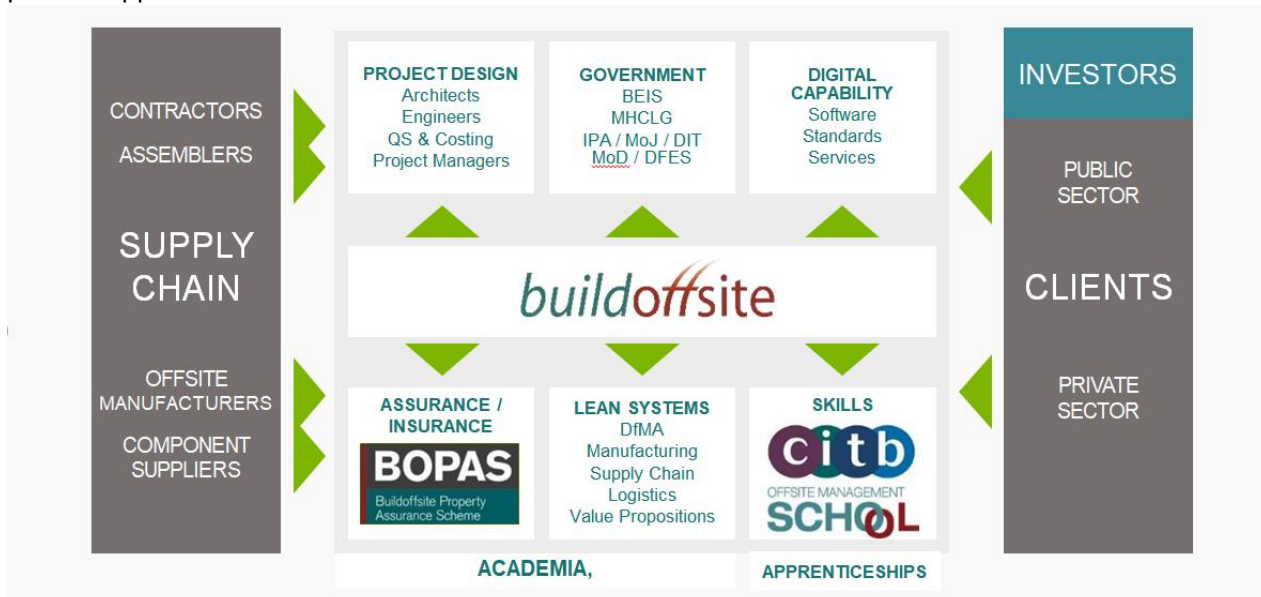


General

Buildoffsite is an industry body with members drawn from across the value chain as shown in the diagram below. By being part of the network, organisations have declared an ambition to improve construction delivery and more likely than many to be open to the concept of a p-DfMA approach.



With such a broad constituency Buildoffsite is responding on behalf of the membership as *trustee* rather than *delegate* representation. The evidence here is based on detailed insight into the challenges and potential across the Offsite sector. The intent is to take a holistic and non-partisan perspective across the value chain, with the underlying ambition being to drive improvement at the construction system level, rather than serve individual organisations.

Government has made a clear statement of intent to Transform Infrastructure Productivity, building on the 2013 Construction Strategy, continued through the 2018 Construction Sector Deal and TIES. This gives a clear statement of “**What**” needs to be done and the “**New Approach to Building**” seeks to articulate the “**How**” to deliver through p-DfMA.



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Q1: How can the government best encourage the adoption and implementation of this approach in its capital programmes?

Across all stakeholders the primary ask of government is

- A clear vision of the ambition for the construction sector
- Consistent policy over multiple years to support it
- Increasing levels of practical detail about how industry can engage to deliver

The Vision is clear and consistent and the Construction Sector Deal gives policy support, although there has been slow progress in communicating options for industry engagement.

The '*presumption in favour of offsite*' is a clear direction but what is needed is to set the ambition for what good looks like and a government roadmap to ensure its adoption. Contrasting with the Government led BIM strategy: There was a clear roadmap and a deadline for adoption of BIM Level 2 and, with less detail, the ambition for higher BIM levels.

Key asks of government

- Articulate the approach to implementing the Presumption in Favour of Offsite and testing on projects across the 5 Core Departments
- A concern is that the House of Lords Science and Technology Committee recommendations were not adopted in 2018.
- Clarity of the Desired outcomes from the 5 Core Departments from p-DfMA
- Set a roadmap of milestones the industry is mandated to meet to supply HMG
- **Link directly to Departmental Capital Investment programmes**
Industry will respond to a clear pipeline of activity – the more consistent the better.
- Refine the programme with increasing detail annually

A challenge is to get the balance right between being too vague / general and too prescriptive too early. Buildoffsite's proposal is to begin with a framework of outcome based requirements for building systems and the interfaces between them. Industry can then align with the standards and innovate to add value. Contrast with the diversity and value of Bluetooth devices working across a standardised framework protocol.

Challenges:

- p-DfMA is a valuable tool: There's a risk of it being a solution looking for a problem.
- Which are the specific challenges for each department? Quality? Speed? Cost?
Which requirements are consistent across all 5 departments?
- With p-DfMA there may be a temptation to jump directly to a solution in a single step. However this has two distinct failure modes: (i) adopting a particular solution that misses wider applicability. (ii) alienating stakeholders with a solution that has no industry ownership or buy-in.

Industry will align behind an approach which is well thought through and where there is a viable opportunity to evolve their business to meet the opportunity. Industry engagement is covered in Question 3.

The construction sector is noted for its inertia and lack of proactive investment. There is however a '*rush to be second*' once a model is proven. Government's role is to enable initial success without over-supporting (e.g. Feed in Tariffs) or solving the wrong problem (e.g. Green Deal)

To Consider:

- P-DfMA is Not just about buildings
- P-DfMA is Not just about volumetric solutions
- Resist the temptation to back individual businesses with direct investment – at best it alienates other businesses, at worst it undermines other industry investment.

Q2: Within the sector what changes are needed, including in relation to technologies, skills and commercial models, for this approach to succeed?

If p-DfMA and other Offsite innovations are to deliver significant value: the most critical change across the sector is to increase levels of collaborative working.

Currently clients and their consultants do not have a good understanding of what drives project cost / value (particularly with offsite solutions). Equally manufacturers and suppliers are not close enough to their clients to be clear on the outcomes they seek to achieve. Contractors, in the middle, perhaps inadvertently, as a result of procurement practices, act as a barrier to collaborative problem solving and the adoption of a p-DfMA approach.

This has led to a highly **transactional** and **litigious** industry (as noted by Project 13 @ ICE). A key role of Buildoffsite is to encourage collaboration and partnership across the value chain so that new ideas can be explored, tested, validated and embedded as business as usual. Only through iteration and continuous improvement can p-DfMA approaches succeed.

People

Behaviours

- Leadership - collaboration across the value chain from boardroom to site
- Inspire, attract and develop new talent - reflect their value with rewards
- Do not tolerate gaming or behaviour which achieves results at the expense of others
- Emphasis on solving and avoiding errors – rather than apportioning blame.

Skills / Knowledge

- Invest in skills / apprenticeships – don't leave it to others
- Shift to Multi-skills not silos – avoid trade and role demarcation
- Creative use of labour pools – Offenders, NEETs retired, part-time, gig economy.
- New perceptions of site and factory roles – e.g. Precision Manufactured Homes

Process / Commercial (more detail in Question 7)

- Use collaborative R&D funding to drive Construction innovation / investment,
- Collective project gain share to drive partnership and share risk.
- Government as a client; recognises and funds IP developed for wider benefit.
- Ring fenced profit £ not % - to encourage innovation that reduces whole life cost.
- Enforce the use of standards to drive scale and reduce complexity
- Capture performance and lessons learned –Open source

Technology

- Converge construction and manufacturing – for success; neither can be dominant
- Blurring of digital, physical, process skills – use of VR / AR and other technology.
- Simplify first to reduce complexity – automate only when process is repeatable
- P-DfMA is part of a spectrum not a single solution: don't jump to an answer too early.
- Digital technology has a key role to enable collaborative workflows across disciplines

Key requests for government to encourage industry change:

- **Recognise and reward positive behaviour and investment in capability**
Government delist suppliers that do not meet the behavioural standards
- **Collaborative R&D Funding as a stimulus to develop p-DfMA standards**
Targeted problems from departments, invest and make framework IP open source
- Encourage collaboration with procurement models that recognise its value
Multi-tier Joint Ventures, Project Bank Accounts, Pooled Gain Share.

Q3: How should government engage with industry to make sure this approach succeeds?

To encourage stakeholders across the industry to engage; Government should respond to the question of “*What's in it for me?*” from stakeholders considering engaging with p-DfMA.

- **Clients (government):** Need central support and coaching to define their construction requirements in line with the Rationalise, Standardise, Optimise, approach of p-DfMA. A funding model where investment in developing high capability in the medium term is not overruled by short term lowest capital cost procurement.
- **Clients (private):** Need confidence in the robustness of supply; Clients will adopt proven p-DfMA supply models if the value is clear. Some repeat clients will further invest in capability where traditional construction is failing to meet requirements. This will be accelerated if there is p-DfMA synergy across public / private clients.
- **Consultants (AEC):** Less enlightened architects, engineers, QSs and construction professionals see p-DfMA as a threat. Buildoffsite members engage with clients and supply chain to add additional creativity and value. Their participation is essential to continue the migration from rationalised to optimised, excellent design and delivery.
- **Contractors:** Increasing Offsite supply changes the nature of a traditional contractor. Some may evolve current models, others may create new models. There will also be new entrant specialists as ‘assemblers’ or ‘integrators’. Their motivation to engage will be based on an opportunity to secure future work or a fear of being obsolete. There are pockets of innovation in most tier 1 contractors and those teams tend to be the people most engaged in Buildoffsite membership.
- **Manufacturers:** Of offsite solutions have often struggled to attract investment for enhancing capability because of the volatility of demand on their businesses. A clear pipeline of *repeatable* projects, where the client requirements are known (but may evolve) and contract award criteria are consistent will encourage participation.
- **Wider Supply Chain:** Component and sub-assembly suppliers are frequently too far removed from the specification stage to influence procurement, even though their solutions may have a significant positive impact. Through collaborative networks they showcase ideas and get market feedback on the problems worth solving.

The construction industry is diverse and there are perhaps too many industry bodies that Government can engage with. If the desired outcome of engagement is as follows:

- **Disseminate** – Share HMG plans, policy and opportunities
Needs a clear understanding of where sections of the industry gather and gain industry insight. Trade press, events and trade bodies are likely to be sufficient.
- **Gather feedback** – from consultation and data from real projects. Respondents may be self-selecting and trade bodies risk taking a partisan perspective.
- **Stimulate activity** – including innovation and the adoption of p-DfMA. Even using Innovate UK as a vehicle government is remote from the SMEs in the sector.

Of the existing cross industry bodies the following are suggested as the most likely to influence industry players to engage in p-DfMA programmes of activity.

- The CLC has broad representation but via voluntary participation and as a result tends to be top down.
- Innovate UK, as the BEIS direct funding body, is an excellent vehicle for stimulating p-DfMA activity. However, many SMEs do not recognise their own potential to participate and so funding applicants tend to be from a limited pool. Buildoffsite is addressing this by putting together bidding consortia as part of its core activity.
- Construction Innovation Hub (CIH) has an ambitious plan to integrate construction and manufacturing and be both a catalyst and enabler of innovation. Through BRE and the mtc there is a plan to connect widely across the industry, from a somewhat standing start. With Buildoffsite & Constructing Excellence as key engagement partners CIH and government will have connections across a breadth of industry.
- Buildoffsite is a platform on which members:
 - Share their insight and current challenges
 - Learn from peers, clients, suppliers and government.
 - Connect to find partners and collaborate to solve member challenges.

This covers all identified areas of government engagement, but is limited to those that have signed up to the membership model. The collaboration with the CIH is a mechanism by which Buildoffsite practical activity

and SME engagement can be increased (currently modestly) to enable wider construction and manufacturing industry engagement in p-DfMA in public and private projects.

- Specialist Bodies, both trade and sector groups (e.g. CITB, BuildUK, CPA, RIBA) have a valuable role to play and the more they can be aligned and integrated with the CIH & CLC perspective the clearer the p-DfMA message to the wider industry.

There is significant benefit from government engaging through established industry bodies to minimise the risk of the default construction reaction of *'Not invented Here'* when non-construction bodies suggest adopting practices from other sectors.

Key suggestions for government to engage:

- **Industry Bodies** – A clearly aligned IPA / BEIS message that HMG is committed to and industrial approach to construction and that the single vehicle to influence both the change and pace is through the CLC as a Government – Industry partnership.
- **Clients** – Government clients engage directly with CIH, CLC & Buildoffsite to set the industry challenges. IPA an investor to develop medium/long-term p-DfMA solutions for government clients, rather than short-term focus on minimum capital cost.
- **Consultants** – Government aligned with CIH / CLC to map out the p-DfMA potential for the professions and press for cross-industry collaboration / alignment.
- **Contractors** – Engage through trade bodies (BuildUK, CECA) for dissemination and feedback. Encourage the contracting innovators through Buildoffsite and CIH.
- **Supply Chain** – Cascade challenges to offsite manufacturers and supply chain via CPA and Buildoffsite. Practical activity through CIH, Buildoffsite engagement for IPA p-DfMA investment or collaborative R&D funding

Q4: How can the benefits of this approach best be measured?

Experience across industries confirms that it is challenging to deliver meaningful and widely accepted top-level industry metrics. Absolute values are open to disagreement and so trends and rates of improvement are more likely to be supported.

The Construction 2025 Metrics (50% faster, 50% less CO₂, 50% reduction in the trade gap, 33% lower whole life cost) are valuable output metrics to monitor progress and should be maintained as the top level with Productivity (value added per labour hour) as a key addition.

Smart construction metrics developed by the CLC 'Innovation in Buildings' group are aligned, but still under development (www.constructionleadershipcouncil.co.uk/building-metrics/) covering: Quality, Safety, Time, Cost, Productivity, BIM level, Premanufactured Value (PMV) and Home Completions. p-DfMA fits with PMV, but workable definitions and mechanisms to capture are proving elusive. As a result pragmatic proxy measures are proposed.

For offsite / p-DfMA progress can be measured by distilling down to two key metrics:

- **Site Productivity: Project Value delivered / site staff hours applied. (£/hr)**
All site logged hours: trades, management, security etc. This will show the trend of increasing work offsite in factories and is an easily measurable proxy for PMV.
- **Value Delivered: Project Capital Investment / Area delivered (£/m²)**
Comparisons are only valid between similar projects (e.g. schools or roads)

- **In tandem Productivity & Value show the impact of p-DfMA**
These are 'lagging' metrics and will support or challenge the success of p-DfMA
- **Whole Life Value: Project Whole Life Cost / Area Delivered (£/m²)**
Takes in to account the cost of operation, maintenance and repairs for each /m² built

Each of the lead p-DfMA government departments should assess the **site productivity** and **value** of similar projects (should be possible retrospectively with these simple metrics). This can be contrasted at both concept and costed technical design phases of a p-DfMA project. This exercise should be done collaboratively for the first project, and theoretically for second and say 5th iterations of the platform delivery. At the first iteration the design investment in rationalised and standard solutions may exceed the productivity benefit. At the second iteration the reduced design

input should be apparent and by the 5th iteration the benefits case for cost and programme is likely to be compelling vs. traditional construction.

If not the underpinning assumptions for p-DfMA need to be reviewed and challenged.

This 'Design for target cost - Df(£)' approach is used in engineering sectors to test viability of product designs. Requirements can be expanded to include speed, specification, CO₂ etc. and each "Design for..." variable become Df(x). At the 'system' level multiple requirements are aggregated and it has recently been proposed by Keith Waller of CIH to designate this as DfΣ - Design for the sum of the parts. DfΣ may include GDP, jobs and societal value.

Key requests for government use of metrics:

- Specify outcome metrics rather than inputs: e.g.: Programme reduction not PMV
- **Use existing data where possible** – do not add to the burden of data collection, but leverage technology adopted for other reasons –cost of data capture is reducing.
- **Planned 'ratcheting up' of metrics** – Clarity of direction and rate of change. e.g. Home Energy performance mapped out in the Code for sustainable homes.
- Recognise suppliers that meet or exceed metrics with additional projects.
- **Build on available existing data** - Don't let perfect be the enemy of good.
- **IPA Hold anonymised benchmark data** (by sector, by stage, concept ,design, cost)
- Metrics should Not be procurement led
- Plan to include Whole Life Cost - as digital data delivers insight.
- **Keep metrics simple** - to Improve ability to audit and test transparency

Q5: What risks and costs (including hidden and associated costs) would this approach create for your organisation or sector?

A p-DfMA approach has potential to **mitigate** some current risks in current construction:

- **Growing skills shortage** – it is faster to upskill in a factory than on site, although there is a greater lag to create new factory capacity than to scale existing.
- **Bespoke design & serial prototypes** - Clear government client requirements with a p-DfMA approach mitigates bespoke manufacturing costs for current offsite suppliers.
- **Lack of demand visibility** – Clear p-DfMA requirements linked to a pipeline of work will give manufacturing supply chains greater confidence to invest.

Risks

- **Procurement / payment misalignment with factory production:** The bulk of p-DfMA material, labour and overhead costs are incurred before the items arrive at site This is a major working capital burden on the supplier or requires a change in project payment schedules. Industry endemic delayed payments to suppliers add to the risk.
- **Government Client Cash-flow:** The investment in p-DfMA for repeatable product solutions is a significant up-front cost for client and/or supply chain. This is at risk unless IPA provides strategic investment that can be recouped by long-term saving.
- **Well-funded overseas suppliers** backed by development investment may out-bid UK supply chains to de-risk the client investment, but exclude UK supply.
- **Vested interest in duplicated workflows** - If architects / engineers are not engaged in the p-DfMA approach, producing bespoke (rather than mass-customised) designs, the benefits of a p-DfMA approach will not be delivered for client or the supply chain.
- **Associated processes not aligned with the approach:** Planning, Building control, insurance and assurance may struggle to keep up with p-DfMA. This has been the logic behind the BOPAS, BSI, BRE and PAS standards; However, multiple standards and warranty assessments add **accreditation duplication and burden** for suppliers.
- **Clients and investors risk selecting an incapable supplier** – this can be mitigated by wider collaboration across the sector.

Costs

- **Investment is significant for a robust repeatable p-DfMA** (structural, fire, energy) If fully borne by the supplier it may be a major barrier to development. With joint investment from supplier, client and government there is shared burden and greater incentive to ensure success. Amortising costs equitably over multiple iterations.
- **Quality system / accreditation costs** – Often undercalled by start-up manufacturers
- **Parent Company or external Guarantee** is required by clients to protect themselves from supplier failure. This adds cost/and or delay and may tip a p-DfMA solution to be unviable. A government backed **Business Investment Guarantee for suppliers would mitigate this cost / barrier.**

Key requests for government support to mitigate Risks / Costs:

- **Government to adopt procurement models that support p-DfMA:**
To manage up-front design investment, cash-flow and shared risk and reward.
- **Minimise duplicated work flows with mandated rationalised design**
Limit the level of design change per iteration of the platform delivery.
- **Cross-government alignment with p-DfMA:** In planning, building control, and a firm mandate to avoid proliferation of competing standards that add cost not value.
- **IPA (for example) to act as investor in p-DfMA approaches.** With the expectation of recouping the investment through reduced project cost over multiple iterations.
- **Creation of a government backed Business Investment Guarantee:** To act as an underwriter of accredited suppliers to avoid the burden of commercial finance bonds.

Q6: How can this approach best be used to support the economy on a local and a national level?

p-DfMA can positively impact the economy in 4 main facets:

- Increasing productivity: in design, procurement, manufacturing, construction and FM.
- Reducing waste in material, energy and human capital
- Accelerating delivery of infrastructure to support growth
- Generating world-leading solutions for export of services and goods.

All these have an impact at both the national and local level.

National economic benefits of p-DfMA

- Mandate that Departments share their reasoning where, despite the *presumption in favour of offsite*, a non p-DfMA approach is used. As proposed by the House of Lords Science and Technology Committee Building for Change (report para 135). Feedback can be used as catalyst for change in capacity, capability or procurement.
- Align innovation across multiple industries to share best practice – Ensure the CIH and the wider High Value Manufacturing Catapult align with best practice in the UK’s world leading Biomedical, Fintec, Digital and Energy sectors.
- Procurement with tangible incentives for supply chains to deliver UK Social and Economic Infrastructure ahead of schedule, based on the additional value, delivered.
- Support from Dept. of International Trade for companies to research international requirements for construction p-DfMA and align solutions with international markets.
- Provide wider opportunities to simultaneously use MoJ prisons as manufacturing sites and offender skills centres, linked to post release jobs and reduced reoffending.
- Work with industry to assess the need for, and stimulate the development of, UK p-DfMA capacity / capability linked to the strategic infrastructure pipeline.

Local economic benefits of p-DfMA

- Enable Local Authorities to offer tapered tax-breaks / incentives to stimulate investment in p-DfMA to deliver Local and National Infrastructure more productively.
- Encourage the use of local assembly factories, linked to national supply chains that productively add value locally, but reduce long-distance shipment of bulky products.

- Use high-technology branded organisations to stimulate local interest in the p-DfMA ecosystem (akin to Silicon roundabout).
- Align with Higher / Further Education to invest in scalable skills development.

Requests for government support to accelerate National economic benefits of p-DfMA

- Mandate Departments to share their logic where a non p-DfMA approach is used.
- Encourage CIH to align innovation across multiple industries to share best practice.
- Incentivise supply chains to deliver UK Infrastructure ahead of schedule.
- Department. of International Trade support for p-DfMA services and product export.
- More MoJ prisons to become p-DfMA manufacturing sites and offender skills centres.
- Align the infrastructure pipeline with the development of p-DfMA capacity / capability.

Requests for government support to accelerate Local economic benefits of p-DfMA

- Enable Local Authorities to incentivise investment in p-DfMA capability and capacity.
- Use of local / pop-up assembly factories to add value locally and reduce transport.
- Align with Higher / Further Education to invest in scalable skills development.

Technical and commercial

Q7: How would current contracting models and building requirements need to change, in order to best facilitate procurement from a product platform?

Procurement is regularly raised amongst Buildoffsite members as a crucial challenge; both by clients and the supply chain. The key aspects to address are:

- **All:** Significant pre-contract investment in developing p-DfMA product specifications, before any return is assured or can be amortised across multiple iterations.
Or possibly the investment is lost if a commercial agreement cannot be reached.
- **Clients:** Identifying suppliers capable of meeting their requirements and engaging them competitively to ensure best value, rather than single source pre-costing.
- **Clients:** Working within OJEU procurement rules to connect with new manufacturers
- **Clients:** Identifying approved contracting partners sufficiently experienced in working with offsite solutions; to avoid introducing additional risk of an unproven collaboration.
- **Contractors:** Managing prelims, overhead and profit at a level to make a viable profit when higher proportions of project cost are in the p-DfMA supply chain.
- **Contractors:** Managing the interface with a nominated manufacturer; perhaps with unknown risks and a lack of experience with the technology.
- **Suppliers:** A need for early project engagement (at risk) to scope the opportunities for p-DfMA solutions, before the design is fixed and potential benefits are missed.
- **Suppliers:** Client recognition of a very different cash-flow profile for p-DfMA supply.
- **Suppliers:** Supply is deemed uncompetitive as a result of supplier margin on margin and / or Client and /or Contractor cost consultants lack of understanding of p-DfMA.

Solution opportunities

- Collaborative R&D funding to drive p-DfMA innovation / investment / improvement,
- Develop a mechanism to invest in Whole Live vs. Capital Cost – unproven benefit
- Collective project gain share to drive partnership and share risk.
- Government as a client; recognises and funds IP developed for wider benefit.
- Central Gov't subsidises department level project investment in p-DfMA
- Enforce the use of standard solutions to drive scale and reduce complexity
- Central funding to support cash-flow for p-DfMA; not to subsidise the supplier.

- P-DfMA IP royalty can then become a revenue stream
- Government as an expert client to take increased project risk to encourage managed innovation and drive collaborative behaviour (enhanced Heathrow T5 model)
 - Central government holistic technical / procurement expertise
- Collaborative supply / value chains rather than Tier 1 subcontract cascade.
- Ring fenced profit £ not % - to encourage innovation to reduce whole life cost.
 - Payment terms transparent and policed – project Bank Accounts
 - Project reward pot – equitable allocation by value not scale (difficult)
 - Project based insurance (pool not duplicate)
- Greater access of specialists to client – not the innovation impasse (e.g. HS2)
- P-DfMA model encourages Small organisations to develop key elements – plug-ins
- A digital procurement for common components / elements / assemblies
 - Develop Block Chain Payment solutions for transparency and repeatability
 - SMART / intelligent Contracts
- P-DfMA solutions contracted to improve in line with target cost / performance criteria.
- Capture performance and lessons learned – Open source
- Rapid and cost effective dispute resolution: Contract arbitration - pendulum

Requests for government influence on p-DfMA contracting and procurement models:

- Collaborative R&D funding or direct investment in p-DfMA models for public works
- Develop mechanisms to avoid duplication in OJEU tendering for repeatable p-DfMA solutions whilst maintaining competitive tension and encouraging improvement.
- Collaborative contracts with central risk / reward / insurance etc.
- Seek technology based solutions to minimise payment delays and disputes

Q8: What unique requirements, including security, do different government departments currently specify that could (not) be rationalised or simplified?

Current departmental technical / space and performance requirements are very likely to include high levels of legacy specification. Diversity across departments will be largely historical rather than necessary.

This indicates a significant opportunity for rationalisation, standardisation and optimisation in-line with the core principles of p-DfMA. Standardisation does not necessarily mean that all buildings have identical components, aesthetics and design. A key principle is to standardise underpinning elements (structural, services and hidden detail) and support differentiation and diversity where it adds value functionally and aesthetically.

Start with some underpinning principles across departments

- Solutions are standardised unless diversity adds value: aesthetically or technically.
- Aesthetic diversity should be designed to have minimal impact on the structure.
- Standardise all hidden details where possible: e.g. M&E risers, lift shafts
- Don't standardise what adds value – e.g. homeowners ability to customise kitchens
- Don't standardise where there is no / marginal improved outcome – wall paint colour.
- Then test for exceptions – challenge whether the exceptions are real.
- Benchmark current commonality and target a future 80% level.
- Recognise and exclude technical outliers e.g. MoJ security walls / locks etc.
- Standardise upwards to higher levels of function or aesthetics:
 - e.g. Toyota standardised on electric windows and reduced costs even compared with the previous manual options.
- Develop a cross government design catalogue / configurator to design in an hour from common components.
- Incentive its use with improved speed of approval, additional funding, shorter leadtimes, reduced programme.

Opportunities for government standardised p-DfMA solutions across departments:

- Use the current 3 draft platform solutions and test across all 5 lead departments.
Identify the level of misalignment of the solutions: Crucial, material, historical.
 - Immediately standardise the historical variations.
 - Challenge the material differences and explore options for standardising in line with p-DfMA, or adapting the p-DfMA solution to accommodate.
 - Analyse the crucial misalignments to identify ways of minimising the impact (in production and operation) of non-standard components.
- Review the current draft platform solution standards at the component, assembly, room, building and asset level to maximise the potential for large scale commonality.
- Standardise towards higher rather than lower specification.
- Develop a Cross government catalogue for components, assemblies, spaces, assets.
- Incentivise its use

Q9: How and by whom should product, process and interoperability standards be set, validated and maintained over time?

If interoperability standards are left to the market there is likely to be a sequence of

- rapid development of alternative standards and solutions
- market is confused by the diversity of competing standards
- one or two solutions emerge as leaders (not necessarily the best technically – e.g. VHS vs. Betamax)
- a few brands become dominant and compete for market share; driving down cost and encouraging improvements in functionality
- potential commoditisation as solutions become optimised

There are examples where markets have recognised the mutual value of industry standards to increase interoperability and to reduce both R&D investment and product costs: The creation of the USB charger became a standardised solution, on a large scale, to drive down the costs of commodity components (not valued) and allowed investment innovation in improved charging technology (valued by customers).

To translate to the offsite sector there is value to multiple manufacturers in standardising on parameters (e.g. floor-ceiling height) as a mass market will encourage material suppliers align (pre-sized plasterboard – zero waste). However in some instances the cost to change away from current standards is a barrier.

Proposed approach to standard setting and maintenance is as follows:

- Initial central government investment to research key p-DfMA criteria across multiple departments:
Assessing; space standards, services, power U-Values etc.
- Summarised as a p-DfMA requirements specification
- Tackled by
 - an unfunded consortium of potential suppliers or
 - Innovate UK collaborative R&D -e.g. Innovate UK funded SEISMIC project
 - suppliers working with the Construction Innovation Hub
- Maintenance and update:
 - To add credibility and rigour; the inclusion of a recognised standards body (BSI, BRE) would be valuable to independently document and maintain the standard.
 - A key requirement is to ensure the costs to maintain and update the standard are justifiable and that users are not penalised by high costs to access.
- The update process should be designed to refine the standards and narrow down the solutions from rationalised, to standardised, to optimised.

Alternative custodians of interoperability standards (and their drawbacks):

Central government database of standards (not HMG's core role)

- Professional institutions? RIBA/ICE/CIBSE (lack of whole systems perspective)
- Industry Organisations such as Buildoffsite (across value chain but insufficient scale)
- Third party insurance providers (commercial interest)

- Funders / lenders including core VC groups (commercial interest)

Q10: What should the balance be between the core Intellectual Property (IP) which is retained and available to companies in the sector, and the proprietary IP that should be owned by individual firms?

In the construction sector and amongst offsite manufacturers in particular; there is anxiety about the leakage of unique IP. In reality there are very few examples of unique and robustly patentable IP within current designs ahead of platform thinking.

However, there will be competitive advantage in suppliers' capabilities to:

- Optimise production processes deliver more competitively
- Develop solutions with added options (above the standard) that government clients value and will pay extra for, or that secure market share as a superior product.

The distinction between core IP and proprietary IP for p-DfMA solutions.

The **core** IP is that which is needed to:

- Define the requirements specification for the p-DfMA solution. The baseline performance of the p-DfMA solution
- Provide the framework / infrastructure within which suppliers can innovate to add additional value whilst maintaining interoperability.
- Set the roadmap for future improvement of standards (e.g. tightening of specification over time akin BIM the maturity mandate)

The **proprietary** IP consists of suppliers know how to:

- Supply the p-DfMA product and service more competitively than alternatives.
- Create added value features and services that the market recognises as beneficial.
- Deliver the same p-DfMA outcomes and interoperability with a more attractive value proposition.

Core IP should either be in the public domain (open-source) or be held on behalf of HM Government and given under license for use by industry if it is of significant national value.

Proprietary IP may be kept secret or protected with patents by the individuals or organisation that generated it. Some proprietary IP may migrate to core IP as the sector matures and suppliers recognise the system benefit of:

- sharing designs and products for others to supply: Open source.
- licencing proprietary designs with a clear innovation valued by other manufacturers

As an analogy for core and proprietary IP:

- Core IP is equivalent to an Android Operating system
- Proprietary IP is equivalent to the Apps and widgets that run on it.

This highlights that, in the same way as some Apps lose compatibility with Android upgrades, proprietary IP may not be compatible as the core p-DfMA IP migrates.

In the digital space significant debates persist about the ownership of aspects of the digital model its components and data. Rather than duplicate the debate p-DfMA core and proprietary IP should aim to align with their digital equivalents.

Q11: Are there any other issues that you believe need to be considered if this approach is to be successfully implemented?

Innovation & investment

- Investment in p-DfMA should be seen as a progression not an instant final solution. There is a risk that draft platforms are fixed to early; ahead of DfΣ requirements.
- Whilst the investment in p-DfMA platforms is small in comparison to the Pharmaceutical industry (for example); it should be noted that designers and suppliers developing IP will not continue to invest if solutions are copied and commoditised so there is no mechanism by which they can get a sustainable return.
- Explore boundaries and potential with industry wide sand-pit test projects

People and skills

- There is an opportunity, with a current and Growing Social purpose amongst young people, to leverage the sustainability and social infrastructure agendas to attract new talent into the industry.
- Similarly the use of leading edge computing and visualisation has potential to attract able, technology focused young people.

Repeatability and pipeline

- Align technology parks nationally (e.g. HAL logistics hubs) as a UK supply ecosystem
- Relentless mandated delivery of p-DfMA through serial clients to refine the approach.
- Identify critical components as core challenges – Set a UK wide competition to develop the new '*widget*' with competing organisations engaged to deliver an optimised solution.

Collaboration & IP

- Technology and software providers should be encouraged to develop interoperable products and platforms to minimise the risk of splitting into different p-DfMA camps.
- Ensure appropriate IP sharing is part of any collaborative construction contract.
- Avoid being fixated by IP - it is often better to focus on the next innovation, rather than invest effort to protect a marginal current iteration.
- Key industry challenges are solved collaboratively, centrally, and cross industry.