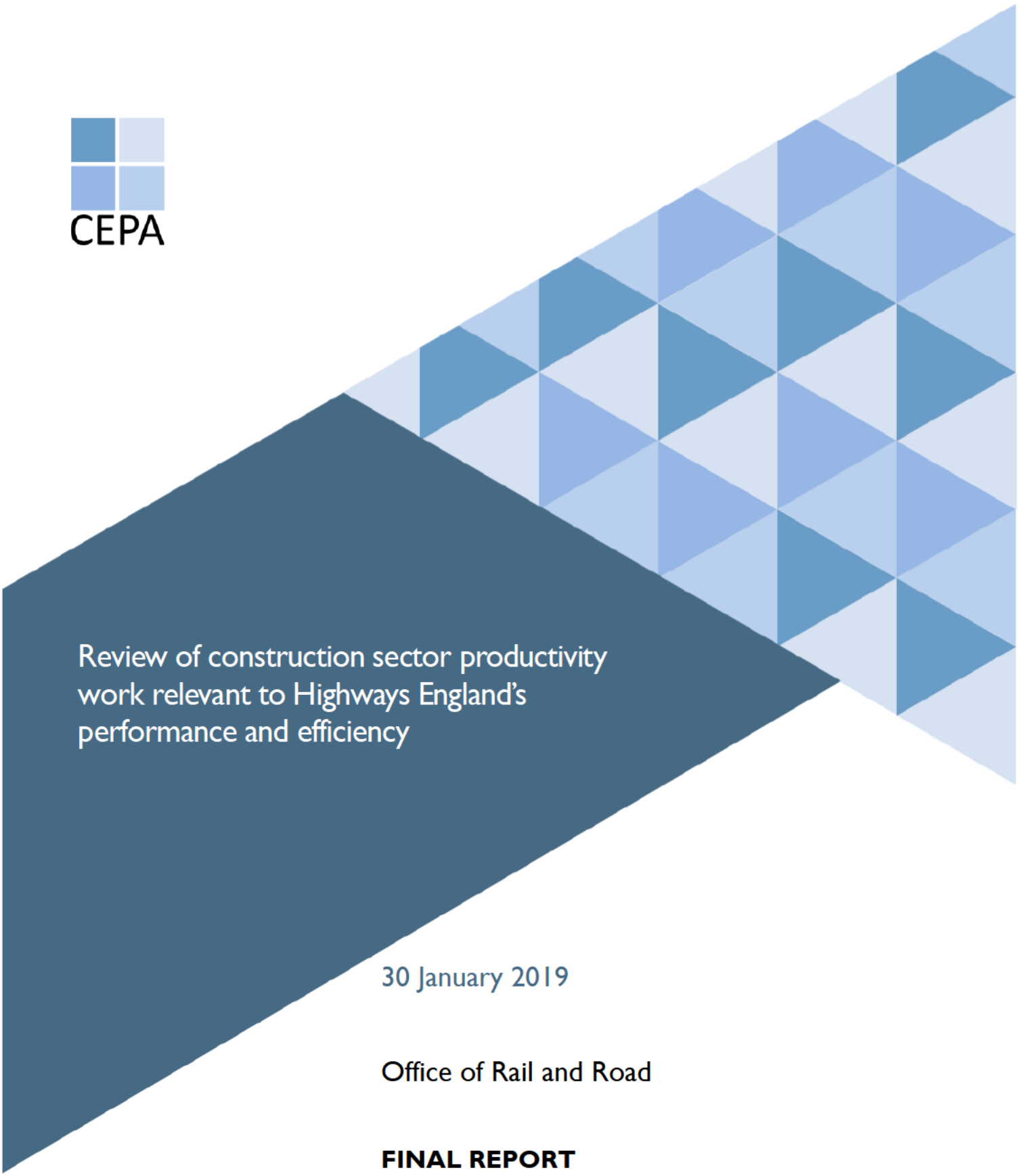

Review of construction sector productivity work relevant to Highways England's performance and efficiency

30 January 2019

Office of Rail and Road

FINAL REPORT

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1. EXECUTIVE SUMMARY

At around 0.5% per year, the overall level of construction labour productivity growth within the UK is relatively high when compared with other wealthy economies around the globe. However, the level of productivity growth differs substantially from other sectors, with construction consistently lagging. In the UK specifically, growth has been an average of 21% lower than the wider economy since 1997. While it may not be feasible for the construction sector to match productivity improvements seen in other sectors due to sector-specific issues such as the site-specific nature of the work and significant uncontrollable variables, there is certainly room for improvement.

We have reviewed ten documents that describe and address the productivity challenges that face the construction sector, and have assessed how much consensus there is around there being clear opportunities for efficiencies from:

- greater modularisation and automation of manufacturing, including off-site assembly;
- enhanced data and information including Building Information Modelling (BIM) and digital design;
- reduced costs of procurement and commercial interfaces through alliancing and enterprise agreements; and
- more advanced modelling and understanding of risk and how to manage it.

We have also examined the productivity challenges that are apparent in the number and skills of the workforce in the construction sector, since improvements in this area underpin progress in delivering productivity improvements in the other four areas.

It is important to note that many of the key areas for productivity improvement are interconnected; improvement in one area reinforces improvements in others. Two areas of innovation are linked: modern methods of construction, including off-site manufacture and modular approaches, and the digitisation of design and utilisation of BIM and other data-reliant approaches. The standard industry approaches and structures for risk and procurement are also intertwined. Improvements in one of these linked areas will make changes in the other both easier and more effective. Underpinning all of these are developments in the skills of the sector, since changes to the industry structure and increased innovation require a reskilled workforce to be fully effective. The structure of the industry sector also limits the incentives for innovation and reduces any drive for increasing skills.

We found extensive reference to **automation and off-site** manufacture in many of the documents reviewed. Much of this is relevant to Highways England, albeit these methods appear most effective when systems, such as mechanical and electrical and control systems, are integrated into the heavier civils works. This might be most appropriate for Highways England's investment in Smart Motorways, for example.

Estimated productivity improvements from automation and off-site methods are substantially larger than any other area that we have examined, though they vary greatly depending upon the level and extent of automation assumed and its integration with the planning process and other construction.

Evidence reported by the House of Lords Science and Technology Committee suggests that the use of off-site methods could improve productivity by up to 50%, while Laing O'Rourke estimate a 60% improvement in productivity. Similarly, the Infrastructure and Project Authority suggested that "smart construction" would allow increased efficiencies of up to 40%. While these values may not be completely comparable, they give an indication of the range of productivity efficiency available from off-site methods.

McKinsey reported the largest potential productivity improvements from automation of manufacture to a full "production system", with improvements of 5x to 10x (i.e. 500% to 1,000%) as plausible in some circumstances. While improvements of this magnitude apply primarily to projects at the "mid-range" of size and complexity, where contractors are large enough to invest but where projects are sufficiently repeatable to allow highly automated manufacture, it seems likely that at least some of Highways England's capital programme will fall into this category.

Off-site manufacture also has a wide range of other benefits, such as better quality buildings and infrastructure, improved health and safety for both the workforce and the public, reduced environmental impact and enabling the jobs created by construction to be more widely spread geographically, rather than concentrated near the locations of investment.

Despite the clear benefits of off-site manufacture, there is limited uptake and minimal further innovation of modern methods for construction. This is largely due to the scale of investment, and hence the assured level of demand required for large scale adoption of this approach. The proposed presumption in favour of off-site manufacture by five government departments, including the Department for Transport, should address some of the reasons for this slow uptake.

Data and digital technology, including BIM, are key enablers in increasing productivity, supporting the move to off-site manufacture and whole life design. Estimates of the productivity impact seem likely to be of the order of 10%-20%.

Measurements of the financial impact of BIM alone appear small, in of the order of 1% of lifecycle costs. This is, however, thought to be an underestimate. The largest financial impact of BIM is the introduction of the ability to plan and optimise throughout the lifecycle of assets, reducing the costs of the operation of assets following their commissioning. We have not found evidence that any such benefits are being widely reported or delivered at present.

There are, however, good examples where advanced use of BIM has made more material differences to projects. For example, Transport for London undertook virtual modelling of a tunnel relining from start to finish. This application of BIM and digital engineering helped to complete the project without impacting the operation or safety of the line, 4.5 months ahead of schedule and 10% under budget.

More widespread use of data and digital technology enables standardisation and maximises the impact of innovation. It is fundamental to the move to off-site manufacture, which relies upon a shared and common dataset that is used by clients, contractors and the supply chain. It also assists in delivering innovation for the other areas studied. For example:

- proper consideration of whole life costs in the design process, and a systematic and agreed way of capturing and benchmarking the performance of assets, would enable the comparison of assets to identify inefficiencies;
- a common data environment, used by clients, contractors and their supply chains, helps to provide a more trusting relationship and makes collaboration both easier and more effective;
- the UK Government Industrial Strategy agrees that large-scale datasets can be used to generate insights and innovation, and highlighted the use of TfL's open and free data on timetables, service status and disruption in generating annual time savings worth around £130m for travellers, London and TfL itself.

There is a clear consensus in the industry that digital technologies will have a positive effect on productivity, and take up of some digital technologies has been, and is expected to be, rapid. The House of Lords noted that the UK is a leader in digitisation, with near universal awareness of BIM and 62% of companies using it.

The documents reviewed suggest that the **procurement and commercial** arrangements in the construction industry are entrenched, with unaligned contractual and incentive structures resulting in distrust, lack of transparency and inefficiencies. This structure acts as a barrier to investment. A McKinsey survey indicated that misaligned contractual structures were viewed as the one of the two highest sources of low productivity. The biggest contractual problems cited were:

- the suspicion and distrust engendered by the competitive bidding process;
- the failure to adequately incorporate project uncertainties into contracts; and
- ineffective risk sharing among all stakeholders, including subcontractors.

McKinsey reported analysis that they had undertaken which found an 80% average cost overrun on large infrastructure projects due to change orders, for example changes in design to account for unexpected ground conditions or clarifications and changes in project scope. In such an environment, where trust is lacking, improving productivity takes a back seat. These issues appear to be generally recognised in the industry and have been understood for decades. There are a wide range of approaches that have been proposed to improve collaboration. For example, common KPIs between owners and contractors, contracts structured to support collaboration, rewards for all project parties based on outcome value and early engagement of suppliers in the design process, combined with clear objectives to invest in innovation.

Significant effort has been expended to develop new models of enterprising and alliancing, for example via Project 13, an industry led initiative aiming to deliver projects through an integrated, aligned and commercially incentivised organisation. However, there appear to be few examples of using these models widely. The existing model of procurement, risk transfer and contractual wrangling to minimise costs and/ or maximise profits appear to be remarkably robust and difficult to dislodge.

It seems that the root of this is the focus of procurement on reducing the initial price and offloading risk. Addressing this issue would require public sector clients in particular to take a whole life view of costs and value of the infrastructure that is being purchased, rather than focussing on the initial price and risks.

We have identified little in the documents reviewed that addresses the **modelling and understanding of risks**, beyond those issues highlighted in the discussion of procurement and commercial interfaces. Ineffective risk sharing is one of the main issues with the contractual framework, and there is a failure to include uncertainty into contracts. The current model in the construction industry is too focused on risk mitigation and cost control, and so the resulting adversarial and transactional relationships disincentivise investment and encourage a focus on short-term objectives and inappropriate risk transfer.

Risk is typically pushed down the supply chain, giving receiving parties a cautious risk appetite. This does not encourage investment in more innovative methods. When risks are not shared it is more difficult to address and manage them, since the risk holder and other parties have differing incentives. The party holding the risk will tend to favour more conservative approaches over innovation.

Underpinning all of these areas is the need for the sector to invest in a workforce such that they have sufficient **skills** to take advantage of new techniques, data and commercial models. In the short term, there is a need to recruit and retain substantial numbers of engineers and skilled trades. This is being addressed via increased investment in apprenticeships and science, technology, engineering and mathematics education, but this will need to be sustained or expanded over the coming decade.

2. CONTEXT AND PURPOSE

At around 0.5% per year, the overall level of construction labour productivity growth within the UK is relatively high when compared with other wealthy economies around the globe.[1] However, the level of productivity growth differs substantially from other sectors, with construction consistently lagging. In the UK specifically, growth has been an average of 21% lower than the wider economy since 1997.[2] While it may not be feasible for the construction sector to match productivity improvements seen in other sectors due to sector-specific issues such as locality and significant uncontrollable variables, there is certainly room for improvement.

Given that the construction sector contributes £138 billion in value to the UK economy and employs 9% of the total workforce[3], it is imperative for the ORR to understand what is possible in terms of efficiency improvements in construction in the context of the UK, and specifically for Highways England's activities. Additionally, it is important to ensure that these opportunities are generally agreed upon by relevant stakeholders, and thus likely to be supported and complimented by efforts in related industries, as well as by Government.

2.1. PURPOSE OF THE REPORT

The purpose of this work is to determine how much consensus there is around there being clear opportunities for efficiencies from:

- greater modularisation and automation of manufacturing, including off-site assembly;
- enhanced data and information including Building Information Modelling (BIM) and digital design;
- reduced costs of procurement and commercial interfaces through alliancing and enterprise agreements; and
- more advanced modelling and understanding of risk and how to manage it.

Additionally, we have assessed these findings in the context of Highways England's various activities to determine how applicable they might be in practical terms. In order to gain a better perspective on how these areas interrelate, industry skill development has been added as an additional area of opportunity.

2.2. STRUCTURE

The remainder of this report is structured as follows:

- Section 3 summarises the connections between the areas of efficiency, in addition to the main findings within each area;
- Section 4 discusses modern methods of construction including automation and modularisation;
- Section 5 presents opportunities from BIM, digital and data;

[1] McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity,* (2017), p.3.

[2] HM Government, *Industrial Strategy: Construction Sector Deal,* (2018), p.6.

[3] Infrastructure and Projects Authority, *Transforming Infrastructure Performance*, (2017), p.7.

- Section 6 explains difficulties stemming from current procurement practices;
- Section 7 discusses of how risk management affects efficiency; and
- Section 8 explores how skills relates to productivity opportunities in all other areas.

Additionally, this report includes the following Appendices:

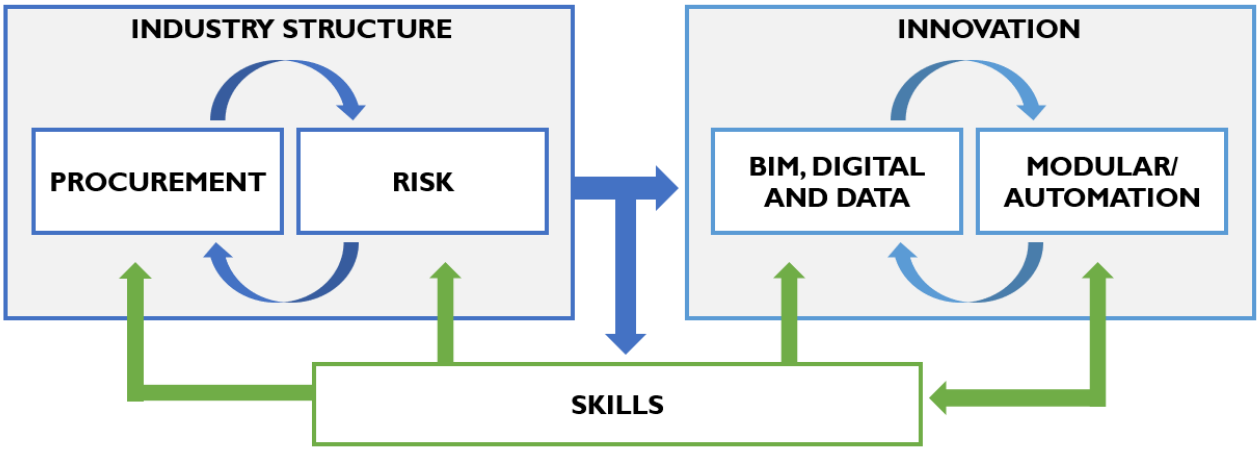
- Appendix A: Document relevance overview;
- Appendix B: Document summaries; and
- Appendix C: Bibliography.

3. INTERCONNECTIONS

The key areas for productivity improvement are closely connected. Improvements in one area reinforce those in others, and improvements in a single area have less effect. Improvements in skills underpin changes in other areas.

It is important to note that many of the key areas for productivity improvement are interconnected; improvement in one area reinforces improvements in others, as shown in Figure 3.1 below. Two areas of innovation are linked: modern methods of construction, including off-site manufacture and modular approaches, and the digitisation of design and utilisation of BIM and other data-reliant approaches. The standard industry approaches and structures for risk and procurement are also intertwined. Improvements in one of these linked areas will make changes in the other both easier and more effective. Underpinning all of these are developments in the skills of the sector, since changes to the industry structure and increased innovation require a reskilled workforce to be fully effective. The structure of the industry sector also limits the incentives for innovation and reduces any drive for increasing skills.

Figure 3.1: Interconnections between efficiency areas in the construction sector.



Source: CEPA analysis

Increased **skills** in the construction sector underpin changes in all other areas. For example:

- construction needs to attract and develop science, technology, engineering and mathematics skills to use and manipulate new technology and digital innovations such as modular construction and automation;
- industry needs to develop skills to manipulate large datasets and big data that allow progressions such as benchmarking, standardisation/ automation and better coordination between tasks, improved planning and reduced waste; and
- industry needs new skills to function effectively in largely unfamiliar collaborative business models such as enterprising.

However, the current industry structure, with a focus on risk and cost, is a barrier to investment in skills. Modular techniques and automation can reduce the need for labour and thereby reduce pressure on the labour market.

Digitisation and increased data underpin the development of modular construction and off-site manufacture. However, it requires a highly skilled workforce to be effective. It also has benefits for other areas through:

- enabling the quantification of benefits for efficiency improvements derived via other productivity areas;
- effectively sharing data assists in collaboration, which in turn can generate more data; and
- improving monitoring and data management enables measurement of whole life asset performance.

As noted above, **modern methods** such as modular construction and off-site manufacture rely on digital design and improved data and would build upon the UK construction sector's generally progressive uptake of digital technologies. There is currently a lack of investment in these modern methods. This is, at least in part, due to a lack of incentive; returns on such an investment require a well-developed and stable pipeline of assured work and this is rarely available given the focus on short-term project delivery at minimum costs. However, the large productivity improvements that are possible from approaches such as off-site manufacture could have a material impact on the labour market, changing both the number of people and the skills required.

The current approach to **procurement and commercial** aspects of construction acts as a barrier to investment in many other areas. The adversarial approach, common to the industry, focuses on minimising costs and transferring risks down the supply chain. This reduces the incentive to invest in digitisation and modern methods of construction, and therefore the upskilling of the workforce. The lack of collaboration between owners, contractors and their supply chains make the standardisation of approaches, techniques and the implementation of benchmarking and process improvement more difficult.

The construction industry's approach to **risk** largely stems from procurement and commercial arrangements and appears endemic to the construction sector both in the UK and elsewhere. As noted above, this greatly reduces incentives to invest.

The remainder of this document examines each of the areas of improvement in more detail.

4. MODERN METHODS

Modern construction methods comprise a spectrum from greater standardisation of components, through to modularisation of sub-assemblies and assemblies, and culminating in a high level of automation where on-site construction is minimised and large parts of the infrastructure are manufactured in a controlled factory setting off-site. In this situation, much greater use is made of plant and equipment, and the use of labour can be greatly reduced.

The use of modern methods such as automation and off-site assembly has the potential to boost productivity during construction. Potential productivity improvements are larger than all other areas examined.

Estimated productivity improvements from automation and off-site methods are substantially larger than any other area that we have examined, albeit that they vary greatly depending upon the level and extent of automation assumed and its integration with the planning process and other construction.

Evidence reported by the House of Lords Science and Technology Committee suggests that the use of off-site methods could improve productivity by "up to 50% … and maybe higher", while Laing O'Rourke set out their "70:60:30" approach, which means that "70% of a project's construction [is] conducted off-site, leading to a 60% improvement in productivity, and a 30% improvement in delivery schedule."[4]

Similarly, the Infrastructure and Project Authority suggested that "smart construction", which includes a range of techniques with greater levels of activity taking place off-site and increased levels of standardisation, underpinned by digital design and engineering, would allow a maximum increased efficiency of 40%.[5] This approach would allow a bespoke solution to be delivered while standardising processes to maximise efficiency.

While these productivity improvements appear to assume slightly different projects, approaches and techniques, they appear to give a reasonably consistent view of the "size of the prize" that could be delivered by increased off-site manufacture, of the order of 40-60%

A good example of the benefits available from off-site manufacture is the delivery of Liverpool Street (LIV) and Tottenham Court Road (TCR) stations for Crossrail.[6] These stations, which were similar in scope, were built using different methods. TCR relied on traditional in-situ construction due to constraints in the amount of access that was possible, while LIV applied Design for Manufacture and Assembly solutions, where 460 precast concrete elements were manufactured in a controlled factory environment. The off-site approach delivered an 11-week programme saving, with fewer people required to work underground and reduced occupational health risk. The TCR platform took 67,000 person-hours to complete whereas the LIV platform took 27,000 person-hours. Taken at face value, this implies a labour productivity of almost 60%, which is consistent with the estimates above.

By moving to a full "production system" with extensive use of modules and standardisation, McKinsey reported the largest potential productivity improvements could be in the magnitude of 5x to 10x (i.e. 500% to 1,000%) in some circumstances, and give an example of a production system that "can build five to ten

[4] House of Lords, *Off-site manufacture for construction: Building for change,* (2018), p.12.

[5] Infrastructure and Projects Authority, *Transforming Infrastructure Performance,* (2017), p.37.

[6] House of Lords, *Off-site manufacture for construction: Building for change,* (2018), p.17.

times more units than traditional construction with the same amount of labor"[7], with a similar example reporting reductions in unit costs of 35%. Other examples that they quote indicate productivity improvements of the order of a 30% increase in labour productivity and a 10-30% reduction in costs.

The financial benefits of modern methods for construction are difficult to quantify more precisely, and are intertwined with benefits of the digitisation of construction, but other benefits of off-site manufacture and standardisation are apparent.

The Department for Transport recognises that digital tools are a key enabler for more extensive adoption of modern construction methods, such as off-site construction and standardisation of assets.[8] The benefits of these modern methods cannot, therefore, be considered in isolation: they are the result of the combination of digitisation, which also has other benefits (see section 0), coupled with innovative construction techniques. A move to a "manufactured" approach in construction would embed best practice from the manufacturing and automotive sectors into construction delivery.[9] This approach reflects the ambition of the Construction Sector Deal.[10]

Additional benefits of modern methods of construction, many of which apply to off-site manufacture in particular, are set out by the House of Lords[11] and the Department for Transport[12]. They include:

- *Better quality buildings and infrastructure*: Building components and modules off-site allows much more precise manufacturing techniques to be used, and designing for these techniques using digital processes allows more efficient, precise and lower cost components to be of much higher precision and more consistent quality. This results in a higher quality product than traditional techniques.
- *Improved health and safety*: Better control and assurance of manufacture and assembly processes, more consistent quality and increased potential to track parts and modules allows better assessment and assurance of health and safety risks of infrastructure. Due to the controlled nature of the factory environment where off-site manufacture is undertaken, it also reduces the health risks of workers involved in construction in both the short and long-term.
- *Addressing the labour shortage*: As noted in section 0, the construction industry is highly dependent on an ageing, and often migrant, workforce. Off-site manufacture would address this both by reducing the number of workers required and making the role more attractive. It would also reduce the reliance of the industry on often undertrained site managers[13], since fewer adjustments and decisions would be needed on-site.
- *Reducing the environmental impact of construction:* Evidence reported by the House of Lords suggested that "precast concrete manufacturing in the UK has reduced carbon emissions by 26%, mains water consumption by 31%, and waste to landfill by 95% over the period 2008 to 2016". Off-site manufacture also reduces movement of materials and personnel, and reducing the time and range of activities completed on-site can reduce noise and traffic congestion for local residents.

[7] McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity*, (2017), p.11.

[8] Department for Transport, *Transport Infrastructure Efficiency Strategy,* (2017), p.63.

[9] Infrastructure and Projects Authority, *Transforming Infrastructure Performance,* (2017), p.36.

[10] HM Government, *Industrial Strategy: Construction Sector Deal*, (2018).

[11] House of Lords, *Off-site manufacture for construction: Building for change,* (2018), p.10-13, 17.

[12] Department for Transport, *Transport Infrastructure Efficiency Strategy*, (2017), p.17, 41, 64.

[13] McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity,* (2017), p.86.

- *Allowing the jobs associated with construction to be geographically spread:* A reduction in the activities undertaken on-site allows more of the work to be undertaken across the UK rather than a small number of UK conurbations. This allows the whole of the UK's manufacturing capacity to be employed to improve productivity, rather than a sub-set of the construction industry that happens to be in a convenient geographical location. This also has political advantages in that it would allow infrastructure investment, which is often in London, to provide tangible advantages elsewhere in the country.

As noted above, there is a strong interaction between modern methods of construction and the digitisation of the industry. The two form a virtuous circle as indicated in Figure 4.1 below.

Figure 4.1: Connections between modern methods and industry digitisation.

Source: CEPA analysis

For example, the Department for Transport stated that "Digital tools will enable the more extensive adoption of modern construction methods, such as off-site construction and standardisation of assets, which will unlock industrial capacity across the UK."[14]

Despite the clear benefits, there is limited uptake and minimal further innovation of modern methods for construction. The proposed presumption in favour of off-site manufacture should, at least in part, address some of the reasons for this slow uptake.

Moving to off-site manufacture, at scale, requires substantial investment from suppliers. McKinsey estimate that an automated facility producing sufficient cement slabs and walls for 12,500 housing units could cost about £30 million.[15] Only an assured level of demand can justify such an investment. The more capital-intensive nature of prefabricated elements therefore requires certainty about the scale of demand in order to justify the capital investment.

[14] Department for Transport, *Transport Infrastructure Efficiency Strategy*, (2017), p.63.

[15] McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity,* (2017), p.117.

The IPA recognises this, describing a lack of long-term planning and confidence in demand to justify investment in facilities, but also in capability.[16] The IPA also highlights that fragmentation in the industry, of both supply chain and clients, acts as a barrier to the development of standard solutions that can be delivered across sectors. A survey by McKinsey[17] concurs with this view, and indicates that the primary reason for slow uptake of modularisation is that is a lack of a clear industry standard approach, which both clients and subcontractors would need to adopt.

This lack of long-term confidence in demand should be addressed, at least in part, by the "presumption in favour" of off-site manufacture of five UK Government Departments by 2019.[18] The Department for Transport is one of the named Departments (along with the Department of Health, the Department for Education, the Ministry of Justice and the Ministry of Defence) that will support off-site manufacture through its procurement process where it represents best value for money.

As noted earlier, McKinsey believe that moving to a "production system" approach could increase productivity by 500% to 1,000%. They acknowledge that a move to such a production system is not suitable for all projects. For heavy construction projects that are large, bespoke and non-repeatable, the approach requires too much investment. At the smallest scale, fragmented trades in housing construction will not have sufficient scale to make use of the approach. In McKinsey's view, projects in the middle of the spectrum are most amenable to this approach. These projects might range from a complete single-family home to an airport. It seems to us that at least some of Highways England's investment would fall into this range, indicating that some works could benefit from the huge efficiencies that appear possible.

[16] Infrastructure and Projects Authority, *Transforming Infrastructure Performance,* (2017), p.37.

[17] McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity,* (2017), p.104.

[18] Infrastructure and Projects Authority, *Transforming Infrastructure Performance,* (2017), p.37.

5. BIM, DIGITAL AND DATA

Data and digital technology are key enablers in increasing productivity, supporting the move to off-site manufacture and whole life design. Estimates of the productivity impact seem likely to be of the order of 10%-20%.

McKinsey estimates that the potential productivity improvement in Design & Engineering and Technology are 8-10% and 14-15%, respectively.[19] These estimates are quoted, and we assume supported, within the Construction Sector Deal. The former productivity estimate is due to the combination of designing for manufacture and an increased focus on constructability. Both of these are materially helped by digitisation. "Technology" primarily comprises digitisation of both the design and production processes, for example by introducing digital collaboration tools, Building Information Management (BIM), on-site monitoring of materials and labour productivity and data flows between client, contractors and sub-contractors. It also includes the impact of new technology.

Increased digitisation, sharing of data, and the use of BIM introduce the ability to plan and optimise throughout the lifecycle of assets. The financial impact of BIM, alone, appears small.

McKinsey highlighted the design processes of projects as one of the highest sources of inefficiencies in construction.[20] Increased digitalisation of designs, including the use of BIM, enables a "single source of truth" to be set up. BIM, if used properly and to its greatest extent, allows owners, contractors and their supply chain to share drawings, models, costs and schedules seamlessly. This improves collaboration and can form the basis of a "project operating system" that integrates management and technical systems.[21] Digitisation is a key enabler for standardisation in design, and so is closely linked to modern methods of manufacture.

During construction, increased sharing of data and appropriate technology in skilled hands can define work processes, optimise inventories, allocate labour and reduce waste and variability.[22] As noted above, the right data used in the right way can improve the way people and organisations work and deliver their services.[23]

BIM enables the creation of a single source of truth. During design and construction this can increase communication and reduce the risk of errors.[24] In addition, BIM allows whole life costs to be better considered and managed during the design process. Crossrail will be the first major UK infrastructure project to fully utilise the BIM lifecycle concept and HS2 Ltd has already invested significantly in BIM.[25]

Evidence from two projects assessed using PwC's Benefits Measurement Methodology for BIM indicates that, by far, the largest impact on costs derived from the use of BIM was in the operation of assets following their commissioning. As a percentage, however, this impact was smaller than the impact on design costs, with a reduction in operation costs of only around 1%. The high lifetime cost of operations of long-lived assets

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[19] McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity,* (2017), p.7.

[20] McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity,* (2017), p.17.

[21] McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity,* (2017), p.75, 87.

[22] McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity,* (2017), p.87, 97.

[23] HM Government, *Industrial Strategy: Construction Sector Deal*, (2018), p.23.

[24] House of Lords, *Off-site manufacture for construction: Building for change,* (2018), p.35.

[25] Department for Transport, *Transport Infrastructure Efficiency Strategy*, (2017), p.64.

resulted in a larger financial impact from reduced maintenance and operation costs, particularly reduced power. These estimates of savings are likely lower than the actual amounts due to the difficulty in evidencing the counterfactual (i.e. the costs and outcome if BIM had not been used).

The requirement for level 2 BIM became mandatory in April 2016.[26] A year later it was found that, despite high levels of awareness, 37% of the construction industry was unclear on how to comply with the mandate and approximately half thought the government was failing to enforce it.[27] It seems to us that this BIM data has not been widely used, or at least widely used effectively, to reduce operations costs to date. However, the mandate is still relatively recent, and as it remains early in the lifecycle of projects that have been built with BIM, the cost reductions may increase as the maintenance needs of the assets develop. As the Co-Chair of the Construction Leadership Council said, "Unless you digitalise at the front end, you lose the opportunity, first, to improve productivity through the delivery, and, secondly, to introduce smart technologies, monitoring and datasets to the life of that asset".[28]

There are good examples where advanced use of BIM has made more material differences to projects. For example, the Department for Transport highlighted an example where virtual modelling of a tunnel relining from start to finish allowed key stakeholders to be convinced that the work could be done safely and allowed the project team to test solutions and plans in the digital world.[29] The model was used to support 3D modelling, 4D planning, coordination, clash detection, innovative solution design, training, familiarisation and safety planning. This application of BIM and digital engineering helped to complete the project without impacting the operation or safety of the line, 4.5 months ahead of schedule and 10% under budget.

Data and digital technology enable standardisation and maximise the impact of innovation.

It is clear that increased digitisation and modelling in design is a key enabler for increased standardisation, standard systems of assembly and off-site manufacture.[30]

As noted above, the largest savings from improved design typically come from reducing the costs of operations and maintenance. Proper consideration of whole life costs in the design process, and a systematic and agreed way of capturing and benchmarking the performance of assets, would enable the comparison of assets to identify inefficiencies.[31] This warranted an entire section of the Infrastructure and Projects Authority Report[32], which highlighted the use of suitable benchmark data to better understand, and so improve, both the delivery of projects and their performance in whole life cost terms. Similarly, the Department for Transport highlighted that "current approaches to capturing cost and performance data is not systematic and

[26] BIM Level 2 requires all project and asset information, documentation and data to be electronic, which supports efficient delivery at the design and construction phases of the project. The UK government's 2011 Construction Strategy embraced the use of BIM and mandated its use to maturity Level 2 on all centrally procured HM Government projects by April 2016.

[27] House of Lords, *Off-site manufacture for construction: Building for change,* (2018), p.36

[28] House of Lords, *Off-site manufacture for construction: Building for change,* (2018), p.100.

[29] Department for Transport, *Transport Infrastructure Efficiency Strategy*, (2017), p.65.

[30] House of Lords, *Off-site manufacture for construction: Building for change,* (2018), p.9-10.

[31] HM Government, *Industrial Strategy: Construction Sector Deal*, (2018), p.34.

[32] Infrastructure and Projects Authority, *Transforming Infrastructure Performance,* (2017), p.19-23.

lacks the consistency required to support decision making".[33] The National Infrastructure Authority concurred, noting that "considerable time and energy is devoted to estimating expected costs and benefits but very little on establishing actual costs and benefits when projects are built."[34]

The National Infrastructure Authority highlighted progress in cost estimation for the UK's roads, stating that, "Highways England routinely publish outturn project evaluations of major investments. This system has led to more accurate estimates of the likely costs of future projects, reducing the average error in forecast costs by 20 per cent between 2000 and 2009."[35]

The Department for Transport also stressed that data, and data sharing, can help to highlight best practice and drive innovation, and can support the construction sector in managing innovation opportunities and maximising their impact.[36] The UK Government Industrial Strategy agrees that large-scale datasets can be used to generate insights and innovation, and highlights the use of TfL's open and free data on timetables, service status and disruption in generating annual time savings worth around £130m for travellers, London and TfL itself.[37]

Despite positive industry opinion in efficiency opportunities from digital technologies and data, investment in innovative approaches beyond those mandated remains limited.

There is a clear consensus in the industry that digital technologies will have a positive effect on productivity, and the uptake of some digital technologies has been, and is expected to be, rapid. For example, 44% of respondents to a McKinsey survey across the construction sector indicated that they used digital approaches such as electronic document and management, with 70% planning to have this in place within three years. McKinsey also reported that 70-80% of contractors believed that BIM would have a positive return on investment.[38] The House of Lords noted that the UK is a leader in digitisation, with near universal awareness of BIM and 62% of companies using it.[39]

Despite this, there is low investment in innovation and research and development in the sector. The UK construction sector has the lowest research and development spend of any sector in the UK, at about 0.1% of output.[40] Respondents to a McKinsey survey suggested that, for digital technologies, this was due to a lack of internal processes for quantifying and communicating benefits.[41] In contrast, the Infrastructure and Projects Authority suggested that traditional procurement practice tends to encourage individual transactional relationships with suppliers and a reliance on tried and tested technology, without providing a sufficient incentive for investment and adoption of innovative techniques.[42]

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[33] Department for Transport, *Transport Infrastructure Efficiency Strategy*, (2017), p.34.

[34] National Infrastructure Commission, *National Infrastructure Assessment,* (2018), p.101.

[35] Ibid.

[36] Department for Transport, *Transport Infrastructure Efficiency Strategy*, (2017), p.33, 58.

[37] HM Government, *Industrial Strategy white paper*, (2017), p.158.

[38] McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity,* (2017), p.98.

[39] House of Lords, *Off-site manufacture for construction: Building for change,* (2018), p.36.

[40] House of Lords, *Off-site manufacture for construction: Building for change,* (2018), p.41.

[41] McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity,* (2017), p.104.

[42] Infrastructure and Projects Authority, *Transforming Infrastructure Performance,* (2017), p.12

6. PROCUREMENT AND COMMERCIAL

The current industry structure is entrenched, with unaligned contractual and incentive structures resulting in distrust, lack of transparency and inefficiencies. This structure acts as a barrier to investment.

A McKinsey survey indicated that misaligned contractual structures were viewed as one of the two highest sources of low productivity.[43] The biggest contractual problems cited were:

- the suspicion and distrust engendered by the competitive bidding process;
- the failure to adequately incorporate project uncertainties into contracts; and
- ineffective risk sharing among all stakeholders, including subcontractors.

McKinsey reported analysis that they had undertaken which found an 80% average cost overrun on large infrastructure projects due to change orders. In such an environment, where trust is lacking, improving productivity takes a back seat.

The House of Lords noted that the construction sector is lacking in collaboration, alignment and trust, and that the current business model is too focused on the cost and risk of individual projects. Practices are entrenched and there is an unwillingness to break with contracting networks that have been established.[44]

As noted in sections 0 and 0, current contractual and payment practices are a barrier to investment in modern methods of construction and digitisation. Without these investments, there is a limited incentive to invest in upskilling the workforce. They also act as a barrier to the development of strategic and collaborative relationships within the supply chain.[45]

Increased collaboration within the supply chain can lead to positive changes in overall productivity and in other measures. There are a range of suggestions to improve collaboration.

There is a very firm view within the all documents reviewed that increased collaboration can improve productivity. McKinsey suggest that improved collaboration and contracting would result in an 8-9% improvement in productivity.[46] It would also contribute to improved supply chain management and on-site execution, which might contribute a further 10-15% to productivity. These estimates are quoted, and we assume supported, within the Construction Sector Deal.

Mace Group delivered an 18% reduction in cost, faster procurement and more flexible scheduling when working for TfL on the Stations Works Improvement Programme on London Underground through a joint delivery partnership model[47], which suggests that these estimates are plausible.

In addition to these productivity benefits, increased collaboration would have other positive effects. These include:

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[43] McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity,* (2017), p.74

[44] House of Lords, *Off-site manufacture for construction: Building for change,* (2018), p.25, 29

[45] HM Government, *Industrial Strategy: Construction Sector Deal*, (2018), p.34

[46] McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity,* (2017), p.63

[47] Department for Transport, *Transport Infrastructure Efficiency Strategy*, (2017), p.46.

- smarter, more collaborative and integrated relationships between owner and delivery team will build mutual understanding of outcomes;[48]
- collaboration switches the focus to adding and delivering value and gives better access to knowledge and innovation;[49]
- incentivisation of the supply chain to find better solutions and to shape delivery;[50]
- reduction in waste;[51]
- faster procurement and a more flexible construction schedule;[52]
- better risk sharing and so more incentive to invest;[53] and
- development of longer-term relationships.[54]

There is a wide range of suggestions of approaches to improve collaboration. For example:

- the owner and contractor should have a common set of KPIs to align incentives;[55]
- contracts should be structured to support collaboration, for example, through Integrated Project Delivery;[56]
- a reward for all project parties, as a whole, based on outcome value, which can incentivise more effective risk sharing;[57] and
- engage suppliers early in the design process and set clear objectives to encourage the supply chain to shape delivery and invest in innovation.[58]

While there are clear benefits to a more collaborative approach and a large number of suggestions of approaches to increase collaboration, it appears to be very difficult to deliver increased collaboration in the current construction industry.

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[48] Infrastructure and Projects Authority, *Transforming Infrastructure Performance,* (2017), p.31.

[49] Institute of Civil Engineers, *Project 13 Blueprint,* (2018), p.7, 23.

[50] Infrastructure and Projects Authority, *Transforming Infrastructure Performance,* (2017), p.31 and Department for Transport, *Transport Infrastructure Efficiency Strategy*, (2017), p.52.

[51] Institute of Civil Engineers, *Project 13 Blueprint,* (2018), p.7, 23.

[52] Department for Transport, *Transport Infrastructure Efficiency Strategy*, (2017), p.46.

[53] Infrastructure and Projects Authority, *Transforming Infrastructure Performance,* (2017), p.31 and Department for Transport, *Transport Infrastructure Efficiency Strategy*, (2017), p.45.

[54] Institute of Civil Engineers, *Project 13 Blueprint,* (2018), p.3.

[55] McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity,* (2017), p.93.

[56] An integrated system for managing the project delivery process, McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity,* (2017), p.75.

[57] Institute of Civil Engineers, *Project 13 Blueprint,* (2018), p.5-6.

[58] Department for Transport, *Transport Infrastructure Efficiency Strategy*, (2017), p.52.

There appear to be few examples of using the enterprising or alliancing models developed by Project 13 (an industry led initiative aiming to deliver projects through an integrated, aligned and commercially incentivised organisation), advocated by McKinsey or highlighted in the UK Government Industry Strategy and the Construction Sector Deal for anything much more than example purposes. The existing model of procurement, risk transfer and contractual wrangling to minimise costs and/ or maximise profits appear to be remarkably robust and difficult to dislodge, and the issues that are apparent now have been clear for a number of decades.

It seems that the root of this is the focus of procurement on reducing the initial price and offloading risk.[59] Unless this central issue can be addressed, the industry is likely to continue to make the same mistakes, with small steps to increase collaboration in some ways. Addressing this issue would require public sector clients in particular, to take a whole life view of costs and value of the infrastructure that is being purchased, rather than focusing on the initial price and risks. It may be that increased digitisation and modelling, together with off-site manufacture, will give sufficient confidence in the costs and performance of future infrastructure. However, this will be a long process that will require successes to be built up over a number of years.

[59] McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity,* (2017), p.39.

7. RISK

Increasing productivity is not a priority when the supply chain is focused on reducing costs and shifting risks.

We have identified little in the documents reviewed that addresses the modelling and understanding of risks, beyond those issues highlighted in the discussion of procurement and commercial interfaces in section 6. Ineffective risk sharing is one of the main issues with the contractual framework, and there is a failure to include uncertainty into contracts.[60]

The current model in the construction industry is too focused on risk mitigation and cost control[61], and so the resulting adversarial and transactional relationships, disincentivise investment and encourage a focus on short-term objectives and inappropriate risk transfer.[62] McKinsey suggest that productivity takes a back seat when stakeholders are focused on minimising risk and cost.[63]

Risk is typically pushed down the supply chain, giving receiving parties a cautious risk appetite. This does not encourage innovation[64], which by its nature involves the risk of failure. Similarly, if one party holds the majority of the risk, a concerted team effort to improve productivity and the project outcome will be more difficult, and the party holding the risk will tend to favour more conservative approaches over innovation.[65]

Managing risk collectively can result in higher value, innovation and efficiency.

Since the issues with risk are driven by the commercial and procurement models identified in section 6, the solutions are similar and involve increased collaboration and risk sharing. For example:

- collaboration along the supply chain and a reward for all project parties, as a whole, based on outcome value provides an incentive to jointly mitigate risk[66];
- risk sharing contributes to increased productivity[67]; and
- risk management can help to maximise innovation opportunities.[68]

[60] McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity,* (2017), p.73.

[61] HM Government, *Industrial Strategy: Construction Sector Deal*, (2018), p.32.

[62] Infrastructure and Projects Authority, *Transforming Infrastructure Performance,* (2017), p.31.

[63] McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity,* (2017), p.50.

[64] House of Lords, *Off-site manufacture for construction: Building for change,* (2018), p.31.

[65] McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity,* (2017), p.50.

[66] Institute of Civil Engineers, *Project 13 Blueprint,* (2018), p.5-6.

[67] Department for Transport, *Transport Infrastructure Efficiency Strategy*, (2017), p.45.

[68] Ibid.

8. SKILLS

Throughout this document review, we were struck by the number of references to increasing skills in the construction industry. It seemed to us that this was a key enabler that underpins the necessary improvements in productivity. We have therefore assembled some of the key issues and benefits associated with attracting and training a sufficiently competent and capable workforce to address the low levels of productivity.

There is not enough investment in the workforce; the industry is struggling to recruit and retain people.

People are one of the five foundations of the UK Government's Industrial Strategy, requiring investment to boost productivity. However, the construction industry is struggling with recruitment and the retention of their workforce[69], and the industry is characterised by a low skilled, ageing workforce with many migrant workers. Additionally, it is perceived as an unattractive industry to the best and the brightest.[70]

There is forecasted to be a shortfall of over 55,000 people to fill jobs available in transport infrastructure by 2020, with 15,000 of these anticipated to be in the roads sector.[71] Skilled labour and trades comprise around half of this shortage, while engineers make up another 14,000. The Infrastructure and Projects Authority suggested that there could be a 20-25% reduction in the available workforce over the next decade due to existing workforce age and current levels of new entrant attraction.[72] There is, therefore, a difficult challenge: to develop the traditional skills of the existing workforce while simultaneously developing the industry to embrace the changes necessary to deliver increased productivity in the coming decades. On top of this challenge, it is acknowledged by Government that the current industry structure creates a barrier to investment in skills.[73]

The workforce will need to be upskilled to harness and exploit efficiency opportunities.

McKinsey estimates capability building could result in 5-7% productivity improvements.[74] These findings are quoted, and we assume supported, by the Construction Sector Deal. At its core, insufficient attention has been given to technical education and science, technology, engineering and mathematics skills.[75] There is also a wide range of areas where additional skills need to be developed, and many of these underpin the other areas of productivity improvement detailed in this report. For example:

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[69] HM Government, *Industrial Strategy: Construction Sector Deal*, (2018), p.27.

[70] McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity,* (2017), p.58.

[71] Department for Transport, *Transport Infrastructure Skills Strategy: Building Sustainable Skills*, (2016), p.18.

[72] Infrastructure and Projects Authority, *Transforming Infrastructure Performance,* (2017), p.35.

[73] HM Government, *Industrial Strategy: Construction Sector Deal*, (2018), p.34.

[74] McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity,* (2017), p.7.

[75] HM Government, *Industrial Strategy white paper*, (2017), p.94.

- People need to be upskilled to meet new sector challenges, exploit new tech and support digital transformation.[76]
- There is a need to build the capacity of the industry to innovate.[77]
- There is a need to build capabilities for off-site manufacture, technology and digital developments[78], and new standards and training must be developed such that the future workforce can manage the adoption of digital and manufacturing technology.[79]
- Off-site manufacture requires the next generation of construction sector workers to be equipped with new skills to design, plan and assemble, but these skills are lacking in the UK.[80]
- Good design is a key factor to increase efficiency, but it requires sufficient design expertise.[81]
- Current worksite management often doesn't have the necessary education, training or tools required to do their jobs effectively.[82]
- Collaborative models require different skills from the traditional transactional model.[83]

The UK is taking steps to address the shortfall in the numbers of people required to meet the demand for construction work and to upskill the future workforce. For example, HS2 has supported a National College for High Speed Rail.[84] Its mission is to train the next generation of engineers for a career in rail, and to upskill the existing workforce with skills for now and the future, and plans to have 1,100 new starters per annum.

[76] Department for Transport, *Transport Infrastructure Skills Strategy: Building Sustainable Skills*, (2016), p.38, 43.

[77] HM Government, *Industrial Strategy: Construction Sector Deal*, (2018), p.23.

[78] Department for Transport, *Transport Infrastructure Skills Strategy: Building Sustainable Skills*, (2016), p.36.

[79] HM Government, *Industrial Strategy: Construction Sector Deal*, (2018), p.26.

[80] House of Lords, *Off-site manufacture for construction: Building for change,* (2018), p.3, 21-23.

[81] National Infrastructure Commission, *National Infrastructure Assessment,* (2018), 102-103.

[82] McKinsey Global Institute, *Reinventing Construction: A Route to Higher Productivity,* (2017), p.86.

[83] Institute of Civil Engineers, *Project 13 Blueprint,* (2018), p.32.

[84] Department for Transport, *Transport Infrastructure Skills Strategy: Building Sustainable Skills*, (2016).

APPENDIX A DOCUMENT RELEVANCE OVERVIEW

Using red, amber and green symbols, the table below indicates how much each document focuses on the areas of efficiency.

- Red: the document does not include this efficiency area.
- Amber: the efficiency area is mentioned.
- Green: the efficiency area is discussed in depth.

Table A.1: RAG table for efficiency areas

Document	Area					
	Modularisation/ Automation	Data and technology	Procurement/ commercial	Managing risk	Skills development	Relevance for Highways England
Reinventing Construction						
Industrial Strategy						
Transforming Infrastructure Performance						
Transport Infrastructure Efficiency Strategy						
Project 13						
National Infrastructure Assessment						
Construction Sector Deal						
BIM Benefits Measurement						
Off-site Manufacture						
Transport Sector Skills Strategy						

APPENDIX B **DOCUMENT SUMMARIES**

NATIONAL INFRASTRUCTURE ASSESSMENT (2018)

National Infrastructure Commission

This 2018 report lays out a long-term strategy to guide UK economic infrastructure development over the course of 2020-2050. Infrastructure investments support our economy over the long-term, and therefore must account for the trends and challenges of the future. This assessment takes an integrated look at the needs of multiple sectors across the UK economy to maximise value by prioritising project selection and ensuring infrastructure projects in one sector account for trends in others (e.g. new roads should be fit for electric and autonomous vehicles).

Explanation and justification for the infrastructure proposals make up the majority of the report content. However, both data and skills are discussed briefly in terms of their efficiency opportunities. Chapter 6, Choosing and Designing Infrastructure, discusses how new digital tech is able to generate useful and high-quality information which can be used to improve infrastructure planning and maintenance. This is particularly helpful at the design stage at which point it can save money, reduce risk, add value and deliver projects on time. However, Chapter 8 (Next Steps) indicates that the workforce must possess the necessary skills to harness and exploit the opportunities if efficiency is to be provided through new technologies. This includes the capability of owners to act as an intelligent client.

Overall, this document is of minimal relevance regarding the opportunities for efficiency in Highways England's construction. However, it does highlight the importance of skills within the supply chain, which underpins all of the efficiency areas.

INDUSTRIAL STRATEGY (2017)

HM Government

This report sets out a policy framework on how Government intends to support businesses and communities, boost innovation, upgrade infrastructure and increase earning power of individuals over the long term. Achieving this requires working in partnership with stakeholders across the economy on the "five foundations of productivity", namely: ideas, people, infrastructure, business environment and places. The report sets Grand Challenges and future policies for the UK Government and the wider economy to support the transformation of the economy through these foundations.

Much of this report consists of Government action, such as the development of funds, being taken to address the five foundations. The efficiency potential of data and digital technologies is reiterated throughout. Using them effectively can help to identify better ways of undertaking complex tasks and enable the use of modern methods. It is suggested that overall, the UK historically and currently does relatively well in terms of innovation and R&D, but needs to learn to capitalise on it. This requires more investment in skills, technology and equipment. The UK workforce currently lacks science, technology, engineering and math skills. The report recognises that the necessary investments in skills and technological innovation are hindered by the lack of collaboration within supply chains, although the allocation of risk is not mentioned.

The report provides some useful insights into the potential of data and its connection with skills and innovation. However, the Construction Sector Deal which stems from the Industrial Strategy is a more targeted and useful document for Highways England.

INDUSTRIAL STRATEGY: CONSTRUCTION SECTOR DEAL (2018)

HM Government

This report is one of the first "Sector Deals" that has come from the Industrial Strategy. These are partnerships between Government and industry aiming to increase sector productivity. The construction sector has historically had lower productivity than the rest of the economy, making its transformation a priority. As with the Industrial Strategy, the Sector Deal follows the five foundations of productivity: ideas, people, infrastructure, business environment and places.

All efficiency areas that are of interest to Highways England are discussed in this document with varying degrees of detail. Issues regarding the structure of the industry, and the important role it plays in the uptake of efficiency opportunities, are contained in both the Business Environment and Ideas chapters. Smarter commercial supply chains can take a more collaborative approach and share the management of risk. This has the potential to lead to collaborative investment in innovation and data, which can change the way people and organisations work through the use of benchmarking and the sharing of best practice. Digital technologies can support benchmarking, as well as the uptake of modern methods such as industrially manufactured kits of component parts. The importance of increasing the recruitment and retention of the workforce, and developing their traditional and future skills is also discussed. The Sector Deal expresses support for the Construction 2025 Vision, which supports a shift in financial perspective to value whole life asset performance.

The Sector Deal provides useful insight into many of the efficiency areas that are of interest to Highways England, with particular attention paid to data and digital technologies, procurement and skills development.

OFF-SITE MANUFACTURE FOR CONSTRUCTION: BUILDING FOR CHANGE (2018)

House of Lords

The Building for Change report lays out the case for the widespread use of off-site manufacture to improve the productivity of the construction sector. It was published after the Construction Sector Deal and the Government's announcement of the presumption in favour for off-site manufacturing. The report argues that the combination of problems plaguing the sector will restrict its ability to meet the infrastructure needs in the UK. Off-site manufacturing has the potential to mitigate these issues, although it is particularly helpful for housing as opposed to civil infrastructure.

As with the Construction Sector Deal, this report emphasises the need to move away from the traditional commercial supply chains which are characterised by a lack of trust, antagonistic relationships and poor risk management. Under the current scenario, supply chains are provided little incentive to invest in innovative methods such as off-site manufacturing, particularly without a consistent project pipeline, although the presumption in favour is helping to change that. The report stresses the importance of designing a project in a holistic manner, and assessing the lifetime value of an asset. Digital and data advances such as BIM enable better design and the inclusion of off-site manufacturing options. With its ongoing use, data can be fed back to increase both quality and innovation. The uptake of off-site manufacturing will require considerable upskilling of the workforce, but also help to reduce the labour shortage. Many additional benefits of off-site manufacturing are outlined in this report, such as waste reduction and health and safety.

This report by the House of Lords provides valuable insights into all efficiency areas of interest to Highways England, also explaining how many of the areas are interconnected.

PROJECT 13 BLUEPRINT (2018)

Institute of Civil Engineers

In response to a widespread understanding of the problems stemming from traditional transactional arrangements in infrastructure, the industry has introduced the Project 13 initiative. It seeks to establish a new project approach based on the idea of an integrated, aligned and commercially incentivised organisation (i.e. an enterprise). It is argued that this will lead to a more skilled and innovative workforce, a more sustainable and productive construction industry, and ultimately, better outcomes for the customers of infrastructure.

The report provides a comparison of traditional versus enterprise structures, and outlines the roles and responsibilities of each actor within the latter as well as the expected improvement in results. Most of the efficiency areas of interest to Highways England are touched on throughout this comparison, with the exception of automation/ off-site manufacture which is not mentioned. The efficiency opportunities from a more collaborative supply chain are inherent throughout. The suggested change in industry structure would enable the sharing of risk and incentivise suppliers and advisors to develop alternative solutions (innovate). It would also require a shift to valuing the whole life asset performance rather than lowest cost. Given that Project 13 represents a significant departure from entrenched practices, it would be necessary to upskill the workforce in order for them to effectively fill their roles. The initiative also mentioned the importance of harnessing digital technologies, including data assets.

While the document may not be wholly relevant to the efficiency areas within this report, it provides a good indication of what an alternative industry structure could look like in order to deliver efficiencies in construction.

TRANSFORMING INFRASTRUCTURE PERFORMANCE (2017)

Infrastructure and Projects Authority

This 2017 report sets out the Government's plan to increase the effectiveness of their investment in infrastructure by improving productivity, not only in the way assets are built, but also designed and operated. The plan spans 10 years and takes a wider look at cross sector and systemic opportunities for productivity. This commitment follows from the Industrial Strategy, which highlights infrastructure as one of the five foundations of productivity in the economy.

The plan stresses that the current industry structure is characterised by transactional relationships in which members of the supply chain rely on tried and tested technology, providing low incentives for investment in innovation and productivity. However, the use of new technologies and data is vital to boost productivity, as it enables the use of innovations such as modern methods of construction. Through performance benchmarking and delivery parameters, data can also boost productivity. It is mentioned that this type of innovation relies on fair risk distribution, not apparent in the current industry structure, and the development of workforce skills. While digital advancements (including off-site manufacture) and supply chain structure are the main focuses of efficiency in this report, there is also regular reiteration of the importance of assessing whole life performance of assets.

This document provides helpful insight into commercial relationships, data/ digital innovations and modular/ automation, and additionally touches on the need for risk management and upskilling of the workforce.

BIM LEVEL 2 BENEFITS MEASUREMENT: APPLICATION OF PWC'S BIM LEVEL 2 BENEFITS MEASUREMENT METHODOLOGY TO PUBLIC SECTOR CAPITAL ASSETS (2018)

PwC

Following the Government target of achieving Building Information Modelling (BIM) Level 2 on all public sector asset procurement by 2016, Innovate UK commissioned PwC to develop a Benefits Measurement Methodology (BMM) in order to measure the benefits that arise from the application of BIM Level 2 to infrastructure and capital assets. This report also included an assessment of two public sector capital assets.

This document provides an overview of BIM in the UK and seeks to address some of the barriers to uptake and implementation. In particular, the lack of hard evidence and the inconsistency in methodology for measuring the benefits of BIM. By developing and applying a consistent methodology to an office refurbishment and a flood barrier upgrade, PwC demonstrates how to use the methodology in multiple settings, and also gives some primary indications of the level of benefits to be expected at different stages of the project lifecycle. The results show that savings are primarily in the design and operation stages, rather than construction. However, the development of a counterfactual proved challenging and PwC suggests their results may be underestimates. This document is solely focused on providing a methodology and assessment of the application of BIM, and as such, only the data and digital technologies efficiency area is discussed in depth.

The assessment and results contained in the report provide useful insight into the benefits of data and digital technologies, in addition to the challenges faced when attempting to quantify the level of opportunity in potential areas of efficiency.

REINVENTING CONSTRUCTION: A ROUTE TO HIGHER PRODUCTIVITY (2017)

McKinsey Global Institute

In an effort to address the low productivity of the construction sector, the McKinsey Global Institute assesses the root causes and discusses potential options to increase efficiency. Additionally, it explores the shift towards productionisation, the barriers and enablers, and how it could affect the industry.

The report indicates that relative to other rich economies, the UK is doing well in terms of productivity, particularly in the awareness and uptake of digital technologies. According to McKinsey's estimates, this area provides the biggest potential for efficiency increases. It supports productionisation (i.e. modular, off-site manufacturing) which could significantly enhance the productivity of the sector. Through better planning and cooperation, data and digital technology can also boost on site execution. However, McKinsey recognises the key market failure of the industry to be unaligned contractual and incentive structures, and suboptimal procurement. This results in price focus, ineffective risk sharing, hostility and change orders, among other negative impacts. It is noted that the ability of the current workforce to effectively harness the efficiency opportunities is limited, in part due to the unattractiveness of the industry, and recommends an increase in education, training and tools.

Overall, this report provides information relevant to all areas of efficiency of interest to Highways England, particularly regarding the issues stemming from traditional procurement and contracting practices. The findings in this report are used to support many of the other reviewed documents.

TRANSPORT INFRASTRUCTURE EFFICIENCY STRATEGY (2017)

Department for Transport

This 2017 report is the outcome of a cooperative effort by public sector transport bodies to assess their collective ability to drive efficiencies and productivity in the sector. Seven challenges are presented, each providing an opportunity to increase efficiency. The intention is for the transport bodies to address these challenges by working with and learning from one another, as well as their supply chains.

Collaboration and the need to overcome the status quo in the industry is the overarching theme in this document. By alliancing with their supply chains, which they commit to doing in this document, transport bodies are better able to align incentives and can expect to see multiple efficiency benefits including reduced waste and a more flexible construction schedule. Collaborative methods such as alliancing can also result in a better management of risk and incentivise investment in innovation and skills. The public sector transport bodies intend to share data and best practice in order to benchmark and increase efficiency across the sector. The importance of data is inherent within this, and also within their commitment to maximise value through whole life cycle assessments. This document sets out their collective intention to increase the use of digital tools and platforms and enable effective use of data and encourage the uptake of modern methods of construction.

This document demonstrates the understanding and consensus of productivity opportunities within the public sector bodies operating in the UK transport sector, and touches on all efficiency areas of interest to Highways England. The importance of data and procurement processes are stressed throughout, mirroring McKinsey's analysis of the construction industry.

TRANSPORT INFRASTRUCTURE SKILLS STRATEGY: BUILDING SUSTAINABLE SKILLS (2016)

Department for Transport

The Transport Infrastructure Skills Strategy intends to address the multiple workforce-related challenges facing the UK transport sector. With the Government supporting significant investments in transport infrastructure, this strategy is critical to ensure there is a large and capable workforce able to meet the demand.

The bulk of this report is focused on Government initiatives that are being introduced to address both the skills shortage and the skills gap in the transport sector. The workforce is aging, lacking in diversity and characterised by low turnover. Coupled with the perceived unattractiveness of the industry and the limited industry investment skills development, the labour shortfall within the next five years is significant. This is apparent in both traditional skills and the new skills that will be required to meet new sector challenges. Science, technology, engineering and maths skills will be vital to enable the workforce to develop, understand and manipulate big data and emerging technologies. Digital and data are recognised as an important opportunity for efficiency, but in this report they are only discussed in so far as they require upskilling of the workforce. Modern methods, procurement practices and risk management are not mentioned.

As skills development underpins the opportunities for enhanced productivity in all other efficiency areas, this document is useful in explaining and quantifying the shortfalls, as well as setting out the intended plans to address the critical skills challenges facing the sector.

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