behaviours
- impacting industry through policy and funding
- impacting industry through changed commissioning

Taken together as a whole, they will help bring about true step-change in construction. Taken together at pace, they will also help support the sector's recovery post Covid-19.

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SYSTEMATIC LITERATURE REVIEW MATRIX

ROOT CAUSES

Root Cause	Industry Analysis: Strategy Consultants				Industry Analysis: Construction Consultancies & Other Stakeholders				Government: Policy Documents								
	WEF Report	EY Report	McKinsey Report	Experian Report	Turner Report	Mace Report	Farmer Report	ICE Report	CITB Skills Plan	Construction 2025	Industrial Strategy	IPA Strategy	NIDP	TIP Report	Building Strategy	Benchmarking	DTI Strategy
Competition is fierce, margins are slim, services are commoditised, tendering exacerbates the cost pressure, and a focus on domestic markets limits growth.	X	X	X				X			X				X			
The industry's volatile project-driven business model constrains investment in the technology and digitization that would help raise productivity.	X	X	X			X		X							X		
A deep-seated cultural resistance to change driving distrust in and perception of risk with innovation and innovative technologies.	X		X				X		X				X				X
Advances in technology, materials and tools provide new opportunities to enhance the performance of existing assets and future-proof new designs, but often require a higher initial investment with benefits realised over the entire lifecycle.	X						X							X			X
Traditional short-term cost-based adversarial and transactional relationships can be a disincentive to long-term investment and encourage a focus on short-term objectives and inappropriate risk transfer.			X		X		X	X	X	X		X		X			
Disproportionate risk sharing in contracting due to supply chain fragmentation.	X		X				X	X						X			
Projects lack sophisticated tools to assess the delivery parameters for their projects.	X						X		X			X	X	X		X	X
Purchasing decisions made ad hoc, on a project to project basis, without collaboration with suppliers or clients.	X		X		X									X			
Competition is fierce, margins are slim, services are commoditised and tendering exacerbates the cost pressure. The ability of construction companies to access the right type of finance is vital for them to operate, grow, and invest in innovation.							X			X						X	
A deep-seated cultural resistance to change driving distrust in and perception of risk with innovation and innovative technologies.							X		X	X							
Competition is fierce, margins are slim, services are commoditised and tendering exacerbates the cost pressure. The ability of construction companies to access the right type of finance is vital for them to operate, grow, and invest in innovation.							X			X							
The current separation between clients, industry and government needs to be fundamentally overcome in a strategic way to change how projects are commissioned and executed such that it enables modernisation and better outcomes for all parties.							X				X						
Immature initial project definition and technical assessment provided by clients.	X		X									X					X
The benefits of large-scale digital transformation (BIM) can only be realised when all participants along the value chain are involved; without this interlinking effect, there is little benefit for the first movers.	X						X	X		X		X	X				
Lack of consensus / 'digital construction' is a catch-all term understood to mean different things by different people.									X								
Internal government fragmentation / individual departments not aligned in message, priorities or responsibility.													X	X			
Competition is fierce, margins are slim, services are commoditised and tendering exacerbates the cost pressure. The ability of construction companies to access the right type of finance is vital for them to operate, grow, and invest in innovation.										X						X	
Change will only happen through a strategic intervention that has strong leadership behind it and makes financial or wider outcome led sense for all key parties.							X			X	X	X		X	X	X	X
Lack of regulation/enforcement to address corruption.	X		X											X			
Lack of strategic incentive or implementation framework in place to drive large scale transformational change.			X							X			X				
Governments often favour their domestic industry or large enterprises when awarding contracts.	X									X	X						
Clients not actively reducing risk/ineffective risk management during contract lifecycle.		X								X							
Internal government fragmentation / individual departments not aligned in message, priorities or responsibility.							X							X			X
A dependency on public-sector demand which is highly cyclical and often lacks transparency inhibits sophisticated planning.			X							X		X	X				
Internal government fragmentation / individual departments not aligned in message, priorities or responsibility.	X									X		X	X	X	X	X	X
Competition is fierce, margins are slim, services are commoditised and tendering exacerbates the cost pressure. The ability of construction companies to access the right type of finance is vital for them to operate, grow, and invest in innovation.										X							
Use of competitive tendering is widespread with low usage of a more collaborative and integrated design, procurement and construction delivery models.							X	X	X			X					X
Government not adequately harnessing buying power as a customer to drive long term objectives in improved productivity, sustainability and carbon reduction.	X						X			X	X	X	X				X
Wide-scale change in the industry only comes when clients expressly change their needs, with 7X% of industry's work commissioned by private clients, they must be the heart of the change process.			X				X										
Industry accepted benchmarks are not available to assist commissioning bodies in making informed evaluations of business cases during tendering.								X			X	X	X	X	X	X	X

SOLUTIONS STRATEGIC

COMPANY LEVEL

Solution	Category	Sub-category	Industry Analysis: Strategy Consultants				Industry Analysis: Construction Consultancies & Other Stakeholders				Government: Policy Documents							
			WEF Report	EY Report	McKinsey Report	Experian Report	Turner Report	Mace Report	Farmer Report	ICE Report	CITB Skills Plan	Construction 2025	Industrial Strategy	IPA Strategy	NIDP	TIP Report	Building Strategy	Benchmarking
Internationalization strategy, differentiated business model and/or targeted consolidation or partnerships to increase scale.	Business Model & Strategy	Business Strategy	X	X	X					X				X				
Long term business strategy must be implemented for asset management and cost/benefit analysis to increase investment in and deployment of digital technologies and processes.		Value Assessment	X	X	X			X	X							X		
Businesses need to assess value in a different way, shift from project specific cost-of-construction value propositions to whole-life costing approaches that are ultimately more productive and innovation-friendly.	Collaboration	Logistics	X		X					X	X	X	X	X	X	X		X
The transition to new collaborative business models and better integrated supply chain management practices to better evaluate long-term investments.					X		X			X	X	X	X	X	X	X		

INDUSTRY LEVEL

Solution	Category	Sub-category	Industry Analysis: Strategy Consultants				Industry Analysis: Construction Consultancies & Other Stakeholders				Government: Policy Documents							
			WEF Report	EY Report	McKinsey Report	Experian Report	Turner Report	Mace Report	Farmer Report	ICE Report	CITB Skills Plan	Construction 2025	Industrial Strategy	IPA Strategy	NIDP	TIP Report	Building Strategy	Benchmarking
Innovative contracting models with balanced risk sharing.	Business Model & Strategy	Contracting Models	X		X				X	X					X			
More data exchange, benchmarking and best practice sharing.		Best Practice Sharing	X						X		X				X	X	X	X
Building smarter commercial relationships between clients and the supply chain to drive long-term value and a sustainable supply chain.	Collaboration	Commercial Relationships	X		X		X								X			
Industry and Government will create the conditions for construction supply chains to thrive by addressing access to finance and payment practices.		Funding Models							X			X				X		
Industry-wide strategy to disseminate the available data and insights to aid both businesses and clients in understanding the business case for embracing innovation.		Innovation / R&D							X		X	X						
Work with finance to improve high PMV property valuation and work to widen the availability and affordability of asset investment finance in those technologies.	Commissioning	Funding Models							X			X						
Integrated Leadership (Clients/Government/ Industry) focused on bringing step-change in investment in skills and technology across the industry, helping to maintain current capabilities and skills while building new capacity through new business models that embrace pre-manufactured techniques.	Culture & Leadership	Aligned Leadership							X				X					
Industry-accepted benchmarks to aid in informed evaluations of business cases and drive a clear project definition up-front.		Benchmarking	X		X									X				X
Mutual consent on industry technological standards that support digital transformation and enable data sharing along the value chain.	Regulation, Policy & Standards	Technological Standards	X							X	X	X	X	X	X			

GOVERNMENT LEVEL

Solution	Category	Sub-category	Industry Analysis: Strategy Consultants				Industry Analysis: Construction Consultancies & Other Stakeholders				Government: Policy Documents							
			WEF Report	EY Report	McKinsey Report	Experian Report	Turner Report	Mace Report	Farmer Report	ICE Report	CITB Skills Plan	Construction 2025	Industrial Strategy	IPA Strategy	NIDP	TIP Report	Building Strategy	Benchmarking
More data exchange, benchmarking and best practice sharing across the industry and government departments.	Collaboration	Best Practice Sharing													X	X		
Industry and Government will create the conditions for construction supply chains to thrive by addressing access to finance and payment practices.		Funding Models										X					X	
Government to work with Clients and Industry leadership to facilitate and incentivise investments in modernisation.	Culture & Leadership	Aligned Leadership							X			X	X	X		X	X	X
Strict implementation of transparency and anti-corruption standards.		Anti-Corruption	X		X										X			
Government legislation in an appropriate carrot and stick framework to influence clients to assist with the modernisation of the industry through reformed commissioning.	Regulation, Policy & Standards	Intelligent Commissioning			X							X	X	X				
Market openness to international firms and SMEs.		Market Diversity	X										X	X				

CLIENT LEVEL

Solution	Category	Sub-category	Industry Analysis: Strategy Consultants				Industry Analysis: Construction Consultancies & Other Stakeholders				Government: Policy Documents							
			WEF Report	EY Report	McKinsey Report	Experian Report	Turner Report	Mace Report	Farmer Report	ICE Report	CITB Skills Plan	Construction 2025	Industrial Strategy	IPA Strategy	NIDP	TIP Report	Building Strategy	Benchmarking
Assessing the long-term risk/return prospects of awarding contracts to lower quality, higher risk operators, in return for lower fees.	Business Model & Strategy	Risk Assessment		X									X					
Government to work with industry to develop a comprehensive pipeline of demand, that includes private developers and investors, to assist with long-term innovation and skills investment planning.		Pipeline			X					X			X	X				
Improve integrated government/industry long-term planning.	Commissioning											X			X	X	X	X
Actively managed and staged Government project pipelines with reliable funding and integrated planning.			X									X		X	X		X	X
Clients (and Government as client) need to assess value in a different way and drive procurement away from project specific competitive tendering to more collaborative long-term approaches.	Culture & Leadership	Lifecycle Cost vs. Cost of Construction							X	X	X			X				X
Government to engage in intelligent commissioning with innovation-friendly and lifecycle optimized procurement.			X							X		X	X	X				X
Clients to increase levels of investment in R&D and innovation in construction by changing commissioning trends from traditional to pre-manufactured approaches.	Regulation, Policy & Standards	Aligned Leadership			X													
Performance measures will strengthen business cases to help government and other sponsors select the best projects.		Performance Measures								X			X	X	X	X	X	X

Table 4.1. Systematic literature review matrix - Strategic

SYSTEMATIC LITERATURE REVIEW MATRIX

ROOT CAUSES

	WEF Report	EY Report	McKinsey Report	Experian Report	Turner Report	Mace Report	Farmer Report	ICE Report	CITB Skills Plan	Construction 2025	Industrial Strategy	IPA Strategy	NIDP	TIP Report	Building Strategy	Benchmarking	DfT Strategy
Digital innovation is often seen as competing with other strategic priorities, rather than a means to support them.									X								
Project-driven business model and industry wide lack of collaboration limits knowledge transfer project to project.	X								X	X							X
Low productivity, uncertainty, waste, and non-value-added activities throughout the entire value chain.	X		X				X			X							
Scoping and planning after tendering and not before.	X						X										
A fragmented supply chain results in a sequential process with input from stakeholders only at specific stages which militates against sophisticated collaboration.	X		X														
Inadequate design processes with limited standardisation.			X			X							X				
Project monitoring consists of little more than post hoc documenting of the cost overruns and construction delays.	X													X			
Organizations aren't taking effective steps to collect or manage data about how their sites are running leaving them blind to problems or opportunities.								X	X								
Lack of internal transparency and industry-accepted benchmarks blind leadership to how and why projects go awry.		X					X	X						X	X		
Informal processes or insufficient rigour and consistency in process execution.	X					X		X									X
Poor planning practices with undisciplined and uncollaborative approaches across the industry and tiers of government.													X	X	X	X	X
Building codes/standards are not always efficient or clear (leading to delays and cost overruns) and do not always facilitate a commitment to carbon reduction.	X		X			X	X									X	X
Poor customer-service in the domestic improvement market distorts the public image of the entire industry.										X							
To drive change and create a culture of cost-led design, capability in estimating and cost planning services needs to be a priority.													X				X
Greater consistency and a higher degree of assurance needs to be provided at the project initiation stage about how projects will be managed to cost and time, whilst securing defined outcomes.													X				X
Departments do not routinely collect or manage data about the running, maintenance or refurbishment costs associated with built-assets leaving them blind to hidden excesses over the complete lifecycle.												X	X	X			

SOLUTIONS

OPERATIONAL

COMPANY LEVEL

	WEF Report	EY Report	McKinsey Report	Experian Report	Turner Report	Mace Report	Farmer Report	ICE Report	CITB Skills Plan	Construction 2025	Industrial Strategy	IPA Strategy	NIDP	TIP Report	Building Strategy	Benchmarking	DfT Strategy
Effective data management helps build the case for digital transformation by contributing information that can be used to make a business case for investment.									X								
Knowledge management to capture, consolidate, disseminate and reuse project knowledge.	X								X	X							X
Lean and safe construction management and on-site operations.	X		X				X			X							
Front-loaded, cost-conscious, and collaborative design and project planning.	X		X				X										
Institutionalizing value engineering into the design process with a greater focus on constructability and repeatable design elements where bespoke solutions are not required.			X			X							X				
Rigorous project monitoring (scope, cost, time).	X								X	X				X			
Projects to benchmark their whole-life cost and schedule estimates during the development of business case and these metrics monitored regularly over the program.		X					X	X						X	X		

INDUSTRY LEVEL

A common and appropriate framework for project management.	Processes & Operations	Project Management	X				X	X									X
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GOVERNMENT LEVEL

Interventions to ensure that projects and programmes are planned in an integrated way, looking across the industry and tiers of government.	Processes & Operations	Project Management											X	X	X	X	X
Harmonised building codes/standards and an efficient permit process with a framework that allows for technological progress and anticipates emerging needs.	Regulation, Policy & Standards	Smart Regulation	X		X		X	X								X	X
Government commitment to expanding the benefits of TrustMark such that it includes a far greater proportion of the industry.	Regulation, Policy & Standards	Quality Scheme									X						

CLIENT LEVEL

Establish a common approach to estimating to improve cost confidence and assurance for client (and government as client).	Processes & Operations	Cost Estimation											X				X
Improve the way clients (and government as client) set up projects to maximise value and prevent inefficiency throughout delivery.	Processes & Operations	Initial Project Definition												X			X
A robust approach to the measurement and analysis of sustainability indicators encompassing the full lifecycle of built assets will help improve the efficiency of the public-sector estate and infrastructure.	Processes & Operations	Data Analysis										X	X	X			

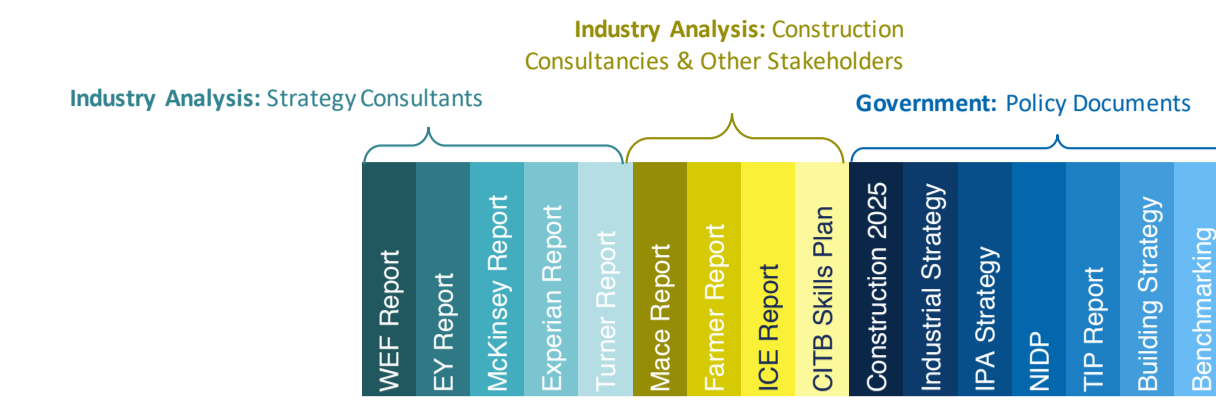


Table 4.2. Systematic literature review matrix - Operational

SYSTEMATIC LITERATURE REVIEW MATRIX

ROOT CAUSES

	WEF Report	EY Report	McKinsey Report	Experian Report	Turner Report	Mace Report	Farmer Report	ICE Report	CITB Skills Plan	Construction 2025	Industrial Strategy	IPA Strategy	NIDP	TIP Report	Building Strategy	Benchmarking	DfT Strategy
Lack of knowledge/education concerning the benefits of new products or processes.	X					X	X	X									
Inadequate design processes with limited standardisation.			X														
The organizations that are most successfully integrating technology are those that are using digital tools to solve specific problems.				X					X								
Automation works best with standardised components and processes.	X					X	X										
Investments in innovation are typically not justified financially unless adopted by the industry at scale.							X										
Lack of knowledge/education concerning the benefits of new products or processes.						X	X		X	X	X			X			
Project-driven business model and industry wide lack of collaboration limits knowledge transfer project to project.							X			X							
Lack of a whole-life costing strategy when evaluating 'smart' and lifecycle optimizing technologies.						X	X			X	X			X			
Lack of collaboration during contracting.	X							X				X	X				
Concerns about privacy and data protections and a shortage of city-related IT standards.	X																X
Improving productivity does not mean making people work harder, it means helping them to work smarter. At the heart of the required change is a need for the industry to digitally upskill its workforce.										X	X						X
Project-driven business model has difficulty monetising the value of long term investments in R&D/innovation.														X	X	X	X
Client demand for bespoke solutions which discourages the use of standardised processes and components.	X		X														
A skills gap in the available workforce and their leadership that inhibits progress (both hard and soft skills).						X											
Investments in innovation are typically not justified financially unless adopted by the industry at scale.				X				X	X	X	X						

SOLUTIONS

TECHNICAL

COMPANY LEVEL

	WEF Report	EY Report	McKinsey Report	Experian Report	Turner Report	Mace Report	Farmer Report	ICE Report	CITB Skills Plan	Construction 2025	Industrial Strategy	IPA Strategy	NIDP	TIP Report	Building Strategy	Benchmarking	DfT Strategy
Increased usage of standardised, modular and pre-manufactured components over bespoke solutions.			X			X	X	X									
Expanded implementation of (semi) automated on-site equipment and 'smart' building methods.					X				X								
Increased usage of standardised, modular and pre-manufactured components over bespoke solutions.	X					X	X										

INDUSTRY LEVEL

	WEF Report	EY Report	McKinsey Report	Experian Report	Turner Report	Mace Report	Farmer Report	ICE Report	CITB Skills Plan	Construction 2025	Industrial Strategy	IPA Strategy	NIDP	TIP Report	Building Strategy	Benchmarking	DfT Strategy
Industry facilitation of 'factory sharing' where SME businesses can coalesce and collaborate in a factory environment without fixed cost risk or by sharing that risk.								X									
Government expansion of its network of catapults and industry promotion of innovation hubs where ideas can be shared and developed.						X	X		X	X	X			X			
Creation of Industry Centres for skills and knowledge to share best practice, inspire collaboration and showcase new opportunities.							X			X							
Industry promotion of demonstrator projects that prove the benefits of 'smart' construction and leverage the increasing power of the Internet of Things (IoT), robotics, nanotechnology, and AR/VR.						X	X			X	X			X			
BIM facilitates collaboration among all stakeholders, creating a level playing field and effective dispute resolution.	X							X				X	X				

GOVERNMENT LEVEL

	WEF Report	EY Report	McKinsey Report	Experian Report	Turner Report	Mace Report	Farmer Report	ICE Report	CITB Skills Plan	Construction 2025	Industrial Strategy	IPA Strategy	NIDP	TIP Report	Building Strategy	Benchmarking	DfT Strategy
Government to provide guidance and standards to address privacy and data protection protocols.	X																X
Government investment in science, research and innovation to fuel technical adoption.	X	X				X				X	X		X	X	X		X
Large infrastructure projects with long timescales, big budgets and government clients are the most viable opportunities to experiment with digital technologies.				X				X		X	X	X					

Table 4.3. Systematic literature review matrix - Technical

SYSTEMATIC LITERATURE REVIEW MATRIX

ROOT CAUSES

	Industry Analysis: Strategy Consultants					Government: Policy Documents											
	WEF Report	EY Report	McKinsey Report	Experian Report	Turner Report	Mace Report	Farmer Report	ICE Report	CTTB Skills Plan	Construction 2025	Industrial Strategy	IPA Strategy	NIDP	TIP Report	Building Strategy	Benchmarking	DfT Strategy
A fragmented supply chain results in a sequential process with input from stakeholders only at specific stages which militates against sophisticated collaboration.	X		X				X	X				X					
Lack of internal transparency and industry-accepted benchmarks blind leadership to how and why projects go awry.	X	X						X	X								
Consultants work hourly and have few incentives to develop alternative solutions with less investment in design and construction, nor margins wide enough to support the large networks of relationships that are critical in keeping abreast of the latest ideas and innovations.			X					X				X					
The industry tends to recruit leadership from within based upon practical aptitude not leadership skill sets									X	X							
Decision makers not knowledgeable about new or innovative building materials.	X							X									
A skills gap in the available workforce and their leadership that inhibits progress (both hard and soft skills).						X											
Heavily siloed organizational structures that do not incentivise change, collaboration or knowledge sharing.	X								X								
Limited experience in the application of pre-manufacture, ABMs, and other innovative materials and processes.	X	X				X											
An aging, overly homogenous workforce that inhibits both change and more diverse recruitment.	X					X				X							
Projected labour led capacity shortages due to an aging workforce that is over-dependent on migrant labour.	X		X														X
A highly cyclical business model that does not prioritize retention (a lack of stability means that those who can find work in other industries, do).	X	X	X			X				X	X	X					
Projected labour led capacity shortages due to an aging workforce that is over-dependent on migrant labour.										X							
A highly cyclical business model that does not prioritize retention (a lack of stability means that those who can find work in other industries, do).	X					X				X	X	X					
Augmented or virtual reality (AR/VR) will have a significant impact on designers and architects in the near future.									X		X						
A dysfunctional funding model that has difficulty monetising the value of training or other long-term investments in the workforce.	X	X						X	X								
A dysfunctional funding model that has difficulty monetising the value of training or other long-term investments in the workforce.	X					X	X			X							
A skills gap in the available workforce and their leadership that inhibits progress (both hard and soft skills).		X	X	X	X			X				X					X
Projected labour led capacity shortages due to an aging workforce that is over-dependent on migrant labour.				X		X											
Knowledge of and familiarity with what digital construction could mean in practice is concentrated among specialists or siloed within companies.									X		X						
Limited experience in the application of pre-manufacture, ABMs, and other innovative materials and processes.						X											
Industry must engage constructively with the public at large and is not always equipped to do so.	X		X							X							
The industry is struggling with its public facing image that is influencing the career decisions of the next generation of workers.	X		X	X	X	X	X	X	X	X	X	X					
An aging, overly homogenous workforce that inhibits both change and more diverse recruitment.			X	X	X	X											X
Advanced data and analytics is projected to have a significant impact on the industry, but many lack a genuine understanding of what data management is.						X		X		X							
Innovation in material sciences, nanotechnology and robotics will fundamentally change how property and infrastructure is designed and built.						X					X						
Augmented or virtual reality (AR/VR) will have a significant impact on designers and architects in the near future.						X											
A deep-seated cultural resistance to change driving distrust in and perception of risk with innovation and innovative technologies.		X						X	X								
Improving productivity does not mean making people work harder, it means helping them to work smarter. At the heart of the required change is a need for the industry to digitally upskill its workforce.		X						X	X								X
Improving productivity does not mean making people work harder, it means helping them to work smarter. At the heart of the required change is a need for the industry to digitally upskill its workforce.										X	X	X	X				X
As the vulnerable occupations and their associated skills become less in demand, the opportunity to reskill employees whose jobs have been affected by innovation and technology is created.						X				X	X	X					
A skills gap in the available workforce and their leadership that inhibits progress (both hard and soft skills).												X					

* This matrix illustrates the (either explicitly or implicitly stated) root causes of established problems plaguing the industry and aligns them with solution strategies put forth by various stakeholders in order to illustrate a portfolio of options.

SOLUTIONS

CULTURAL

COMPANY LEVEL

	Industry Analysis: Strategy Consultants					Government: Policy Documents											
	WEF Report	EY Report	McKinsey Report	Experian Report	Turner Report	Mace Report	Farmer Report	ICE Report	CTTB Skills Plan	Construction 2025	Industrial Strategy	IPA Strategy	NIDP	TIP Report	Building Strategy	Benchmarking	DfT Strategy
Enhanced management of subcontractors and suppliers, regarding the entire supply chain as a business partner.			X	X			X	X				X					
Companies must implement a very strong central office function with coordinated communication.			X	X				X	X								
Leadership to drive coalitions of suppliers, forming effective teams with collaborative relationships that encourage an exchange of knowledge and capabilities to drive improvement and innovation.			X					X				X					
Leadership must be equipped with the skills and knowledge to implement digital technologies, innovative processes and advanced materials in their business.	X					X		X	X								
Drive towards a high-performance organisational structure, an iterative process which requires careful alignment of company culture and goals, organisational design and incentive schemes.	X							X									
Building an in-house knowledge base on innovative materials and processes.	X	X				X											
Smart hiring strategies and recruitment efforts targeting increased diversity.	X					X				X							
Smart hiring strategies and recruitment efforts specifically targeting young talent.	X		X														X
Strategic workforce planning: Taking a long-term view of workforce demand by simulating the future project pipeline and workforce supply, identify gaps or risks and institute interventions as appropriate.	X	X	X			X				X	X	X	X				
Companies must be able to recruit, retain and develop skilled, hard-working people in sufficient numbers to meet the increasing demand for construction.	X					X				X	X	X	X				
Companies must recognise the potential for digital tools like AR/VR to help resolve wider problems and invest in the skills staff need to support this.									X		X						
Developing the competencies (soft skills) that enable a flexible mind-set (e.g. curiosity, problem-solving, creativity, communication and emotional intelligence) creates adaptable teams that better embrace change and integrate new technologies.	X	X						X	X								
Upskilling the workforce in new developments in technology, processes, materials and tools (hard skills) to meet the industry's future needs.	X	X	X	X	X	X	X	X	X	X	X	X					X

INDUSTRY LEVEL

	Industry Analysis: Strategy Consultants					Government: Policy Documents											
	WEF Report	EY Report	McKinsey Report	Experian Report	Turner Report	Mace Report	Farmer Report	ICE Report	CTTB Skills Plan	Construction 2025	Industrial Strategy	IPA Strategy	NIDP	TIP Report	Building Strategy	Benchmarking	DfT Strategy
Support a general education of the wider stakeholder community in making high PMV approaches 'mainstream' and acceptable based on clear benefits case analysis.						X	X			X							
Joint industry self-advocacy strategy and coordinated communication to engage constructively with the public.	X		X							X							
Industry wide collaboration on recruitment efforts that educate and inspire a diverse young audience.	X		X	X	X	X	X	X	X	X	X	X	X				
Revolutionise our traditional education programmes to prioritise data management, advanced data and analytics.						X		X		X		X					
Revolutionise construction-focused education programmes to better align with industry future needs, with expanded focus including material sciences, nanotechnology and robotics						X						X					
The industry should accelerate the use of AR/VR in the training of new skills.						X											
Address the structural and cultural barriers to wider technology adoption by embedding the softer skills and competencies needed to underpin that technology in their training programs.			X					X	X								
Digital competence requirements across the industry must be standardised and embedded in qualifications, training and employer HR planning.		X						X	X								X

GOVERNMENT LEVEL

	Industry Analysis: Strategy Consultants					Government: Policy Documents											
	WEF Report	EY Report	McKinsey Report	Experian Report	Turner Report	Mace Report	Farmer Report	ICE Report	CTTB Skills Plan	Construction 2025	Industrial Strategy	IPA Strategy	NIDP	TIP Report	Building Strategy	Benchmarking	DfT Strategy
Government intervention to facilitate and fund both an expansion of both traditional and technical education programmes and a reskilling of the existing workforce to meet industry's future needs.						X				X	X	X	X				X

Table 4.4. Systematic literature review matrix - Cultural

Transformational change model

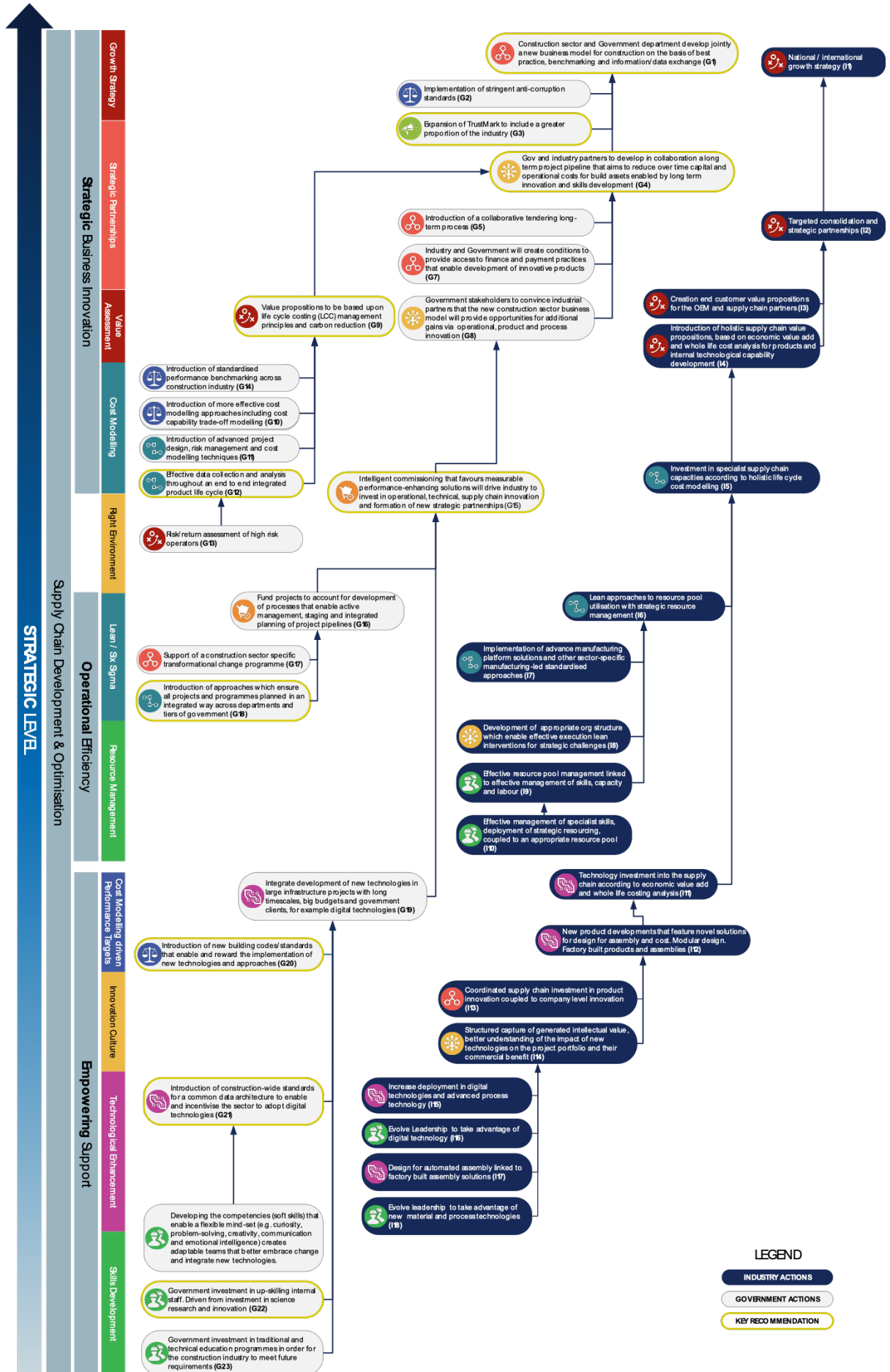


Figure 6. Transformational change model

The Construction Innovation Hub is funded by UK Research and Innovation through the Industrial Strategy Challenge Fund



The Construction Innovation Hub is a consortium between:

