Reinventing infrastructure

Design for manufacture
and assembly and beyond

Contents

1 A modern approach to building infrastructure **p3**
2 Defining the business need **p5**
3 Procuring with the end in mind **p10**
4 Designing for manufacture **p14**
5 Designing for logistics and assembly **p17**
6 Managing assets through to end-of-life and disassembly **p19**
7 Smart cities and value creation **p22**

1 A modern approach to building infrastructure

Applying design for manufacture and assembly to our infrastructure assets has the potential to cut waste by half, reduce energy use by a quarter and dramatically improve construction productivity.

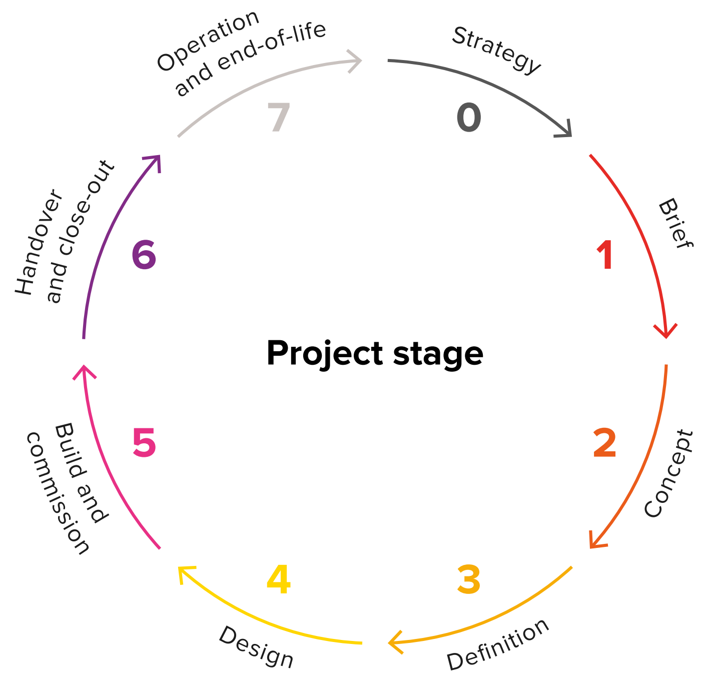
For centuries, our infrastructure assets have been created through design and construction techniques that evolved in line with, or sometimes lagged behind, contemporary industrial developments.

Almost since people first started to mechanise product manufacture during the first Industrial Revolution, designers and manufacturers have continually revised their ideas about how those items could be produced and assembled efficiently and cost-effectively. Electrification and then the advent of computer automation reshaped entire industries, transforming automotive, aerospace and consumer product manufacturing. But construction has been slower than other industries to reshape itself and to adopt digital technologies.

Digital engineering processes such as building information modelling (BIM) support 'lean manufacturing' approaches of the kind pioneered in the automotive sector by Toyota. Anything that does not add customer value should be considered waste and eliminated. Accordingly, lean design and construction seeks to:

- Eliminate needless production – to schedule and produce only what is needed
- Eliminate waiting times – to link processes so that one feeds directly into the next
- Reduce product transportation and handling time – to think 'just in time'
- Process appropriately
- Reduce inventory
- Cut unnecessary or excess motion
- Minimise or eliminate defects – cut rework and waste

BIM helps project teams to leverage data and be lean; working with manufacturers, we can standardise design processes, use repeatable digital components and even automate some design processes. With early access to accurate, detailed design data, we can quickly identify opportunities for design for lean manufacture, assembly and operation – which goes beyond DfMA (design for manufacture and assembly) to include managing assets through their whole lifecycle.



BIM and DfMA are often linked in recommendations to modernise construction and to reduce carbon; digital information enables more effective design for manufacture, which in turn has the potential to deliver assets with half the waste and 25% less energy in use. BIM and prefabricated building components have been identified as the two developments most likely to deliver high impact in improving global productivity in construction.

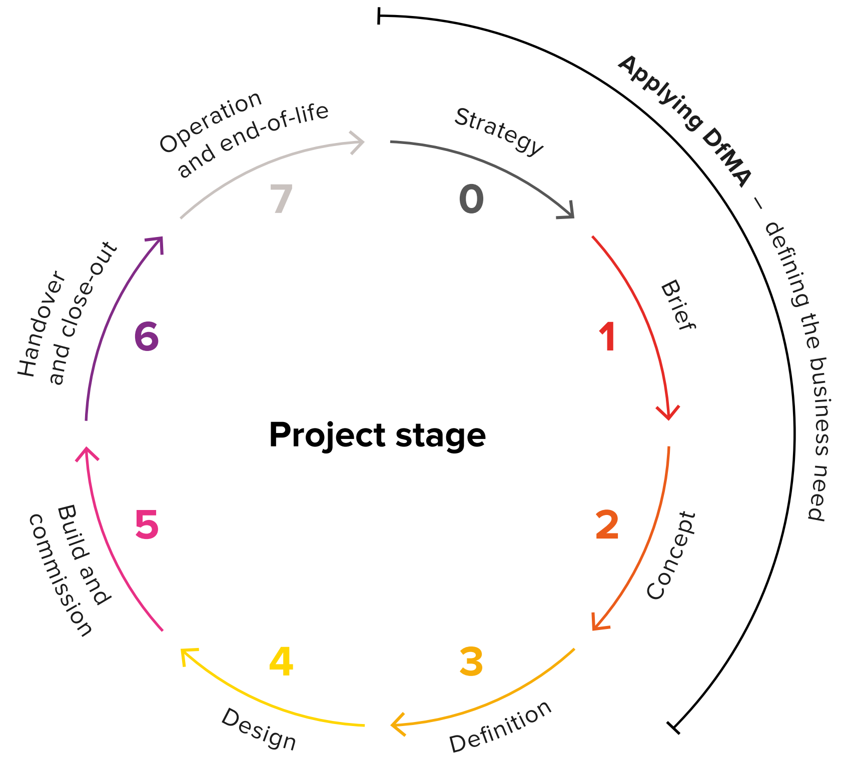
In the UK, contractors such as Laing O'Rourke and Skanska, and housebuilders, including Berkeley Homes and Legal & General, are investing in factories to produce components and modular buildings. UK government departments are adopting a presumption in favour off offsite construction when it represents best value for money. Such client demand reflects growing awareness that combining digital working and DfMA across the asset lifecyle can deliver infrastructure assets that better meet the needs of end users.

Our approach overlays design for manufacture, assembly and operation across project and asset lifecycles. We look at the initial briefing, conceptual and procurement stages of a project or programme, and identify issues relating to designing for manufacture and for logistics and assembly, including handover. We also consider how DfMA might impact on the whole-life operation and maintenance of a built asset, even its disassembly and reuse. We then look at some of the bigger macroeconomic and social opportunities that come from applying design for manufacture, assembly and operation approaches across multiple built assets – linking designers, manufacturers and constructors, owners and operators and end users – in connected 'Smart cities'.

Potential benefits from DfMA

- More efficient design
- Shorter construction programmes
- Fewer project team interfaces
- Less material waste
- Fewer site deliveries
- Improved site logistics
- Less onsite labour and accommodation
- Fewer onsite queries
- Less onsite noise, dust, etc
- Better health and safety
- Higher quality and fewer defects
- Lower whole-life costs
- Lower whole-life carbon
- Better asset performance in use
- Potential reuse of assets for new purposes
- Higher reuse of components

2 Defining the business need



Regardless of the type of project or programme, the starting point must be the business objectives of the client.

Defining the client's need is the first step towards describing the possible requirements of the project.

Design for manufacture, assembly and operation is a collaborative approach that focuses on ease of manufacture, efficiency of assembly, and future efficiency of operation. By simplifying the design of elements of a project it is possible to manufacture and assemble them more efficiently, more quickly and at a lower whole-life cost. In some cases, DfMA may be an explicit requirement from the outset.

Temporary structures
The type and duration of a project can dictate that DfMA is adopted. For example, the 2012 London Olympics programme required a series of temporary sporting venues that could be erected for the duration of the games and then easily dismantled and reused elsewhere or recycled (see p40).

Urgent or time-constrained building
DfMA building options are sometimes specified so that a structure is completed in a short period of time. For example, the construction of new school buildings at an existing site may not be possible during term time – however, DfMA can enable buildings to be assembled quickly during a holiday, and be operational by the beginning of term.

Local restrictions
Delivering a new building on a tightly constrained site may lead the design and construction team to look at DfMA from the outset to maximise offsite fabrication processes, minimise materials and waste storage, reduce site labour needs, limit vehicle movements, and minimise health and safety or environmental impacts, such as dust, air pollution, and noise and vibration.

Laing O'Rourke's construction of the 'Cheesegrater' building, at 122 Leadenhall Street in the City of London, relied heavily on offsite techniques to overcome site constraints.

Where DfMA helps avoid or reduce disruption to the wider community, it can help generate a favourable response during public consultations.

Weather challenges can also limit the time window for site-based processes, particularly in challenging environments. For example, in North America we opted for offsite fabrication of precast bridge sections on Hodder Avenue underpass in Ontario, Canada, because extreme winter conditions prevented onsite concrete pouring.

Repeatability and standardisation

Some experienced clients will be familiar with DfMA, and so it is incorporated from the outset. DfMA enables infrastructure projects to be delivered efficiently and with higher levels of standardisation, and to be more efficiently operated and maintained.

In England, the Education and Skills Funding Agency's (ESFA) Priority School Building Programme (see p16) aimed for a modular approach to meeting the demand for additional space. Schools and local authorities were given access to a set of design guides to underpin their work with designers and contractors, and to create standard types of functional spaces.

For Anglian Water (p15), we developed a 'product-based design' approach, creating standardised designs for common items of equipment. This generated cost savings of up to 45% and time savings of up to 90%. The new approach also helps optimise through-life asset management.

Lesson learned

The ESFA schools project highlighted the importance of client leadership and buy-in, with the whole design team working collaboratively and sharing BIM and other information effectively.

Our DfMA work for the ESFA and Anglian Water demonstrated the innovative manufacturing capacity that can be found among specialist contractors, and the importance of exploiting their knowledge and expertise at the beginning of projects.

We believe this learning can be applied for multiple clients across entire industry sectors.

Royal Victoria Building

In Scotland, we have provided detailed civil and structural engineering design for contractor Laing O'Rourke on the construction of a new hospital block in a confined working space, with limited access and noise restrictions.

By value, 55% of the £35M Royal Victoria Building at Edinburgh's Western General Hospital was made offsite under factory conditions. Dimensions and structural information in a 3D BIM model was used by the factory to produce components. Steel reinforcement was cut, bent and laid out robotically and concrete was mixed to the right strength in the right quantities, eliminating waste. Finished units were delivered just in time to be craned into place. The approach eliminated onsite steel fixing injuries, and the need for concrete formwork. The project was completed 20 weeks faster than using traditional construction methods, and employed 25% fewer workers onsite.

25%
reduction in onsite workforce

20 weeks
less time to deliver project

Northern line extension

The Northern line extension in London is using prefabricated beams, columns, lattice slabs and twin walls, among other prefabricated elements. Use of DfMA is expected to not only reduce construction time on the underground line, but the simpler site logistics associated with offsite manufacture will result in less disruption to residents affected by the project.

Our work as lead designer for the contractor has placed a major focus on supply chain collaboration and working to a DfMA modelling protocol, which we developed. This project was the first major infrastructure project to leverage contractor Laing O'Rourke's investment in factory facilities, capitalising on the firm's desire to extend its DfMA expertise and to maximise use of its precast concrete unit manufacturing plant.

"DfMA above ground is no problem but it's hard work and risky below ground. Going top-down in underground station excavation involves building underneath something that was previously installed. Ground movement can also be a factor, as walls move inwards as we excavate down."

Project manager

@one Alliance

45%
cost savings

90%
time savings

20%
less embodied carbon

We are a member of Anglian Water's @one Alliance, the consortium responsible for designing and building the company's capital construction programme.

We have helped identified more than 200 common items of equipment that can be created as standardised designs. Depending on project needs, these can be manufactured offsite and combined onsite.

Typically, 90% of construction work is in factory conditions, improving productivity, product quality and health and safety, while reducing waste.

To support the process, we have created an online catalogue storing a 3D model and all related data about each product. This includes information on dimensions, materials, operating capacity, cost, embodied carbon, and operational energy demand and associated carbon emissions.

Guidance on commissioning, operational and maintenance procedures, and on how to order and fit replacement parts is also provided – supporting whole-life management of assets.

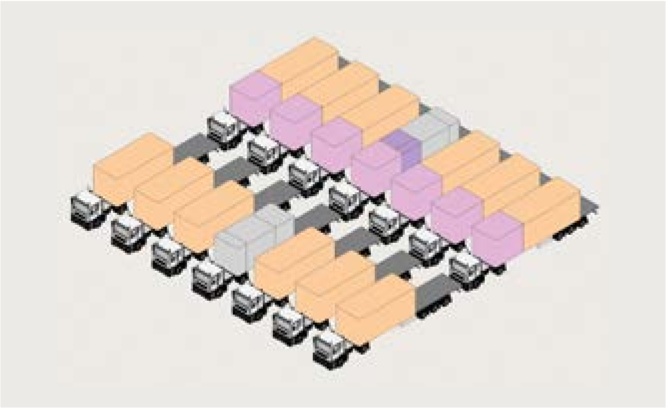
Often clients across an entire sector have the same needs. We are collaborating with Anglian Water, United Utilities, Laing O'Rourke and other firms on DfMA, prefabricated assemblies and standard products.

Priority School Building Programme

In 2015, we worked with design consultancy Bryden Wood to provide technical advisory and design management services on the Priority School Building Programme. As part of the project, the team reviewed the space needs of schools, developed a set of standards to be applied for various types of rooms, and then looked at the capabilities of specialist modular contractors to deliver against those standards.

Of the 277 school projects across the South West of England, around 90 were constructed using the modular, DfMA approach. Each modular school took three months to complete – compared with 10 months for traditional approaches – minimising disruption during construction and creating space quickly to meet demand and improve facilities.

The lessons learned were applied on a subsequent project to replace small primary school blocks. We worked with modular contractors to create 'flatpack' components, reducing the number of deliveries to site, while cutting time onsite to deliver a 400m² project to just 3-4 weeks.



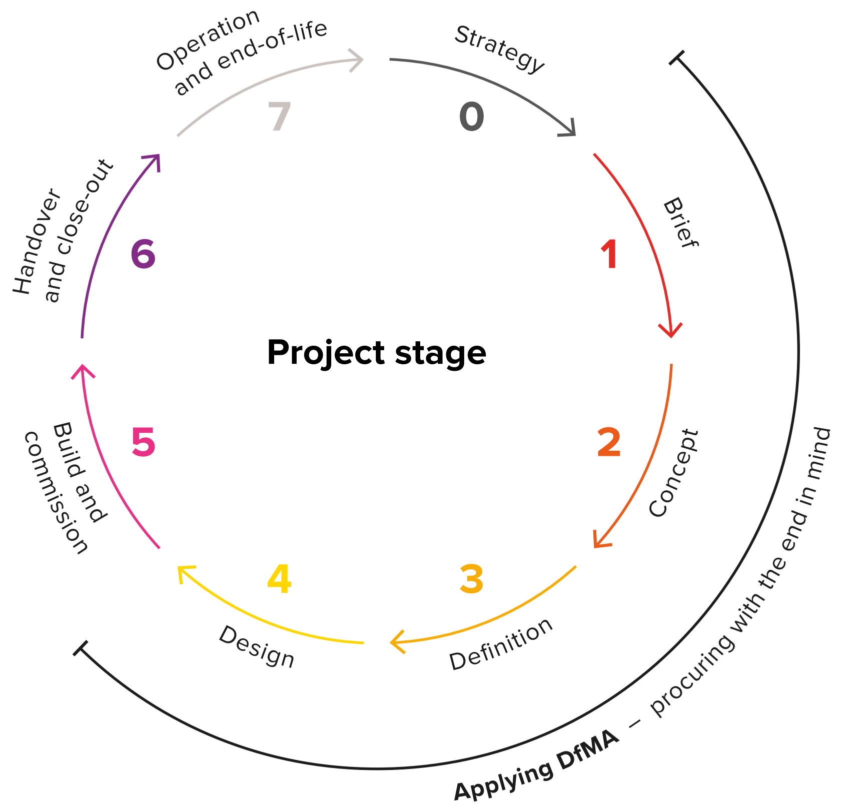
"We were careful to catch all the design lessons learned on phase one, and to target suppliers with relevant capabilities. Lowering the barriers to entry let small companies compete – they proved very agile and very innovative. Looking at smaller firms gave us access to a really hungry market with fantastic ideas."

Project director

66%

reduction in onsite delivery time

3 Procuring with the end in mind



The UK BIM programme is based on a desire by government departments to get more for less from their expenditure on built assets.

The UK Construction 2025 targets include reducing costs by one third, delivering projects in half the time take using conventional design methods, and halving a scheme's greenhouse gas emissions.

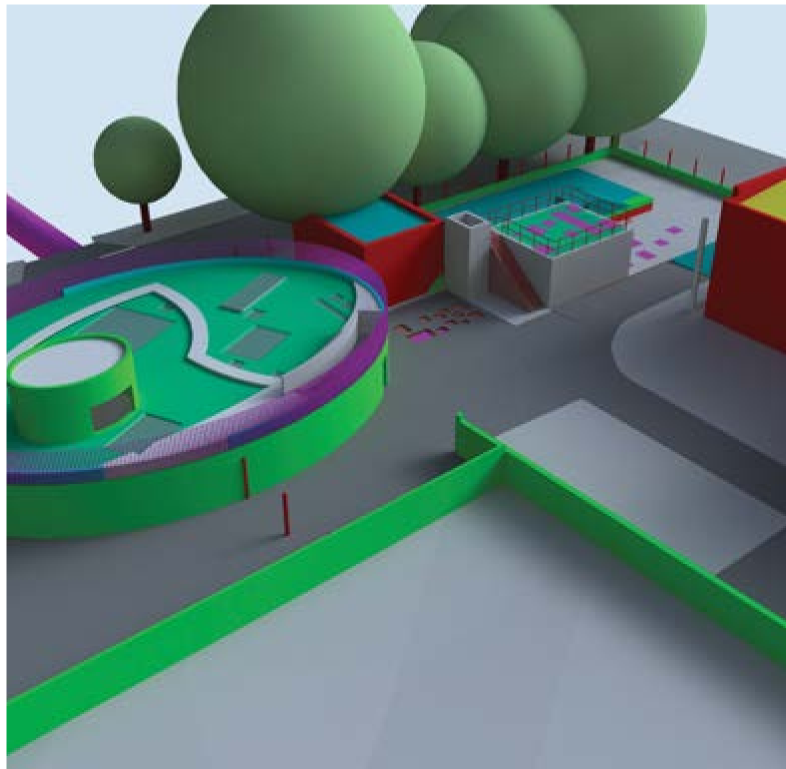
The goals underline the government's ambitions, and its BIM programme has been accompanied by initiatives to improve procurement. Contracts are being updated to explicitly support BIM, while the Cabinet Office has advocated new models of construction procurement, such as cost-led procurement, two-stage open book and integrated project insurance, to encourage better supply chain collaboration and reduce commercial risks. Clients adhere to three basic principles.

Clearly define the desired functional outcome – including specific requirements, such as carbon reduction (embodied and in-use), and use of apprentices.

Identify typical costs and delivery outcomes – using available data, benchmarking and cost-planning work to set a challenging cost ceiling, with costs further reduced over a series of projects or programmes of work.

"The DfMA challenge for suppliers is dependent on what they can do, and at what price. Now we're having some collaboration at an early stage, so we can evolve our thinking as the design evolves."

Senior project manager



> "A client's attitude to procurement and risk is critical. They need to believe that adopting early contractor involvement is not a reduction in their competitive tendering power, but an advantage in terms of reduced risk."
>
> **Director**

Engage the value chain early
– early involvement of contractor (and manufacturer) and a high level of supply chain integration with the aim of delivering best whole-life value.

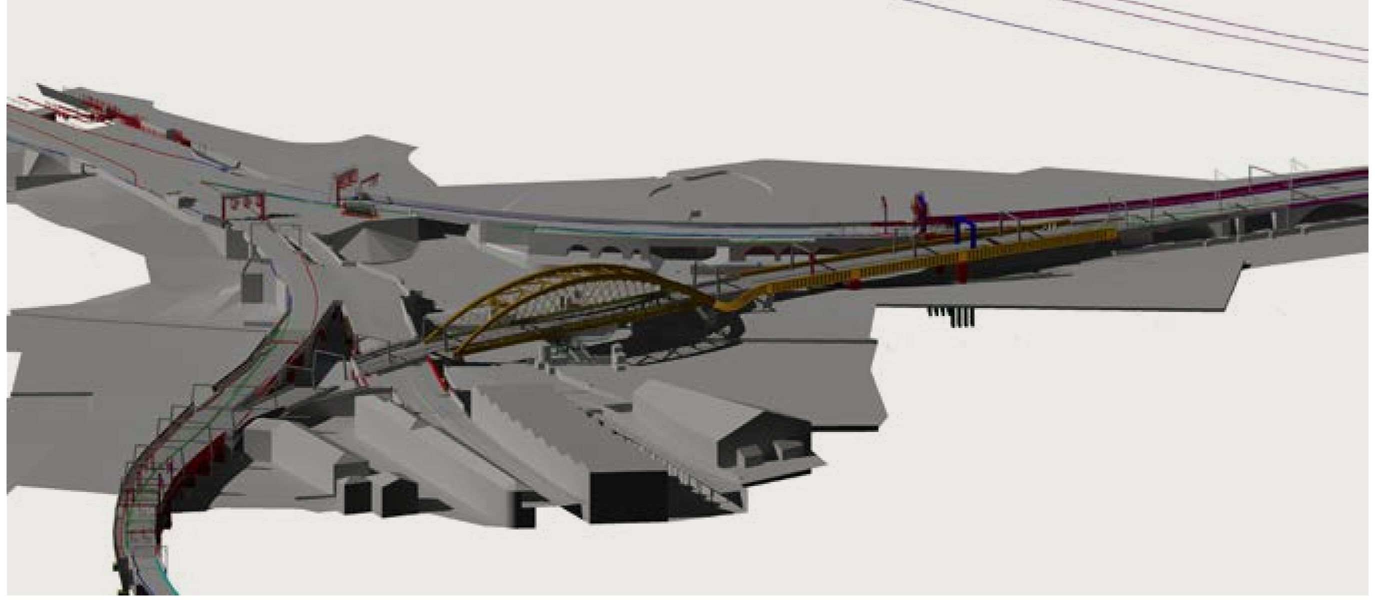
Similar approaches to procurement are being emulated outside government projects, and the combined impacts of BIM implementation, DfMA and rethinking procurement is already evident and driving new forms of collaboration. We believe professionals need to develop the collaborative behaviours required to deliver greater innovation, particularly at the boundaries between design and manufacturing, and onsite assembly and construction.

To facilitate this change, we have been working to embed new approaches into our digital delivery processes. We have established a:

- **Digital component catalogue** populated with information-rich BIM objects, ready for consideration and application in DfMA
- **Common data environment** that helps us provide efficiency and quality in information development and exchange
- **Specialist BIM consultancy team** to assist asset owners globally to transform their own ways of working and procuring projects
- **Global delivery service** to ensure we deploy engineers to work on a wide range of projects spanning disciplines and continents, enabling them to apply best practice regardless of its origins

BIM is a key to exploiting the opportunities that DfMA brings. But for a successful approach to BIM and DfMA, integration of the supply chain is essential. DfMA blurs the old divide between manufacturers and suppliers and contractors – some main contractors are developing manufacturing facilities, while some manufacturers are working directly for owner-operator clients keen to harness their product design expertise. DfMA is also blurring the boundaries between once-separate disciplines and their specialist designers and suppliers. Systems should not be developed in isolation but looked at holistically and, where possible, integrated and combined.

Procurement must ensure contractors and manufacturers are involved in design development and construction planning early in project inception. When assembling teams, the client should consider its ability to deliver innovation using BIM and DfMA. BIM must be included from the beginning, with a focus on information and considering the whole lifecycle. The UK government's approach to BIM has ensured the whole lifecycle is considered, with a suite of standards in place to support industry on its journey. DfMA can also help reduce the number of firms involved in project delivery.



Approval process cut from four weeks to

one day

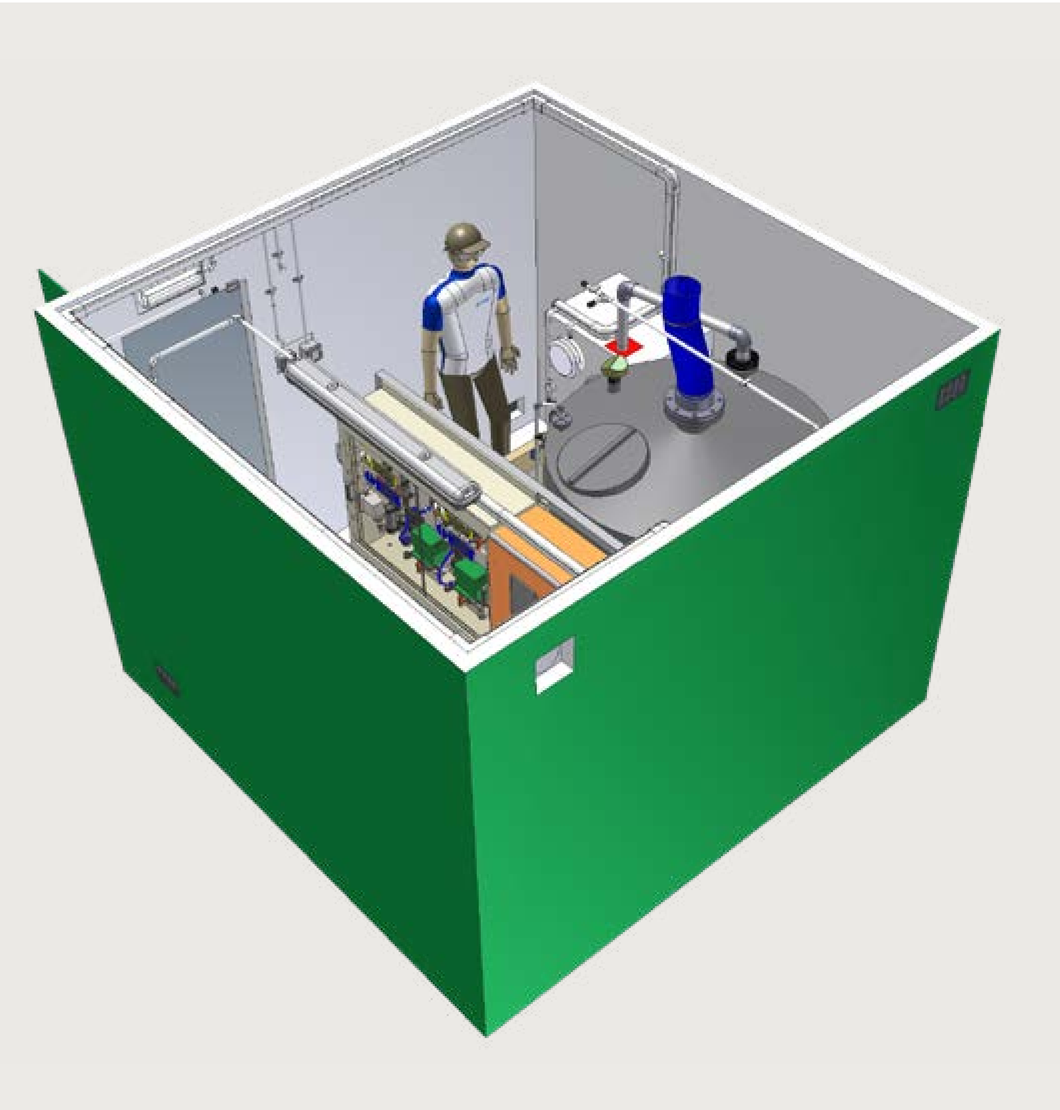
Ordsall Chord

For the Ordsall Chord railway link project in central Manchester, our joint venture with AECOM worked with steelwork fabricator Severfield to model designs for a footbridge over the River Irwell. The combined team aimed to eliminate 2D drawings, instead managing design and fabrication through a single 3D building information model.

Instead of the normal four-week approvals process, an approved model was agreed after a meeting lasting just over five hours. Compared with previous projects, the number of change orders was significantly reduced. Eliminating drawing production saved around £10,000, while Severfield estimates that its design time was halved.

Anglian Water

At Anglian Water, ‘stretch’ targets for suppliers include carbon reduction. At a programme level, the utility had managed by 2013 to reduce capital carbon by 39% and operational carbon by 34% against a 2009 baseline. Extensive use of standard products and supply chain efficiencies from early contractor involvement played a vital part.



39%
less embodied carbon

34%
less operational carbon

2014 Commonwealth Games

Our teams designed major ‘overlays’ for the London Olympics, as well as the 2014 Commonwealth Games in Glasgow, UK, and the 2015 Pan American Games in Toronto, Canada. Much of the work involved procuring standardised components – power generators, toilet blocks, broadcast trailers, etc – most of which are rented.

Applying BIM approaches, we created an asset database of virtual components that could be tagged with attributes telling suppliers exactly what had to be provided. For the Rio Olympics in 2016, 250 distinct asset classes were created, reusing data from previous events. These asset classes incorporated many thousands of BIM objects, and numerous configurations of standardised kit were specified to meet them.

4 Designing for manufacture

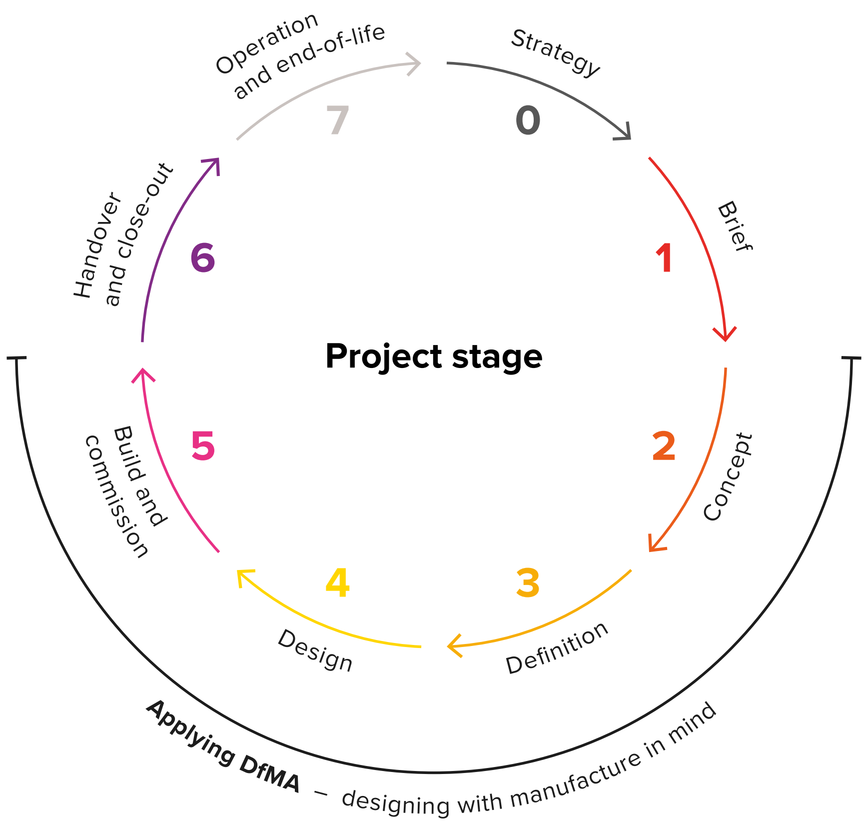
Like 'lean construction', design for manufacture enables waste and inefficiency to be minimised.

Design with manufacture in mind means designing so the most cost-effective materials and processes can be used in production, and minimising the complexity of the manufacturing operations. Several principles are applied:

- The DfMA process seeks to minimise the number of components, thereby reducing assembly and ordering costs and reducing work-in-process.
- Parts are designed with tolerances that are within the manufacturing capabilities of the manufacturer.
- Components are designed so they can only be assembled one way, particularly where they are to be installed by non-specialist personnel.
- Parts should require no adjustment.
- Minimising the use of components that make handling and assembly more difficult.

We have been working to create digital catalogues of products that can be included in our designs and then manufactured for a project when required.

As well as BIM, related technologies such as virtual and augmented reality can be exploited to help us visualise DfMA processes of manufacture and assembly, while embedded sensors can deliver real-time feedback on the products' operational performance. The emergence of robotics in construction, particularly in relation to additive manufacturing (building three-dimensional objects), is also making us rethink how we might design for additive manufacture in the future.



Davyhulme

We've been working with the Laing O'Rourke Imtech joint venture on the £200M upgrade of the Davyhulme treatment works outside Manchester – the largest wastewater plant in North West England. DfMA has been employed widely on the project, with almost 4000 prefabricated elements, from pipe bridges and walkways to tie beams and Abetong panels, being installed. New primary and final settlement tanks are among the 50% of items being manufactured offsite.

The use of precast, pre-stressed concrete wall panels and post-tensioning strands enables tank walls to be thinner than if they were constructed using traditional reinforced concrete poured onsite. The prefabricated elements reduce concrete and steel reinforcements by up to 20%. Offsite manufacture also reduces time onsite by between 50% and 90%, which has health and safety benefits.

Overall, DfMA is estimated to have achieved design savings of around £150,000, material savings in the range of 10-20%, and cut the delivery programme by three months.

£150,000
design savings

10-20%
material savings

Water industry

Investments in water infrastructure across England and Wales have been delivered since the 1990s through five-year asset management plans (AMPs). Consortia of contractors, consultants and suppliers compete to win contracts to deliver each five-year programme, with the successful groups working with familiar supply chains across a succession of projects. Mott MacDonald Bentley (MMB) has secured AMP work with Yorkshire Water, Severn Trent, Dŵr Cymru Welsh Water, Anglian Water, United Utilities and Northumbrian Water.

As part of its information platform, MMB includes a digital component catalogue, a library of high quality water-specific components that can be used time and time again. The catalogue started with 700 core items but grew rapidly in 12 months to more than 5000 standard components, supporting wider use of more sustainable DfMA techniques.

"With a component catalogue or a digital library, you can effectively drag and drop these solutions into your virtual workspace and plug them together, very much like virtual Lego, and then configure all sorts of different solutions."

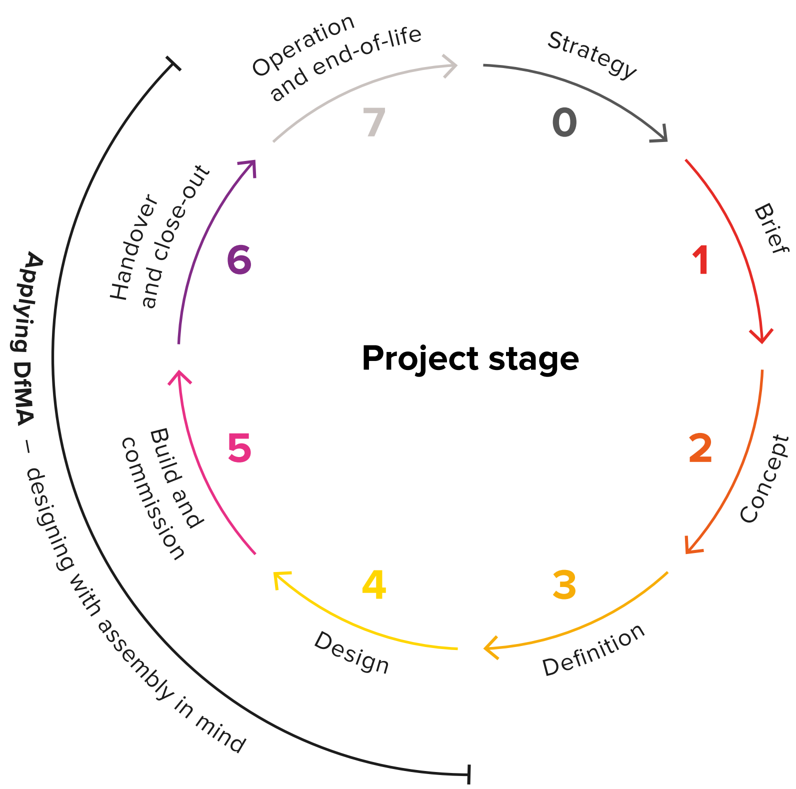
Technical director

Engineering Hope

In 2017, we published a report, Engineering Hope, looking at issues relating to refugees trying to escape conflict, or humanitarian or natural disasters. Part of its proposed strategy included the development of off-the-shelf, scaleable and flexible designs to enable developers to quickly plan and manufacture a city in the event of a crisis.

We're partners on a project led by the University of Bath and funded by EPSRC Global Challenges Research Fund to develop better and healthier housing solutions for displaced people using DfMA. Various prototypes are being constructed (right) and tested at the university's building research park in Swindon.

5 Designing for logistics and assembly



Design for logistics and assembly covers two areas: how a product or system will be assembled and installed, and how it will be transported to site and moved to its intended position as efficiently as possible.

Designers, manufacturers and constructors need to consider both aspects.

Designing for logistics aims to reduce the number of deliveries to site, and to simplify the transport and onsite handling processes. Several principles apply:

Evaluation
How will fabricated components, particularly bulky ones or completed modules, be delivered to the construction site?

Assessment
Can intermediate logistics centres be established near to the destination site so deliveries can be consolidated and enable just-in-time delivery? For the 2012 London Olympics sites, a depot was established just off the M11 motorway to consolidate deliveries to the Olympic Park.

Optimisation
Select and position appropriate cranes, hoists and other site machinery, plus loading bays, tool stores for example.

Alternatives
Consider flat-pack kits of components, so avoiding the need to transport bulky pre-built items with large voids.

Design for assembly will focus on ease and cost of assembly. This includes minimising assembly time by utilising standard assembly practices such as vertical assembly and self-aligning parts.

To make it easier to assemble structures, design a base for locating other components quickly and accurately, and using snap-fits and adhesive bonding rather than threaded fasteners such as nuts and bolts. Meanwhile, reducing the number of unique parts can cut the amount of labour required.

Think about testing, commissioning and handover requirements from the outset so that tasks can be managed safely, quickly and efficiently can speed up the assembly process. Standardised solutions allow components or modules to be tested before installation, reducing risk of installer errors.

Early collaboration over logistical capabilities and the sequencing of onsite activities (4D BIM) is crucial, particularly where infrastructure may be temporary. A client may require that a facility be dismantled after use and be capable of reassembly and reuse elsewhere.

Denton service reservoir

To replace an unstable earth embankment at Denton service reservoir in Greater Manchester, our engineers decided against the usual gabion wall solution, opting instead for a DfMA approach using precast concrete Legato blocks to form the 100m-long wall. As the blocks were heavier than gabion baskets, the wall height could be lowered, reducing excavation and the need for temporary works. The approach minimised risks, reduced time on site from 47 days to 27 days, and cut total costs by nearly 20%, while requiring almost no long-term maintenance.

Reduced time on site from

47

to

27

days

20%

total cost savings

6 Managing assets through to end-of-life and disassembly

Design for operation will directly relate to the core purposes of the asset.

Once a built asset has been assembled and commissioned, it begins the longest phase of its lifecycle: performing the function for which it was specified, procured, commissioned and delivered. It also starts to require professional operation and maintenance, and periodic repair and refurbishment.

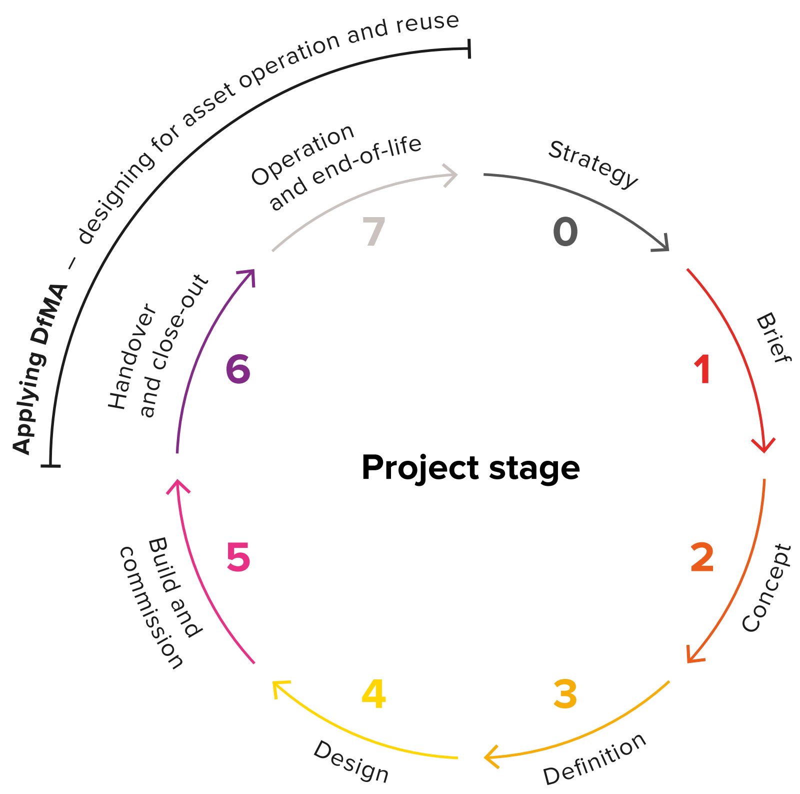
Design for operation considerations will directly relate to the core purposes of the asset. For example, designing assets that are:

- Durable and resilient
- Reliable and easy to maintain, perhaps with components that can be quickly, easily and economically replaced when necessary
- 'Smart' – incorporating sensors and data streaming devices so all stakeholders, including owners and manufacturers, can assess the performance and adjust their interactions with it. For example, being alerted before a breakdown occurs or when a fault is detected

Service life expectations will vary widely depending on the type of asset – some buildings may be temporary structures created for a one-off event, while core elements of other infrastructure may be designed to last decades or even centuries. So, it is important that we look well beyond the initial handover phase.

Whole-life performance

Conventional approaches to project lifecycles tend to adopt a linear view, working from early project stages through to end-of-life, but with little thought to the latter, often because this was going to be somebody else's problem at a distant future date. The approach is sometimes summed up as 'take-make-dispose'. In UK construction, one consequence of this attitude is that only 14% of construction and demolition waste is recycled or reused.



With some existing buildings and infrastructure being retrofitted with smart meters and other technologies, and new infrastructure often incorporating such ‘intelligent’ devices from the outset, we can start to reconsider our approaches to asset delivery and operation.

Circular economy thinking is prompting built asset owners and their delivery teams to look at more sustainable, even regenerative systems. The core principles are:

- Designing out waste and pollution
- Keeping products and materials in use
- Regenerating natural systems

In a circular economy, resource inputs and waste, emissions and energy leakage are minimised by slowing, closing and narrowing material and energy loops. This is achieved through a more holistic approach to long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing and recycling. This can involve:

- Increasing utilisation of an asset – so buildings have multiple uses during a working day, for example
- ‘Looping’ – using an asset more than once so that it has successive use cycles
- Extending asset use cycles so they have longer service lives

Asset owners and operators, their designers and the rest of the value chain must not only consider optimising the initial whole-life of an envisaged built asset, but also make provisions for its potential future life or lives. For assets with relatively short service lives in their initial state, this may involve provision of movable non-load-bearing partitions so that floor spaces can be reconfigured for new purposes.

Manchester City Council is already demanding that its developments are flexible so buildings can be redeveloped in a relatively short period as needs and requirements change and new users and functions take over.

Combining circular economy thinking with more vertically and horizontally integrated industry processes and systems, as well as data from intelligent assets, can help us deliver infrastructure assets that perform well across their lifetime(s). This can deliver greater economic and social benefits to society, without adversely impacting on our planet.

“We need to challenge construction to take circular economy thinking beyond recycling and waste management. Otherwise it’s like asking a funeral director to manage your health.”

Global head of sustainability

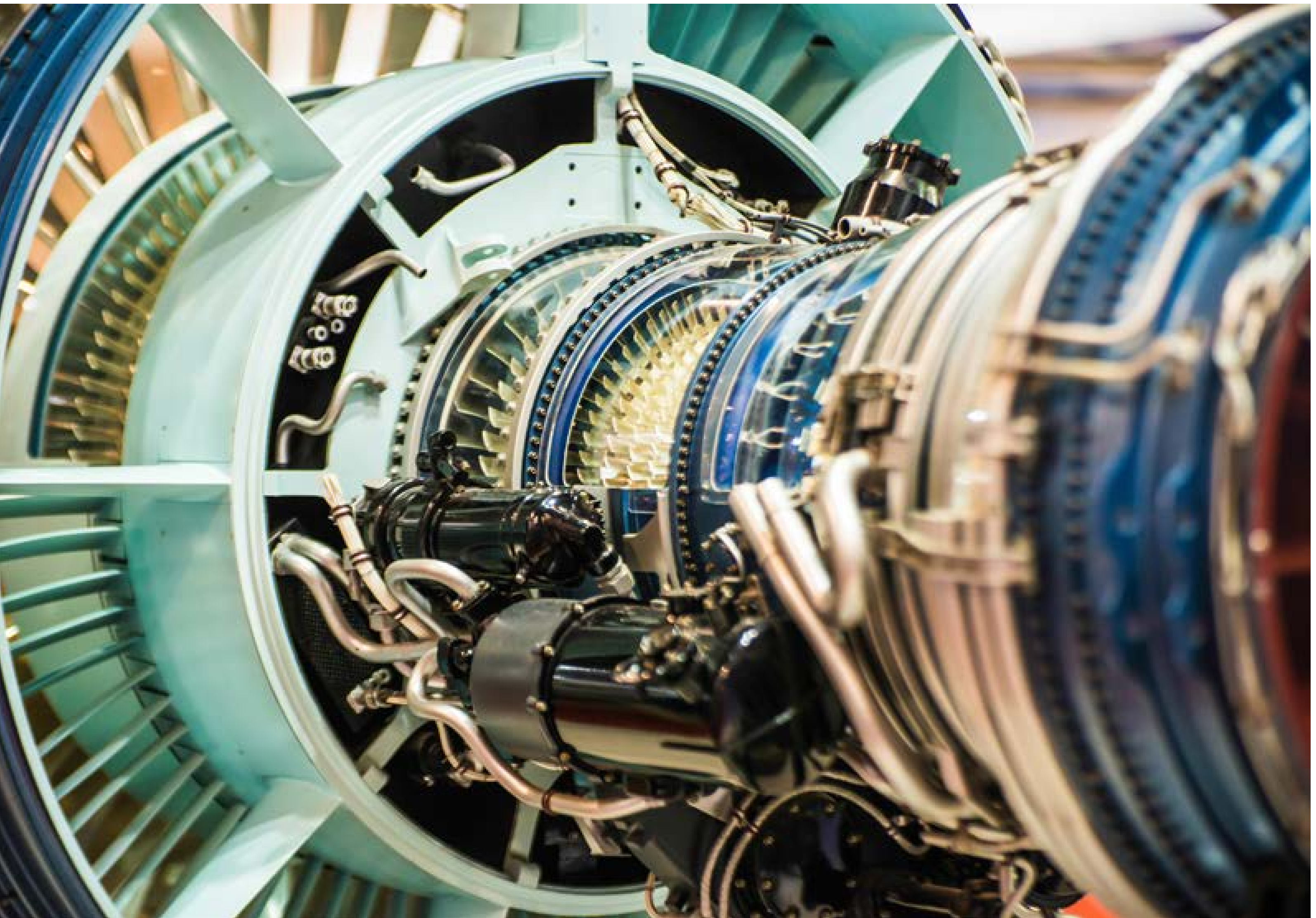
London 2012

Our design of the temporary facilities for the Woolwich shooting ranges for the 2012 London Olympics included reusing structural steel frames that had previously been used for Madonna's 2008 world music tour and for the Chelsea Flower Show. The piles holding down the tented structures were recycled sections of oil pipelines.

London 2012 used temporary venues for shooting, water polo, basketball and field hockey. After the games, the hockey stadium was scaled down and relocated to a new location in Leyton, just north of the Olympic Park.

7 Smart cities and value creation

Globalisation is speeding economic, financial, trade and communications integration.



Industry 4.0 is a term coined to reflect technology shifts combining automation, data exchange and manufacturing. It incorporates cyber-physical systems, the Internet of Things (IoT), and cloud and cognitive computing, enabling individual and systems of assets to communicate with each other and with humans in real time. The impact of industry 4.0 will be particularly acute on the built environment.

The construction industry has tended to lag behind other sectors in terms of digital transformation. It needs to catch up.

Design for manufacture, assembly and operation can help. It is a way for clients and industry teams to challenge existing business models by encouraging greater collaboration built around digital capabilities. We see it as a necessary disruption, forcing reconsideration of conventional models of project delivery.

The winners will be the disruptors who innovate and deliver successive high-performing infrastructure assets for their clients. By adopting a more holistic whole-life approach and investing for the long term, they cease to be providers of commodity construction services and products. Instead, they become leaner, value-adding businesses delivering 'assets as a service'.

Servitisation

Servitisation is the concept of manufacturers offering services tightly coupled to their products. It's about delivering a capability, not just selling a product, and features long-term, incentivised, 'pay-as-you-go' contracts. Since 1962, the jet engine division of Rolls-Royce has provided power by the hour. Its CorporateCare programme aligns the interests of the manufacturer and the aircraft operator, which pays only for engines that perform well.

A variation on the idea is being applied in the corporate real estate world by WeWork. It has developed co-working spaces, and systematically mines data on how customers use facilities to help it refine them so they are more efficient.

Connected environment

Creating a more connected built environment is not just about the creation of new infrastructure assets. It must encompass how we manage existing, legacy assets. With new build activities adding only about 0.5% to our asset base annually, we must be 'smart' about how we repair, maintain and refurbish the existing estate, and how we can apply DfMA during retrofits.

Reward for value creation

Data created from connected assets will help us measure the activities conducted inside buildings, across a wider digital estate, or even across an entire class of building or structure types.

For newly-developed infrastructure, this potentially provides a powerful feedback loop between the effectiveness of an asset's design and construction and the business outcomes that the owner-operator envisaged when the project was first conceived. It can also provide a feed-forward loop to help design the next iteration of those assets.

As we move to developing smarter cities, people's interactions with built assets can provide aggregated feedback on the economic, social and environmental performance of city systems.

As business models evolve, it will be collaborators that are rewarded across the lifecycle of our built assets for their value-adding contributions to a more efficient, connected, low-carbon economy.

Opening opportunities with connected thinking

Talk to us: ben.carlisle@mottmac.com

mottmac.com