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CIB Global Report - Revisiting Offsite:

A New Capability-Driven Research Roadmap for Offsite Design, Manufacturing and Construction

W121 Offsite Construction

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NOTE FROM THE AUTHORS

Offsite continues to gain momentum, with significant advances being evidenced over the last 10 years or so. This growth, pervasiveness and market uptake was not really fully appreciated or anticipated back in 2013 when we produced CIB's first Research Roadmap for Offsite Production and Manufacturing (TG74 Publication 372).

In order to address these new developments, this report reflects upon the antecedents of TG74 and its findings, highlighting the significant developments made in offsite since this publication. In doing so, it presents readers with a new capability-driven roadmap for offsite. This has certainly been a long but exciting journey. We are very grateful to everyone who has helped us get to this stage.

Thank you all.

Jack Goulding
Mohammed Arif
Volkan Ezcan
Jeff Rankin
Brandon Searle

Foreword: CIB Chief Executive

The International Council for Research and Innovation in Building and Construction (CIB) first established a Task Group TG74 – New Production and Business Models in Construction, with Jack Goulding and Mohammed Arif as the Joint Co-Coordinators. In 2013 this Task Group produced a Research Roadmap on Offsite Production and Manufacturing, presenting an overview of the offsite manufacturing market at the time, highlighting the key requirements needed for successful adoption and uptake. It presented findings from a three-year study, created through a series of workshops with domain experts taken from the design, manufacturing, construction, and research communities. Ten years on, this Roadmap continues to inform the offsite community, an impressive longevity.

At the time, offsite construction was seen as part of a holistic approach of construction as process, system, and business model. It had the potential to help our industry evolve into a modern one, with a magnitude of customer appreciation that architects, engineers, and constructors in most parts of the world could then only dream about. The research agenda was seen as vital to help the industry to develop, implement and apply new technologies, process and business models and people skills that will help the integrated model of offsite construction to mature.

TG74 was subsequently upgraded to a full Working Commission W121 – Offsite Construction in 2017, and CIB remains grateful to the two Coordinators for agreeing to continue in their roles. Deliverables were to include:

- a community of researchers and practitioners and in particular to promote CIB's work in this area with early career researchers and doctoral students;
- a series of developmental (sessions within) conferences, to run special issues in leading international journals and to organise a series of designated CIB Innovation Webinars;
- a research strategy to address theories relating to process innovation for Offsite Construction and to develop a second edition of the Research Roadmap addressing strategies, theories, and quick wins.

In the lifetime of the Commission the adoption of offsite production techniques has seen considerable acceleration around the world. Enabled in part by digitalisation, it has been a pillar of many government-industry strategies designed to transform construction and deliver on concepts such as Construction 4.0. With the publication of this second Research Roadmap, it gives me great pleasure to congratulate the Coordinators and Commission members on the conclusion of another very successful phase of CIB's work. There remain considerable improvements to be achieved, and barriers to be overcome, and we trust that the latest evolution of this research roadmap will help facilitate the research and evidence base necessary to support the industry's progress in this regard.

In closing, CIB wishes to place on record our appreciation to Coordinators Jack Goulding and Mohammed Arif of Working Commission W121 for leading this work for more than ten years. Special thanks are also extended to co-authors Volkan Ezcan, Jeff Rankin and Brandon Searle for their direct support and professional guidance throughout. Finally, CIB would like to express its gratitude to all W121 Commission members and external stakeholders, without whom this pioneering work would not have been possible.

Don Ward
CIB Chief Executive
International Council for Research and Innovation in Building and Construction
August 2023

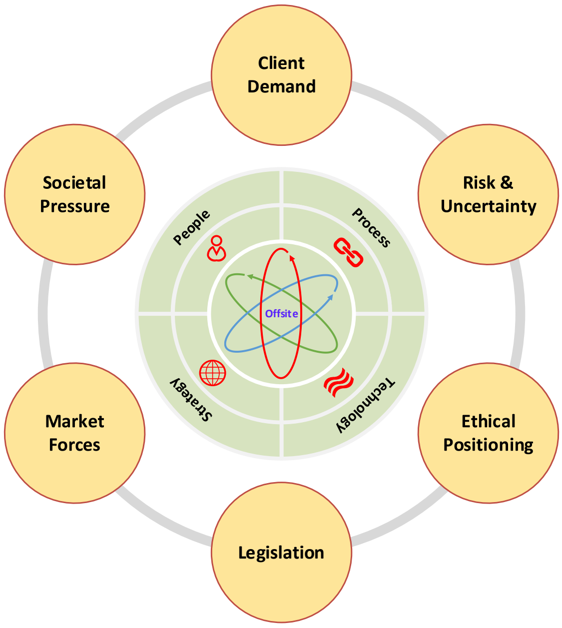
Executive Summary

The concepts, approaches, and application of Off-Site Manufacturing (OSM) in Architecture, Engineering and Construction (AEC) are seemingly evolving at an exponential rate. Where OSM terminologies embrace numerable (interchangeable) terms, including: off-site construction; modern methods of construction; advanced fabrication; pod technologies; industrialised building systems; modular construction; volumetric and hybrid construction. This growth is partially attributed to increased evidence supporting 'tried and tested' approaches, particularly when measured against 'traditional' productivity metrics. Perhaps more importantly, it is equally important to note here that the **OSM market has significantly matured over the last 10 years.**

Novel and highly innovative OSM solutions are now being showcased as leading exemplars. Where for example, innovation is now starting to pave the way for others to follow, with many organisations leveraging novel approaches to support the transition to Industry 5.0 (*Forbes*).

That being said, some might say that this transition is somewhat arbitrary and eclectic, evidenced by tiny 'pockets of excellence' on one hand; counterbalanced with poor uptake on the other. Arguably, the real challenge here is the lack of industry 'shared and collective vision'.

However, the OSM sector now has a much richer understanding of the market than it did 10 years ago, with firm evidence and improved knowledge supporting business models and platform strategies. This includes nuanced insight on organisational thematic boundaries across the 'traditional' silos of Design, Manufacturing and Construction. From this, greater insight is now being used to inform a range of issues, not least: risk, design, resources, skills, processes, automation and robotics, logistics and infrastructure demands.



The traditional, labour-intensive practices of the construction industry are no longer scalable. As we experience what is now an accelerated structural decline in the available and competent workforce, labour scarcity combined with growing technical regulatory challenges, including decarbonisation, are going to increasingly turn the spotlight on the need for improved productivity and exploration of different physical delivery models.
Mark Farmer, Cast Consulting

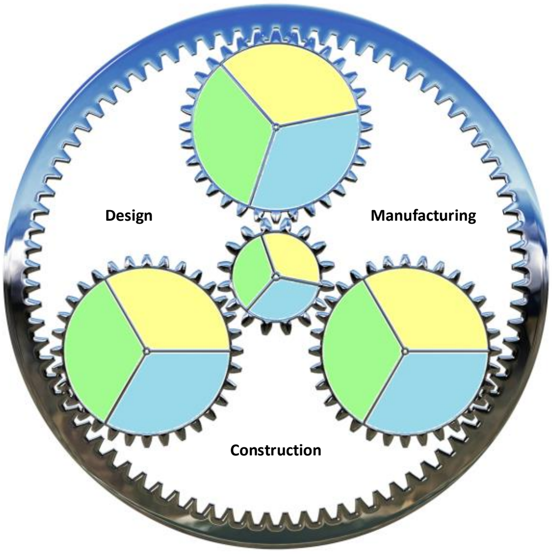
This report reflects back on the first CIB Research Roadmap for Offsite Production and Manufacturing (publication 372) published in 2013. The antecedents of this were critically examined and updated to reflect current thinking, culminating in the production of a new CIB W121 "Capability-Driven Research Roadmap". This was informed by leading experts from Design, Manufacturing and Construction, and provides a unique insight into the transitional pathways needed to support success for the next 10 years (or more).

This roadmap was initiated to update the previous roadmap and incorporate significant changes observed in the offsite sector over the past decade. The development process consisted of 11 distinct steps, each building upon the previous one to shape subsequent stages. Findings from this work were validated with domain experts from around the world in order to represent various geographical regions and contexts.

In an environment of uncertainty with volatile commodity pricing, unreliable shipping networks, spiking interest rates and a lack of confidence in pricing stability, off-site construction has the potential to become the shining beacon of stability in construction for those that have never considered it before. Just as it has always been for those that know the power of the method through experience, offsite manufacturing cannot remain construction's best kept secret for much longer. As the force that continue to threaten construction viability are consistently mitigated by building off-site, the industry must galvanize its capacity and prepare that the floodgates will continue to open wider, and this is only the beginning.
Vaughan Buckley, Volumetric Building Companies

This roadmap was developed on the principles of Crosby (1979) and Paulk et al (1993), which are rooted in the concepts and principles of quality and capability respectively.

This new roadmap leverages three main pillars: People, Process, and Technology – each of which are mapped across three thematic boundaries: Design, Manufacturing, and Construction.



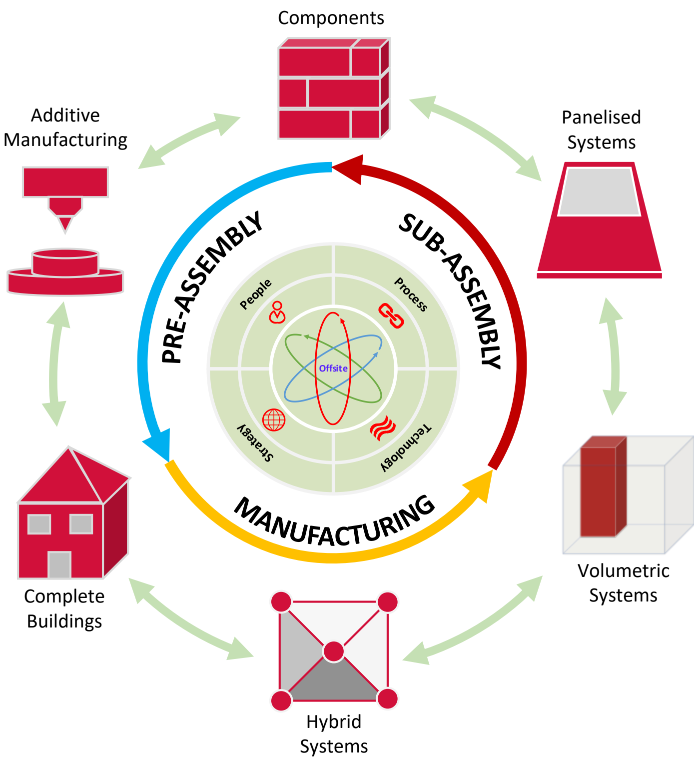
By shifting conventional above-grade construction from the job site to the manufacturing plant, EllisDon's Modular Division provides highly innovative and cost-effective solutions, which are systematically transforming the construction industry.
Tom Howell, EllisDon

In summary, this new roadmap provides a robust and systematic approach for addressing current and future offsite industry needs. Not only to enhance organisational capabilities, processes, and end-products *per se*; but also, to help the industry drive and leverage offsite's innovation potential. Whilst there are still many challenges ahead, collectively, we can state with much more confidence that with this greater awareness, we are now much better positioned and informed to do something positive about them. **In simple terms, offsite opportunities have never been greater!**

OFFSITE MANUFACTURING: HORIZON SCANNING

Offsite Manufacturing: Reflective Overview

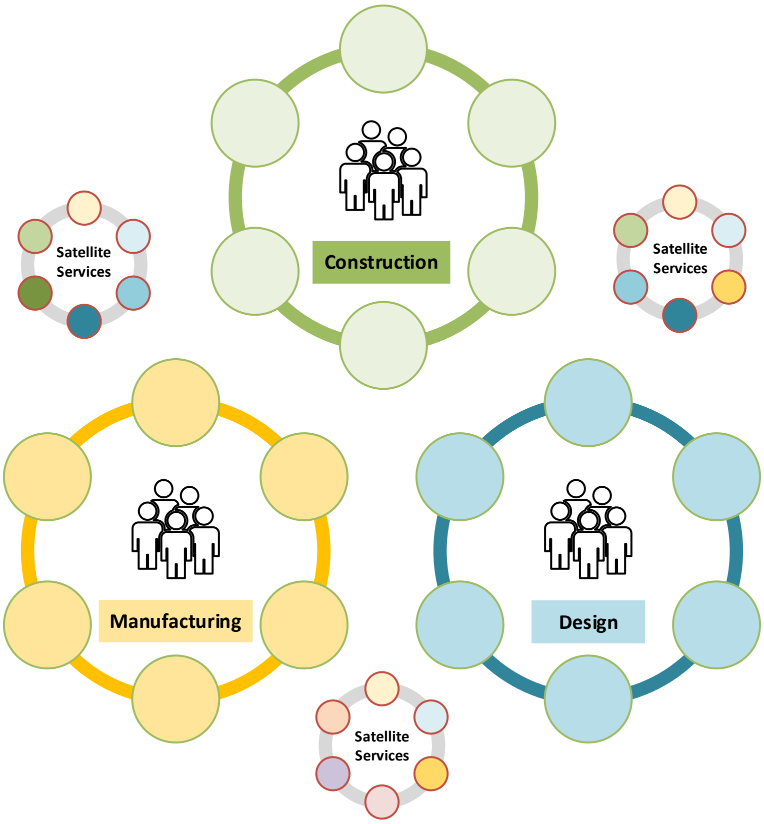
The term "Offsite Construction" or "Offsite Manufacturing" is not new, either as a concept or methodology, with variants and typologies originating back to the 17th Century. Some of the earliest recorded iterations include: prefabricated panelised housing shipped from England to Cape Ann (c. 1624); housing delivery in Australia (c. 1837); construction of Crystal Palace for The Great Exhibition in the UK (c. 1851), and for mainstream housing in the US – see Sears Modern Home "kit house" (c. 1908) and Lustron Home (c.1945). Given the wide variety of offsite approaches used today, a number of different terminologies exist which explain these differences (cf. Gibb and Pendlebury, 2006; Taylor, 2010); including (but not limited to): modern methods of construction; pod technology; off-site construction/fabrication/production; industrialised building systems; industrialised construction; modular construction; pre-cast panels/foundations; volumetric/hybrid construction; component manufacture; and planar-type prefabricated construction.



In simple terms, offsite manufacturing (OSM) as an umbrella term, can broadly be considered as a process or methodology which moves 'traditional' construction effort into a 'controlled' environment in order to benefit from modern industrial techniques. In doing so, this brings a number of benefits - from speed of construction, through to higher quality thresholds, lower environmental impact, improved Health and Safety etc. Moreover, OSM has matured significantly over the last 10 years, particularly in the US, UK, Canada, Norway, Sweden, Japan, Malaysia, Germany, and Poland (to name but a few). This maturity has created several 'spin-off' business niches, each offering high levels of innovation for greater market exploitation. Whilst, historical perception, entrenched positioning and 'traditionalist' thinking are still seen as barriers; some companies are abandoning the "wait and see" approach [often associated with innovation adoption] (Rogers, 2003), and are starting to pioneer new offsite products and services that transcend traditional thinking.

Offsite Stakeholders: Design, Manufacturing & Construction

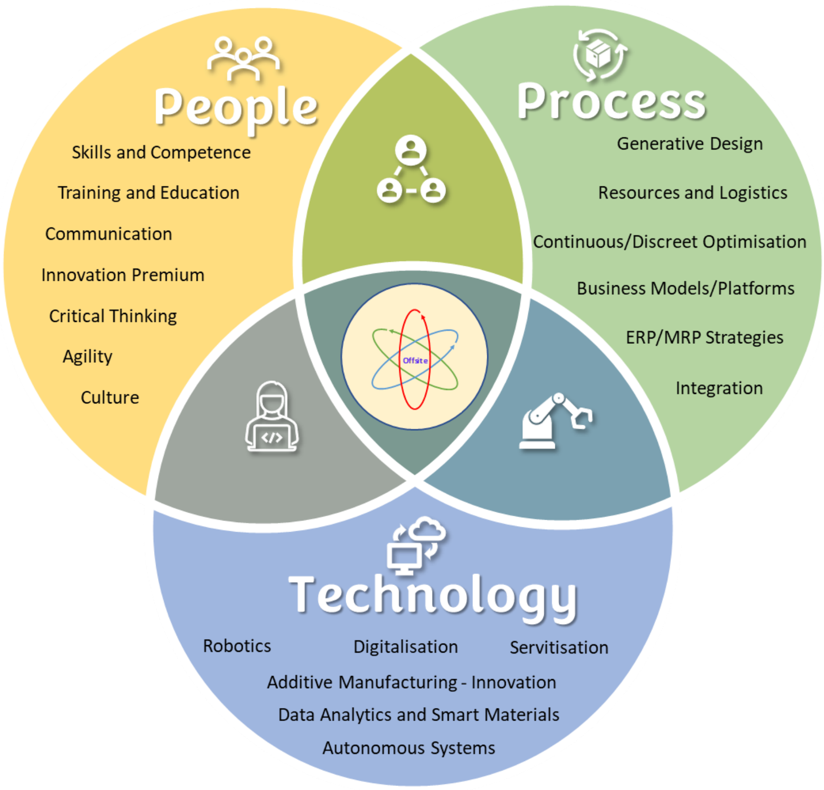
There are numerous stakeholders involved in the offsite sector. Principal engagement tends to include client representatives from the Design, Manufacturing and Construction sectors; where these stakeholders tend to work in a number of defined areas - from strategy, procurement, and marketing, through to assembly, maintenance and servitisation. Historically, these activities were operationalised through each respective silo, with minimal crossover between the three sectors. Arguably, this dissonance stifled the wider uptake and development of the offsite market, which subsequently hindered progression (even though significant areas of commonality in thinking, roles/skills and processes existed). This siloed approach was predicated on the assumption that each sector knew best - ergo its inherited explicit and tacit knowledge was considered immutable. This in turn influenced thinking, processes, and roles. A good example of this is to consider "process", where the philosophical and technical underpinnings of this are significantly different in Manufacturing compared with the Design or Construction sectors. These differences include: "methods, material, equipment and people (thinking)" [n.b. the references section provides additional reading on these differences]. However, in recent years, due in part to the increased use and prevalence of offsite, things have now started to change, with stakeholders from Design, Manufacturing and Construction (and satellite services) now starting to "talk to each other". They are now learning to understand these subtle differences, and perhaps more importantly, starting to 'cherry pick' best practice and thinking from each other in order to improve their offering. Simply put, there is a lot to be learned from domain transference.



Other major offsite stakeholders/influencers include: public/private end-users, supply chain partners, insurance providers and underwriters, governance/legal/regulatory bodies, maintenance organisations, and the servitisation sector (to name but a few). There are also several cross-over satellite services supporting offsite, including organisations involved in: prefabrication, component assembly, retrofitting, compound materials (sandwich panels, walls, beams etc), volumetric modules (bathroom pods, hotel bedrooms, prison cells, school classrooms etc), substructure/superstructure, and logistics (planning, transportation, consumption modelling, warehouse management services etc).

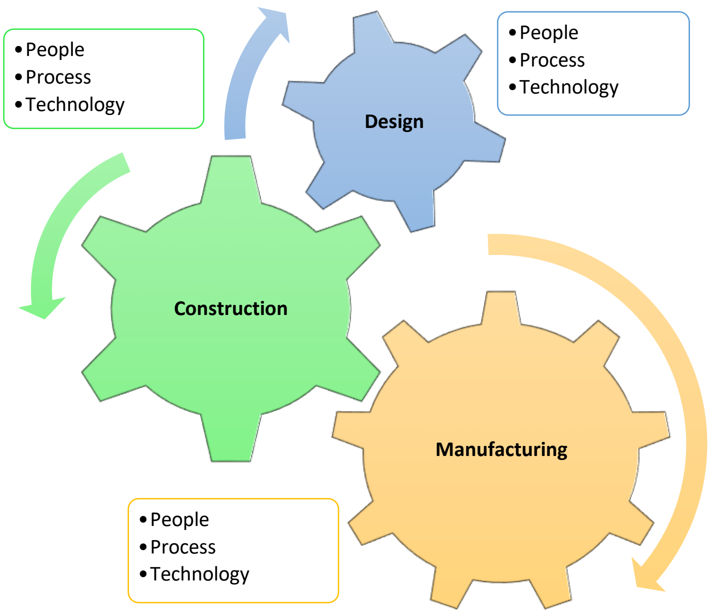
Offsite Drivers: People, Process and Technology

One of the challenges of understanding offsite as a business is to appreciate the main business functions that deliver the end product. In this respect, previous work recognised that this could be most effectively appreciated through the three main tenets of: People, Process and Technology – following the principles of Leavitt's Diamond Model (1965). Where, Goulding and Arif (2013) applied this approach to offsite using 'spheres of influence' – identifying the main co-dependencies and drivers of the offsite market. Since then, these concepts have been further extended to highlight the main components of these spheres and corresponding interactions (see below).



However, whilst these drivers are considered fundamental to the operation of offsite, it is equally important to recognise that the offsite sector also engages other areas, with different stakeholders and (arguably) different ways of thinking and approach to offsite. These main sectors include offsite within Design, Manufacturing and Construction. This in itself creates a number of challenges, as each has its own unique way of managing and operationalising its People, Process and Technology elements. Where, the interactions and management of these three areas are considered crucial, especially when 'shared and collective understanding' is needed. This complexity can be broadly seen as a nested 'subsystem', where causal relationships, dominant paradigms, and dependent force-field relationships all exist. Each of these have specific push-pull forces, and each have to interface with the different sectors they work with. For example, People, Process and Technology for Design, is different to People, Process and Technology for Manufacturing; which in turn is different to People, Process and Technology for Construction. In essence, a system of 3 x 3 x 3 relationships, or different combinations of 'forces' needs to be examined, contextualised, and critiqued before any real understanding can take place.

Given these issues, for the purpose of this report, the main challenge was to investigate the People, Process, and Technology dimensions; particularly, and perhaps more importantly, how these interfaced with Design, Manufacturing, and Construction.



The interaction, impact, and significance of these relationships form the main focus of this report, where the nuances from each help shape 'collective' understanding.

These nested relationships, contextual anchors, and 'nuanced' understanding helped inform the basic constructs for later analysis – including the development of the research roadmap.

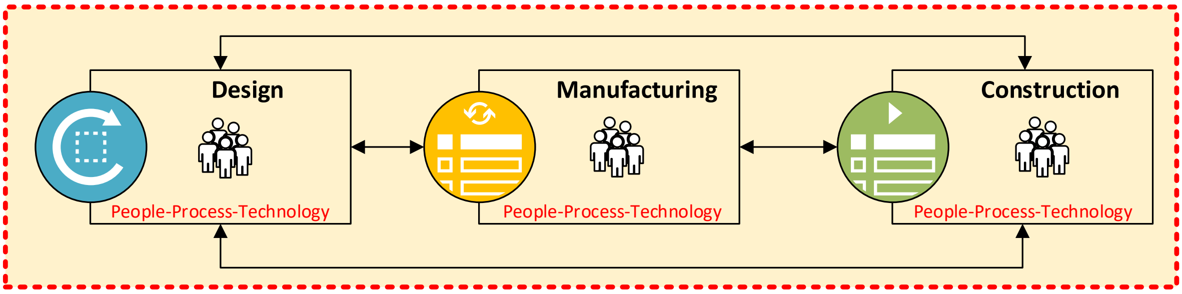
The People component encompasses all human related resources such as skills, capabilities, and capacity-building requirements for OSC; from individual level, through to team and organisational levels. This focuses on the behavioural, management, and strategic aspects that often influence OSC organisations' delivery (such as motivation, leadership, culture, and change) including market positioning. It also extends to the human side of supply chain relationships. In this respect, skills (and the development of skills) within an offsite organisation is probably one of the most important issues to address from the outset. In essence, skills (also termed intellectual capital) can be seen as the main key differentiator of one company over another. It is therefore important to acknowledge the importance of maintaining people-skills in line with changing business imperatives – especially those relating to Process and Technology in order to effectively manage the interface between offsite elements (Nadim and Goulding, 2011).

The Process component covers the work step processes, methodologies, mechanisms and resources involved in producing the offsite product. This naturally embraces workflow elements, from Concurrent Engineering (CE), through to Design for Manufacture and Assembly (DfMA), including the steps needed for future changes, including repurposing and demolition and/or disassembly. Process also includes the knowledge and integration of specialist skills, ranging from Building Information Modelling (BIM), Enterprise Resource Planning (ERP), Material Resource Planning (MRP), Integrated Product Delivery (IPD), process simulation techniques, along with processes associated with materials and information flow. This is also important for logistics management, particularly for supply chain management, warehousing, and transportation.

The Technology component includes all technology-related issues needed to produce the offsite product, ranging from hardware and software, through to machines, equipment, robotics, and automation. This remit also includes: advanced sensor technologies, drones, image recognition, artificial intelligence, machine learning and virtual/augmented reality (to name but a few). In this respect, the rate and pace of technology continues to evolve at an ever-increasing pace, with tangible business benefits being evidenced through several areas, including additive manufacturing (Lim *et al*, 2012) as well as a wide range of smart and emerging technologies (Assaad *et al*, 2021). These developments are now starting to have a significant impact on the offsite sector. There are some interesting parallels to explore here on harvesting the innovation premium from these technological developments, particularly in line with Winch's (1998) view of "complex product systems", and being able to manage two key innovation dynamics i) the top-down adoption/implementation dynamic, and ii) the bottom-up problem solving/learning dynamic.

Aligning People, Process and Technology with Design, Manufacturing and Construction

It is important to evaluate the links between People, Process and Technology across the spheres of Design, Manufacturing and Construction. In doing so, many different combinations of 'forces' can be evaluated for their impact on the business offering – ergo the offsite product (see below).



These relationships are examined in the roadmap development stage of this report. However, a snapshot of some of these issues (using just the Design sector as an example) include:

Design-People: In order to effectively plan/design an offsite product, it is important that all the people involved in this are aware of such issues as CE, Design for Manufacturing (DfM) and DfMA. New thinking is therefore needed (to work with Manufacturing and Construction).

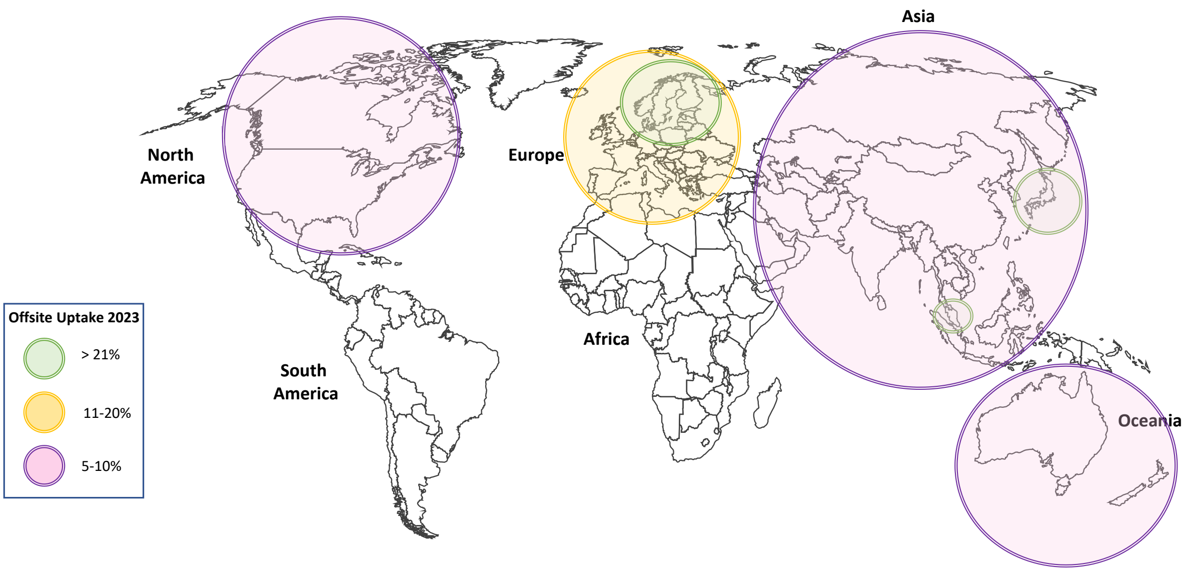
Design-Process: Design needs to be more systematic, but flexible enough to accommodate the different process variables in Manufacturing and Construction. This requires critical reflection of design decisions on processes.

Design-Technology: In order to embrace technological solutions quicker and more effectively, it is important to consider the concepts of Design for Variety (DFV) principles in order to embed technology into the design process itself (to analyse the different options available before committing to a particular design or configuration).

The Impact & Pervasiveness of Offsite

The overall growth, uptake and impact of offsite construction continues to grow globally, evidenced by several leading reports and policy documents. On face value alone, this phenomenon cannot be attributed to one particular aspect, rather a number of interconnected issues. Some of the main issues include: an increase in high-level, high-quality offsite solutions; improved product understanding (technology, processes, finance, skills etc); better appreciation of market drivers (sustainability, client need, innovation etc); and an overall increase in the number of supply chain partners with the specialist products, services and knowledge needed to create diversified and novel (bespoke) solutions. Whilst, some countries are well 'ahead of the curve', pushing the boundaries of what is currently possible, others are still in 'catch-up' mode – not too dissimilar to the "leaders and laggards" analogy proffered by Rogers in the early 1960's *cf.* (Rogers, 2003) on adopter diffusion. Whilst global offsite challenges continue to exist in one form or another, the need for more integrated solutions is still being promoted as part of the wider solution.

Since the publication of the first CIB offsite roadmap in 2013 (Goulding and Arif, 2013), there has been considerable growth in the uptake and pervasiveness of offsite over the last 10 years. For example, Africa's increased urbanisation is now actively engaging offsite as a viable solution to address its housing needs. Similarly, countries throughout Asia are expanding their offsite products and services, with notable pockets of excellence in Malaysia and Japan. Where Malaysia adopted the Industrialised Building Systems approach in the 1960's to support the adoption and uptake of offsite. Likewise, Japan continues to champion offsite through its innovative solutions, long heritage, and high demand for offsite. In Europe, growth and uptake is increasing year by year, due in part to improved supply chains, where the offsite market share is currently around 5-15%. The exceptions to this are the Scandinavian countries, where these continue to lead the way, with some reports highlighting that countries such as Sweden's are reporting that offsite now accounts for 45% of their housing provision. From a North American perspective, the offsite market continues to evolve, with large offsite "clusters of excellence" spanning from California, through to Texas, Indiana, and Pennsylvania in the US; and from British Columbia through to Ontario and Québec in Canada. The current offsite market share for North America is around 5-8%, with strong growth in new build and renovation work. Whereas, the offsite market in Oceania is predominantly driven through Australia and New Zealand (NZ), with offsite accounting for around 3-7% of the market (Australia), and compound annual growth rates (CAGR) of around 7.5%–15% being predicted by 2026. NZ is very similar, with around 5-11% of the market, and similar predicated CAGR to Australia. Moreover, prefabricated housebuilding continues to evolve in NZ (Masood et al, 2023). Collectively, the offsite market in Oceania covers a wide spectrum of activities, from schools and hospitals, through to mass housing and private sector offerings (traditional/specialist high-end). Finally, the South American offsite market is a little more difficult to assess, with concrete and timber being the dominant solutions. However, a number of reports highlight the growth potential, with CAGR's around 7.3%. Main growth areas include the need to provide affordable housing and sustainable solutions, with some companies delivering four-story multifamily buildings (16 apartments) in just six days, or new hospitals in 35 days using 2D panels, 3D modules and fully integrated kits.



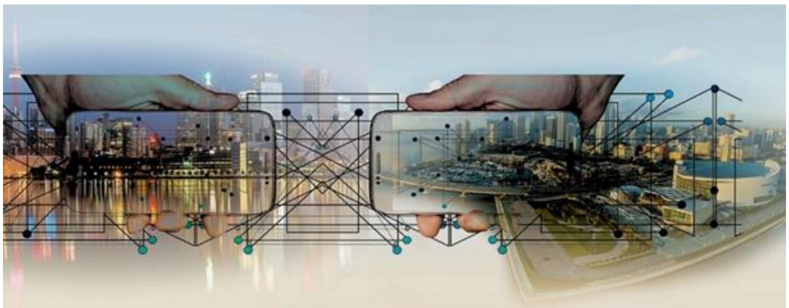
Many of the countries examined have highlighted the need to address housing challenges through various offsite solutions. Several factors have helped support their business case, particularly though offsite's enhanced sustainable credentials and ability to meet mass customisation requirements (particularly with low-cost housing). Worldwide, offsite demand continues to grow, especially in Africa and Asia. Where for example, the World Bank highlighted that the housing crisis could impact 1.6bn people by 2025. In addition, there is also an urgent need to respond to climate change adaptation – principally the shift in energy for renewables and solutions towards net-zero (*cf.* to reduce emissions). Offsite is therefore very well positioned to address some of these challenges, especially through climate-smart affordable housing and green-growth acceleration models. However, whilst these opportunities may sound somewhat altruistic, it is important to recognise that certain 'reality checks' have to be acknowledged. One of these can broadly be categorised as skills, or more specifically, the skills gap. Where the type, level and availability of offsite skills are simply not sufficient to support the sector as a whole in some regions. Moreover, this has repeatedly been highlighted as a significant barrier to the uptake of offsite. This in itself creates uncertainty in the market and process (which very much overlaps with general topic of innovation in construction). These can be collectively addressed through such things as: the adoption of new procurement approaches specifically for offsite; the involvement of governmental support initiatives and reform measure that purposefully stimulate growth; the provision of offsite warranty schemes/guarantees to galvanise 'quality and assurance'; collective development of common standards to support 'open systems' [ergo 'kit of parts'] for wider integration and interoperability; the introduction of enhanced mechanisms for early design involvement, collaboration and coordination (to support integration synergy); and establishing 'recognised' offsite qualifications at various levels (trade-operational-multiskilled, through to technical-managerial). Whilst this list is certainly not exhaustive, and setting rhetoric hyperbole aside for one moment, it is easy to recognise why and how these issues are still hindering progress.

In summary, whilst these issues have been around for a very long time now; they are certainly not insurmountable, with many of them being able to be addressed through a raft of measures such as "integrated solutions". This requires consideration of scale (in order to address the grand challenges). More importantly perhaps, there is an argument to proffer that we need to start performing at scale (e.g., renewables, platform strategies, supply chain structures, manufacturing capacity, DfMA, Hub and Spoke, upskilling of labour etc). On this theme, offsite can be viewed as a major market disruptor in this respect. In fact, many have acknowledged that it already has (and still is). However, there are still many lessons that can be learned from previous "at scale" successes and failures. This new W121 Roadmap is only one starting point in this journey.

Planning for the Future of Offsite: Crystal Ball Gazing

The growth and impact of offsite is encouraging, with a number of different typologies and new hybrid variants of offsite now being offered. This may be in part attributed to improved market 'acceptance', but perhaps more importantly, acknowledgement that the industry as a whole is becoming more familiar with these types of approaches (compared to traditional forms). In doing so, the market and supply chain infrastructure has started to coalesce, with conjoined and integrated solutions now starting to pay dividends.

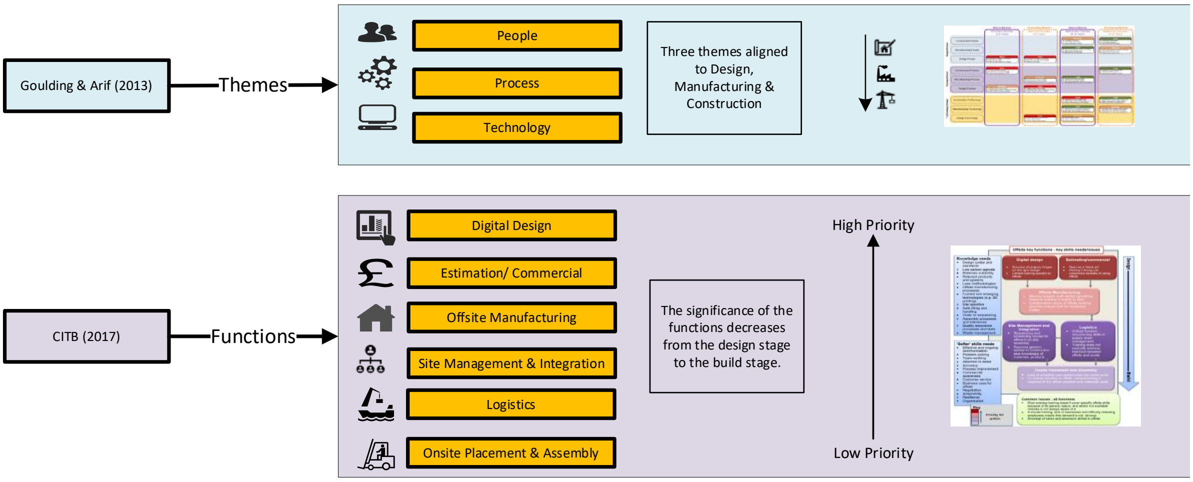
That being said, (arguably) the industry is not 'resting on its laurels' (especially given the competitive nature of the industry), but rather, is continuing to look ahead. Next generation offsite solutions are continually being developed to take full advantage of this maturity. For example, advanced integrative solutions using Design for Manufacture and Assembly (DfMA) are now actively incorporating Artificial Intelligence (AI), machine learning and blockchain technologies to maximise efficiency. This takes full advantage of such issues as: design for deconstruction, design for re-use, and design for reconfiguration and redeployment – all of which support the need to evidence cradle-to-cradle and circular economy metrics.



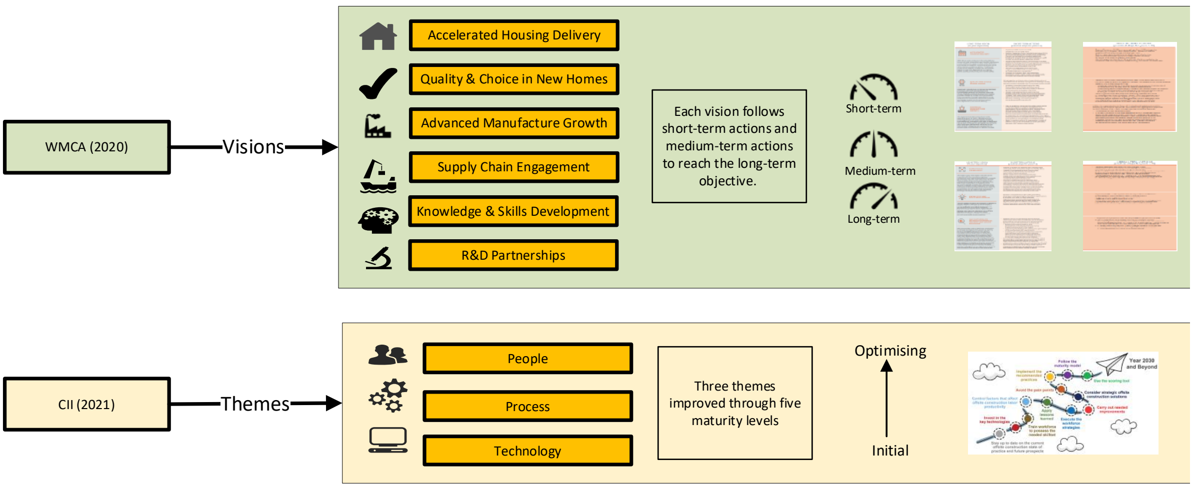
Given the increased growing popularity of Industry 4.0 and subsequent transition to Industry 5.0, a number of exciting initiatives are now starting to emerge. For example, the use of real time digital integration of processes - from initial design through to end-product delivery. The key to this is integration, where multiple web-based systems 'talk' to each other; and where these become mainstream – almost part of a defacto prerequisite selection process. Ergo, companies can now openly compete (and demonstrate) their high-tech credentials in the delivery process. In doing so, increased emphasis on sustainable development goals can be showcased, focusing on offsite green materials, green design, and green supply chains. Where offsite has been proven to actively decarbonise many of the processes and materials used in traditional construction. In this respect, many new business models and platform strategies are now starting to emerge as part of this transition. This includes the use of innovative procurement models capable of promoting low-carbon solutions which proactively consider the environmental impact of issues such as: design, materials, construction methods/processes, maintenance, demolition, and re-use. Whilst arguably these are not new ideas or concepts (from an offsite prism), they so offer significant scope. For example, the sector as a whole is now moving into an era where automation is significantly cheaper, and much more capable than ever before. Added to this, new materials and hybrid technologies are increasingly being used to deliver everything from smart homes, through to reactive skins with embedded sensors for cladding systems, panels and energy pods – all of which can be interconnected and evaluated by central monitoring systems. The underpinning nexus of these solutions emanate from new developments in AI and Generative Design (GD), which when combined, are able evaluate and optimise almost infinite design variations, with novel and innovative solutions now becoming mainstream and commonplace. These types of approaches not only support, lean, agile and concurrent engineering (as part of the quest for continuous improvement); but more fundamentally, they also support long-range planning, which in turn aids mass customisation, automation, and the development of more versatile automation and robotic systems. Finally, as new self-learning software systems continue to evolve, it is only a matter of time before we see companies sharing their offsite knowledge and expertise (particularly through open-source mandates); which inter alia, will undoubtedly help the next stage of OSM evolution. This in turn would support sector maturity, but also enable, encourage and nurture more flexible, adaptive and innovative offsite solutions to reach the market.

Offsite Roadmaps: Development Initiatives and Guidance Perspectives

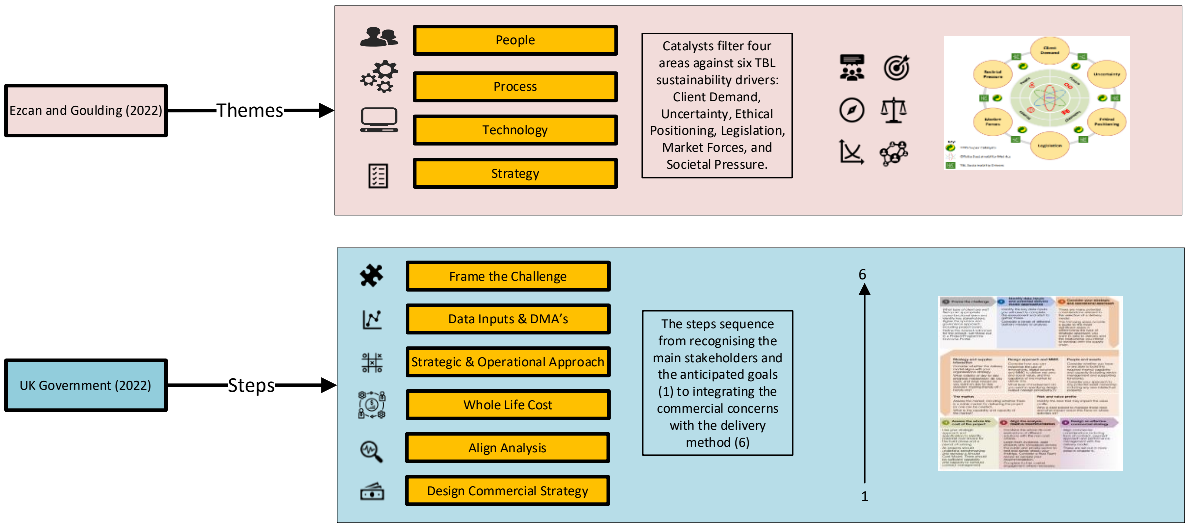
Offsite roadmaps and guidance initiatives can often be particularly effective for highlighting inertia and direction of travel. The following section provides a general insight into the rubrics of some of these, where this portrayal is not meant to be chronologically exhaustive per se, more 'representative' of these developments. For example, one of the first roadmaps developed for offsite emanated from a CIB Task Group (TG74) established by CIB in 2008. Work from this led to the publication of "A Prioritised Offsite Production & Manufacturing Research Roadmap" (Goulding and Arif, 2013). This was the first formal offsite roadmap which mapped People, Process and Technology against the three main dimensions of OSC (Design, Manufacturing and Construction). These relationships were analysed at macro, meso and micro levels, particularly for their impact on the offsite delivery process and subsequent end product. This roadmap also included mature and developing markets spanning both short-term (0-5 years) and long-term priorities (6-10 years). Later in 2017, a Construction Industry Training Board roadmap was developed in the UK to emphasise the actions needed to improve OSC processes, particularly when moving from the design phase to the build phase. Where for example, issues in the estimating/ commercial function (in the design phase) impinged upon other following activities. This roadmap highlighted the needs shared by all functions, such as site specifications as a 'knowledge need' and teamworking as a 'softer skill need' (CITB, 2017).



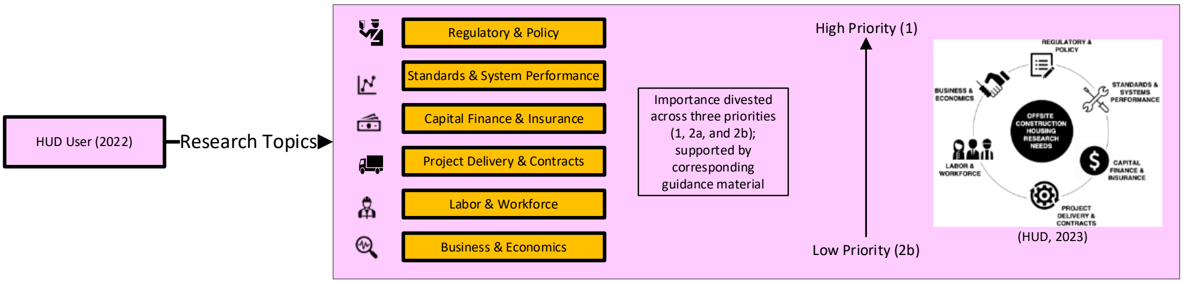
In 2020, in the UK, the West Midlands Combined Authority developed a roadmap (WMCA, 2020) to raise Advanced Manufacture in Construction adoption as an advanced subset of modern methods of construction. This roadmap contained short-term (1-3 years) and medium-term actions (4-10 years) to accomplish the long-term vision (10 years) – all of which were presented through six major areas (visions). Later in 2021, the Construction Industry Institute used the same themes (People, Process, Technology) to develop their five-stage maturity model as a prefinal stage of their OSC roadmap (CII, 2021). This long-term roadmap starts with updating current practices, investing in technologies, and upskilling the workforce, and ends up following the proposed maturity model with an accompanying scoring system. The three themes in the maturity model are elevated from the 'Defined' level to the 'Optimising' level. For instance, the people theme begins with hiring and educating workers and concludes with creating excellence centres and quality assurance initiatives.



In 2022, Ezcan and Goulding (2022) added 'strategy' as the fourth area to Goulding and Arif's original roadmap (Goulding and Arif, 2013). This was developed to help organisations embed the Triple Bottom Line (TBL) into their OSC business processes, using Technology Diffusion for Sustainability (TDfS) factors to reach TBL sustainability drivers. These included: "Client Demand"; "Uncertainty"; "Ethical Positioning"; "Legislation"; "Market Forces"; and "Societal Pressure" – the culmination of which was presented as vehicle for evidencing offsite sustainability through "conjoined thinking". Correspondingly, in 2022 the UK Government continued its "Transforming Infrastructure Performance: Roadmap to 2030" mandate, highlighting the need to develop a Platform approach for Design for Manufacture and Assembly (P-DfMA). This led to the development of a delivery model assessment for public works projects and programmes using Delivery Model Assessment (DMA) from the Construction Playbook (UK Government, 2022). This evaluated six areas, from: (1) "Frame the Challenge", through to (6) "design and Effective Commercial Strategy".



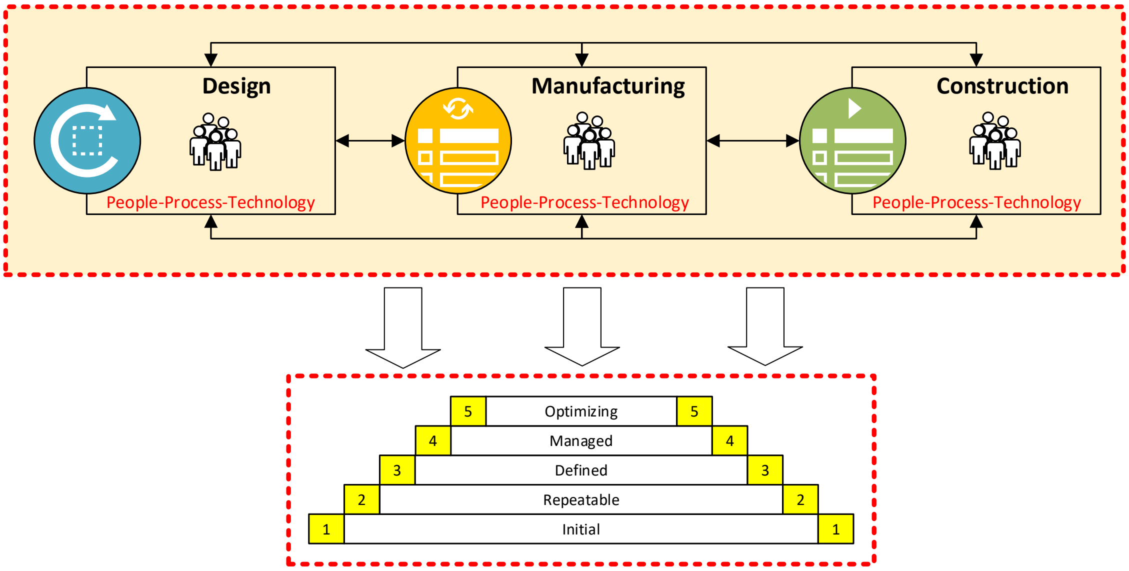
More recently, the U.S. Department of Housing and Urban Development's (HUD) Office of Policy Development and Research (PD&R) initiated the drive to develop a new roadmap for offsite construction. This roadmap was devised by HUD, the National Institute of Building Sciences (NIBS), and MOD X. It described HUD's six research priorities and guidelines to foster the adoption of industrialised construction. Ranging from level of importance, these topics included: "Regulatory Framework and Capital, Finance, and Insurance" [level 1 priority], with "Standards & System Performance" [level 2a priority], and "Project Delivery and Contracts; Labor and Workforce Training and Management; Business Models and Economic Performance" [level 2b priority] (HUDUser, 2023). As all these topics are interrelated, the need for prioritisation was proffered as an appropriate way forward.



The Need for a New Offsite Roadmap

Research roadmaps have been used in many different sectors and organisations to help people understand the stages and processes needed to move from one developmental stage to another. In many respects, they can be seen as a pseudo 'guidance vehicle', which articulates often complicated issues and processes into simple steps or stages – incrementally moving forward. These roadmaps take shape and manifest in many different forms, from micro-level product development analysis, through to high impact macro strategy documents - often associated with policy documents and governmental directives. One of the main pioneers of this roadmap-driven philosophy/approach was devised by Motorola in the 1970's, where they used this concept to help their organisation map technological capabilities against market needs (Willyard and McClees, 1987). Since then, the roadmap approach has gained significant momentum in many other diverse industries.

From an offsite perspective, the original roadmap produced by Goulding and Arif, (2013), had a predictive timespan of 10 years. This period has now elapsed, creating a need to revisit this from the ground up. One of the main drivers for developing this new roadmap was to reflect on the rapid advances made in offsite in order to see whether the original roadmap was indeed still 'fit-for-purpose'; or whether this needed to be radically revisited in order to meet current and future challenges. Given this, a two-year consultation exercise was conducted with a number of industry experts and offsite practitioners. This evaluated 'state-of-the-art' technologies, processes, and strategies, along with critical thinking underpinning *People*, *Process* and *Technology*. The consensus of this consultation exercise was to adopt a new approach. The rationale behind this thinking was to embrace a new approach which encouraged evaluative assessment. Moreover, that a roadmap was needed which could contextually accommodate organisational differences, scale, and complexity - embracing flexibility as a 'living' [evolving] entity - which also supported commercial relevance. In doing so, a capability-driven approach was adopted as the formal means of developing this new CIB Offsite Roadmap.

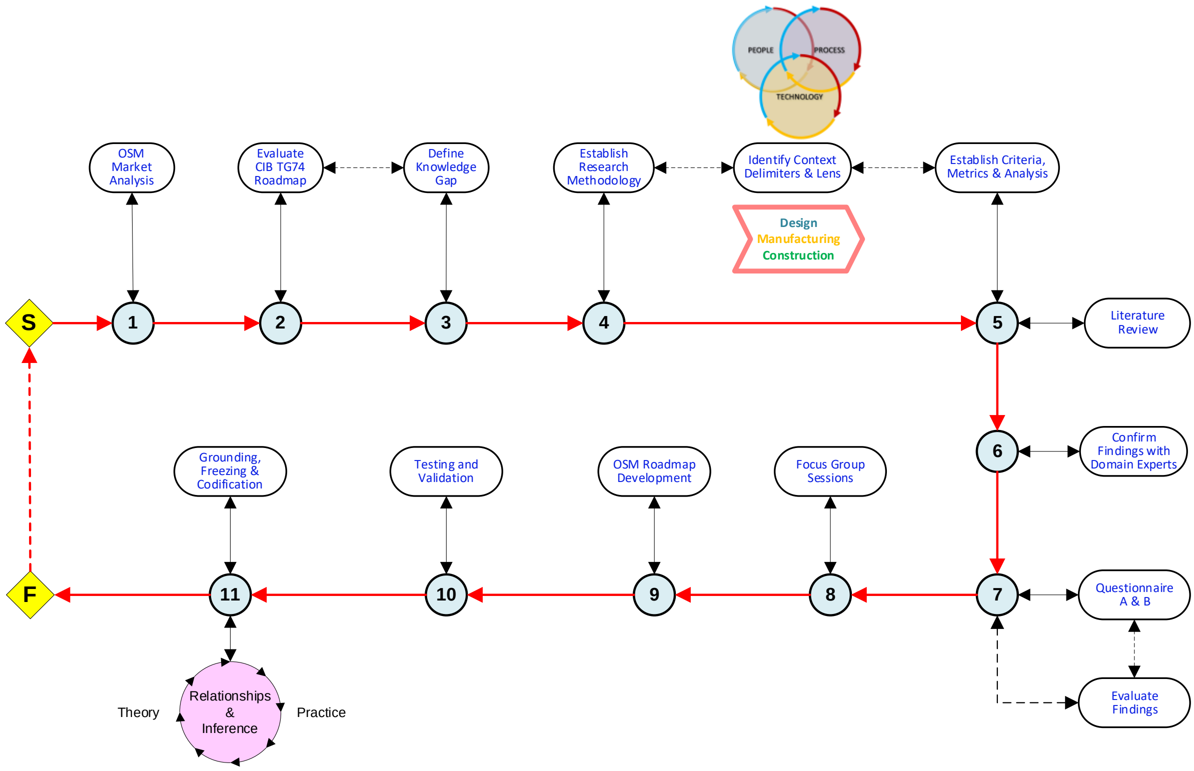


Capability Maturity Modelling

OFFSITE ROADMAP DEVELOPMENT APPROACH

New CIB W121 OSM Roadmap Development Methodology

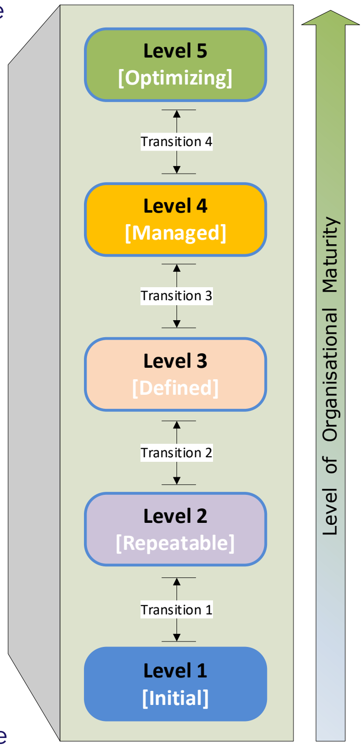
The need to develop a new roadmap for OSM was initially predicated on the need to update the previous CIB roadmap (Publication 372) launched in 2013. However, given the significant changes evidenced in the offsite sector over the last 10 years or so, the development team decided to completely re-visit the methodological approach to this undertaking (see below) – especially given anticipated market impact and future growth trajectories.



This development approach was divided into 11 discreet steps, each stage of which either shaped/informed subsequent stages. Where, Step 1 involved horizon scanning (capturing current and future offsite developments); Step 2 evaluated the previous roadmap to determine legacy transfer components; Step 3 was used to define the knowledge gap (ergo Stage 1 and Stage 2); Step 4 was used to establish the research lens (prism), along with accompanying parameters (People, Process, Technology: Design, Manufacturing, Construction); Step 5 was used to determine the capture instrument, along with criteria, metrics and analytical approaches (for Steps 5-11), including the coding parameters needed for the literature review; Step 6 applied conventional synthesising techniques and pattern matching to confirm initial findings with domain experts; Step 7 used findings from Step 6 to establish two semi-structured questionnaires for online distribution (purposive sampling) to respective experts to ensure representative geographical representation – the results of which were then evaluated; Step 8 engaged three focus group sessions to evaluate maturity indicators across People, Process and Technology – the results of which were critiqued through an open panel session; Step 9 involved the development of the OSM roadmap and accompanying model (to assess organisational maturity); Step 10 engaged formal testing and validation approaches to ensure construct veracity (internal and external) and measures supporting reliability and homogeneity; and finally, Step 11 was used to ground, freeze and codify all findings against OSM practice settings, including impact on theoretical assumptions/understanding.

Capability Maturity Modelling: An OSM Approach

The epistemological underpinning and formative roots of using maturity models for organisational improvement can be traced back to concepts discussed by Crosby (1979). From this emerged the term 'Capability Maturity Models' (CMMs), where these were seen as being a particularly good approach for evaluating and improving the maturity and effectiveness of business processes. In this respect, CMMs were introduced by the US Department of Defense in the 1980's as a means of evaluating/improving the software development processes of their contractors. These were refined and documented by the Software Engineering Institute (US Defense Department) at Carnegie-Mellon University into a Capability Maturity Model for Software (Paulk et al., 1993). From this, there are now literally hundreds of CMMs, adopted across various sectors, industries, and diverse application areas.



The use and application of CMM's within organisational settings are based on the concepts of 'levels of maturity', where each level represents a different level of maturity (and corresponding level of capability). Most CMMs commonly consist of five levels of increasing maturity, each level of which represents higher performance criteria. For example, Level 1 [Initial] represents chaotic systems and processes, with little or no structure; Level 2 [Repeatable] engages some repeatable processes with some control; Level 3 [Defined] involves some level of standardisation and synergy; Level 4 [Managed] uses performance measures to structure integration in order to support optimisation; and Level 5 [Optimizing] represents the highest level of achievement, where organisations are exclusively focussed on continuous process improvement to promote business stability and market agility, but also, develop avenues for innovation exploitation (based on their best in class position). In simple terms, each level represents a higher level of process maturity, with higher levels indicating more controlled and efficient processes; where the goal of CMMs is to help organisations improve and move up the levels of the framework (ultimately achieving a higher level of maturity and capability). This approach is particularly applicable to the offsite sector. With notable developments including: the People Capability Maturity Model (P-CMM) (Curtis et al., 2009), the Organizational Project Management Maturity Model (OPM3) (PMI 2003) and the Business Motivation Model (BMM) (Object Management Group, 2008). Each of these models have broadened the application and scope of CMMs. Where for example: P-CMM acknowledges the importance of developing the workforce (people) in parallel with processes; OPM3 explicitly recognises the three integrated pillars of people, process and technology; and the BMM is structured across a broader organisational transformation - as processes and capability are improved, it becomes more definitive with respect to the involvement of management, leveraging best practices, statistical control and formal innovation practices towards business objectives.

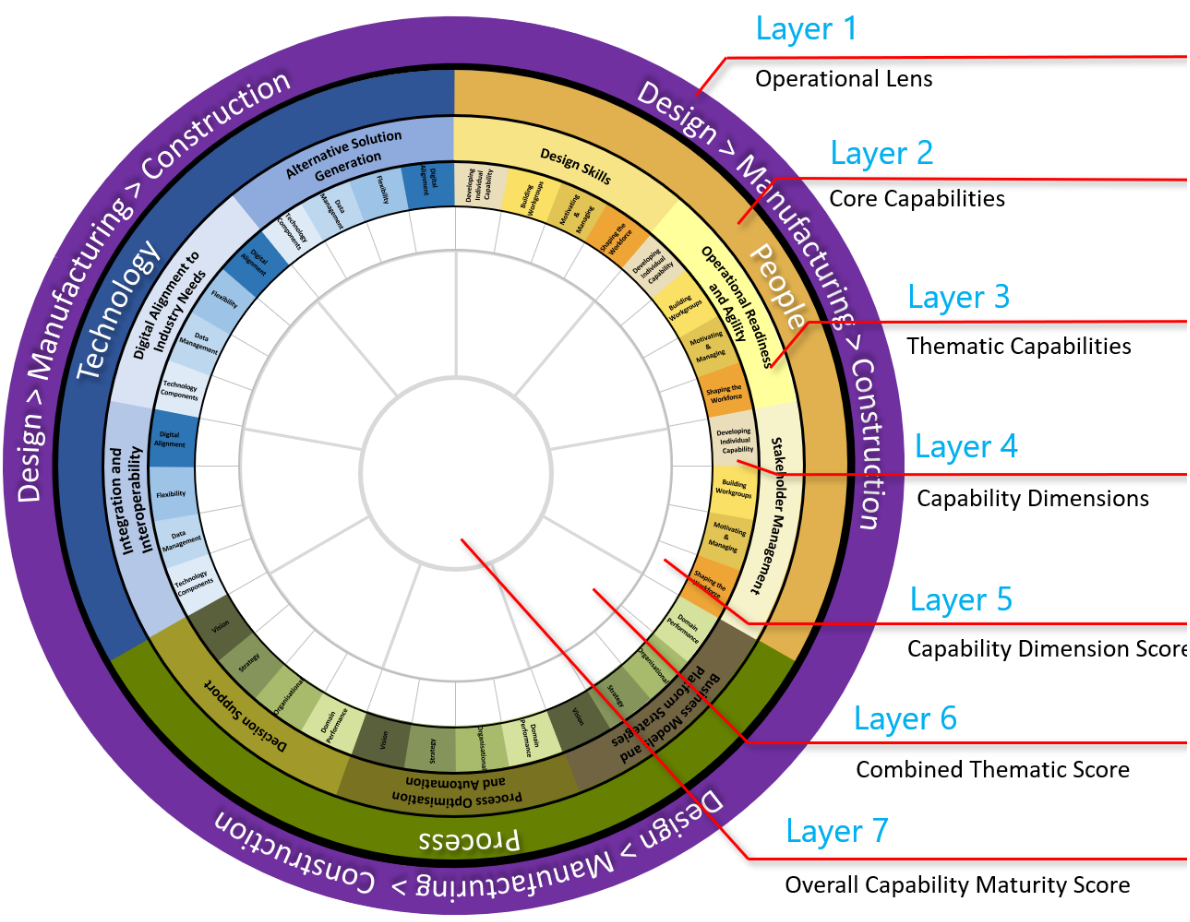
In summary, CMMs can be seen as particularly useful mechanism for assessing organisational ability through well-defined maturity levels. These levels not only identify areas for improvement *per se*, but also act as a formal roadmap for future direction of travel - with detailed metrics for achieving higher levels of maturity over time. However, there are several different approaches that can be used to support transition pathways (to move from one maturity level to another); but each needs to be tailored to suit the corresponding business environment. The underpinning concepts of these resonate with the need to have clear benchmarks and performance criteria – not too dissimilar from the Balanced Scorecard (Kaplan and Norton, 1992) or the EFQM Model (EFQM, 2023). Given this proven heritage and increased veracity of these approaches, the development methodology adopted for this new W121 OSM Roadmap engages the three main tenets of: People, Process and Technology mapped against the three organisational thematic boundaries of: Design, Manufacturing and Construction. This uses a bespoke CMM-driven model for interaction, assessment, and evaluation.

A New CIB W121 OSM Roadmap: Overview and Structural Elements

The new CIB Offsite Roadmap follows the concepts of Capability Maturity Modelling initially developed by Paulk et al. (1993). The underpinning rationale for adopting this approach was to provide users with a clear indication of the steps needed to migrate from one organisational level of maturity to another; thereby achieving a staged progression, supported by clear metrics for evaluation. The roadmap consists of two main parts, (i) the **model** itself [Appendix 1], and (ii) the **accompanying tables** [Appendix 2] used to determine the maturity levels. Nb. Maturity assessment tables are needed to cover Design, Manufacturing and Construction (across the People, Process and Technology dimensions). In this respect, in order to provide an indication of the assessment criteria required, Appendix 2 presents only one such example of the maturity levels needed for Design, i.e., DESIGN: PROCESS: [Business Models and Platform Strategies]. However, in order to populate the whole model for Design, additional maturity assessment tables are needed for: DESIGN: PROCESS: [Process Optimisation and Automation]; DESIGN: PROCESS: [Decision Support]. The next stage is to capture data from a Manufacturing perspective, this includes MANUFACTURING: PROCESS: [Business Models and Platform Strategies]; MANUFACTURING: PROCESS: [Process Optimisation and Automation]; MANUFACTURING: PROCESS: [Decision Support]. The next stage includes capturing data from a Construction perspective, this includes CONSTRUCTION: PROCESS: [Business Models and Platform Strategies]; CONSTRUCTION: PROCESS: [Process Optimisation and Automation]; and CONSTRUCTION: PROCESS: [Decision Support]. Collectively, this approach is then replicated for the People and Technology dimensions, ergo: DESIGN: PEOPLE [Business Models and

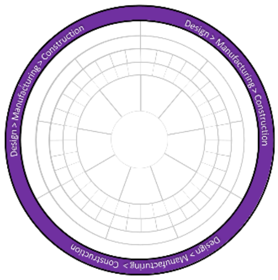
Platform Strategies; Process Optimisation and Automation; and Decision Support] and DESIGN: TECHNOLOGY [Business Models and Platform Strategies; Process Optimisation and Automation; and Decision Support].

This new offsite model is represented through seven structural layers, each one of which provides end-users with an opportunity to evaluate maturity scores at either macro or micro level depending on need. In this respect, the level of granularity and detail varies in each of these layers. Collectively, end-users can therefore evaluate maturity performance in detail, covering any particular aspect of the organisation (Layer 5, Layer 6), or at a much higher level, on the performance of the organisation as a whole (Layer 7). Based on performance across these seven layers, a colour-coding system [red = 1; green = 5) is subsequently applied to represent capability maturity levels across 36 areas, including an overall capability maturity score for the organisation (see Appendix 1). Nb. The lowest score achieved across any of the 36 areas governs the overall score in Layer 6, and consequently, the overall score provided in Layer 7.

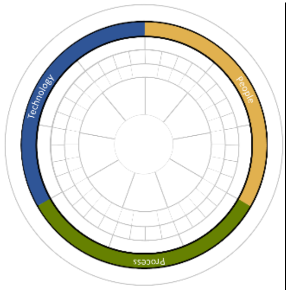


Seven-Layered Capability Assessment Model

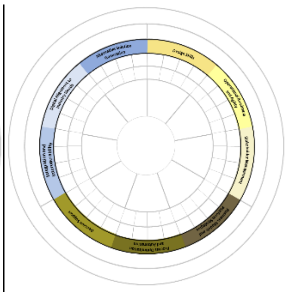
The first four layers (below) present the outer core segments of the capability model.



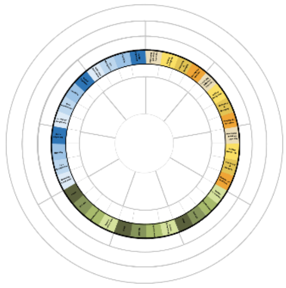
Layer 1:
Operational Lens



Layer 2:
Core Capabilities



Layer 3:
Thematic Capabilities



Layer 4:
Capability Dimensions

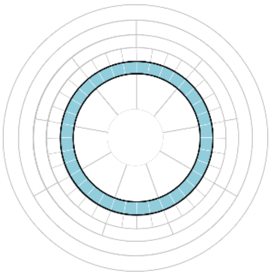
Layer 1 (the outer layer) presents the main operational lens of focus, *ergo* Design, Manufacturing or Construction. Users need to select one of these three options, where upon selection, this governs the choice of analysis [People, Process or Technology] identified in Layer 2.

Layer 2 presents users with a choice of three core 'offsite capabilities', represented through People, Process or Technology. For example, if users chose Design in Layer 1, then any selection in Layer 2 would be design-related. For example, Design:People, Design:Process or Design:Technology. Once a choice has been made, users then move into Layer 3 where each of these core organisational capabilities are presented in greater detail.

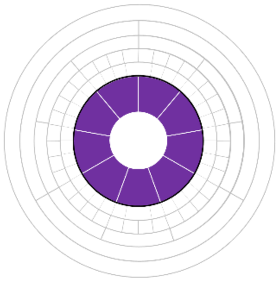
Layer 3 represents the thematic capabilities associated with Layer 2 capabilities. For example, under People, the main thematic capabilities are: "Design Skills", "Operational Readiness and Agility" and "Stakeholder Management"; whereas for Process, these are: "Business Models and Platform Strategies", "Process Optimisation and Automation", and Decision Support", and for Technology, the thematic capabilities are: "Integration and Interoperability", "Digital Alignment to Industry Needs", and "Alternative Solution Generation". Similar to Layer 2, the choice at this layer determines the primary focus, where this is both informed and contextually bound to the previous higher layer(s).

Layer 4 presents the sub-capability dimensions needed to deliver Layer 3 thematic capabilities. Collectively, these sub-capabilities present the detailed attributes of the corresponding capabilities needed to deliver the accompanying thematic category. For example, if users chose the "People" category [from Layer 2], then "Design Skills" [from Layer 3], then they would be presented with four sub-capability dimensions [from Layer 4] to evaluate, namely: "Developing Individual Capability", "Building Workgroups", "Motivating and Managing", and "Shaping the Workforce". However, in order to evaluate all capability dimensions for People, then the corresponding four sub-capability dimensions would need to be assessed for the other two thematic capabilities of "Organisational Readiness and Agility" and "Stakeholder Management" [from Layer 3].

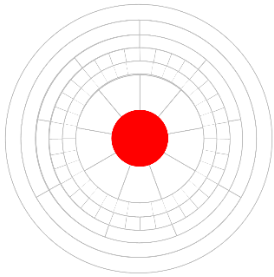
The next three layers (below) present the inner core workings of the model.



Layer 5:
Capability Dimension Score



Layer 6:
Combined Thematic Score



Layer 7:
Overall Capability Maturity Score

Layer 5 presents the Capability Dimension Scores. These are generated from maturity criteria evaluation based on a rating of Level 1 (Initial) to Level 5 (Continuous Improvement) following the five-tier capability maturity modelling approach – where Level 1 indicates the lowest level of maturity, and Level 5 represents the highest level of maturity. In this respect, the Layer 5 score is determined by assessing Layer 4 sub-capability dimensions against performance metrics. An example of these metrics can be seen for "Design:Process" (Appendix 2). To complete all of Layer 5, users need to determine a maturity score for all 36 sub-capabilities (from Layer 4).

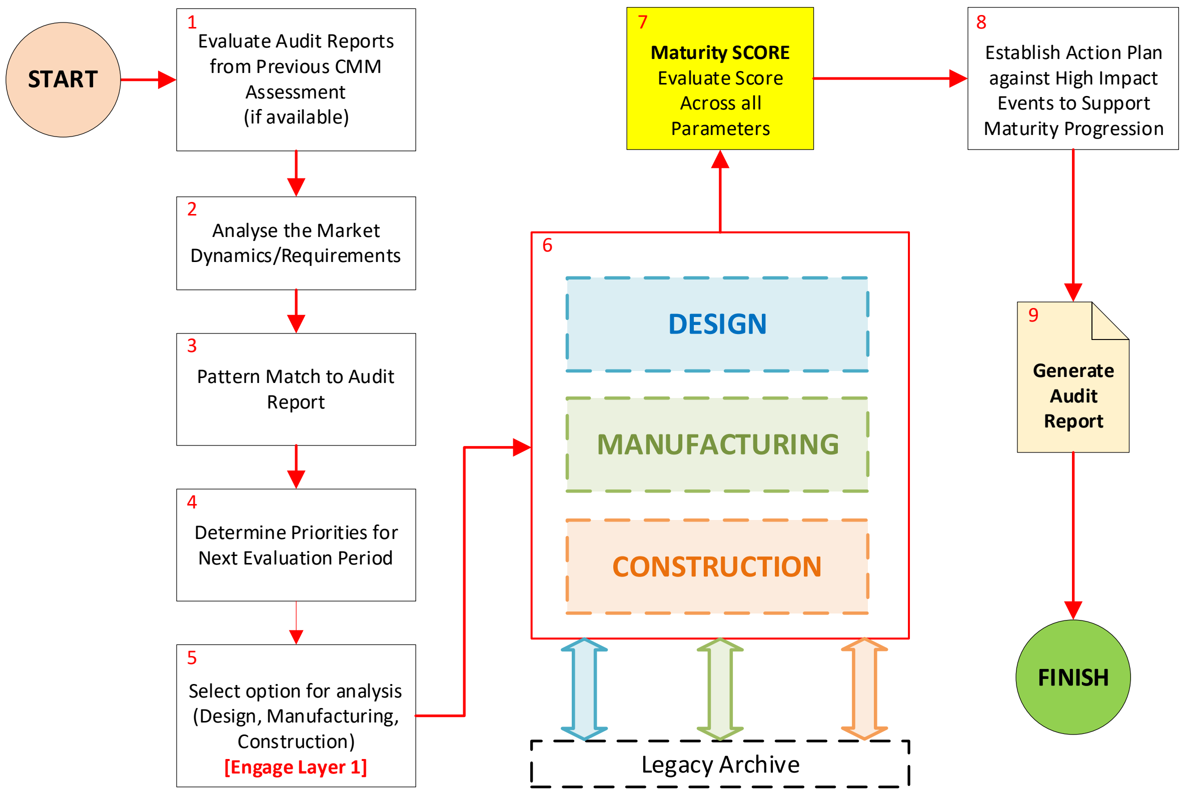
Layer 6 presents the combined thematic score from Layer 5 results. In this respect, the combined scores of all Layer 5 results are aggregated, where the lowest maturity score is presented. This represents the lowest level of maturity across the thematic boundary. For example, selecting People [Layer 2], then Design Skills [Layer 3], provides Layer 5 results as follows: "Developing Individual Capability" [2], "Building Workgroups" [2], "Motivating and Managing" [1], and "Shaping the Workforce" [5]. The lowest score of [1] is attributed to "Motivating and Managing". This therefore governs the overall score for Layer 6 [Appendix 1].

Layer 7 is the final stage of the model. The central core provides the lowest maturity score across all dimensions of the organisation [People, Process, Technology]. For example, Appendix 1 highlights the following results: "Design Skills" [1], "Operational Readiness and Agility" [5], "Stakeholder Management" [4]; "Business Models and Platform Strategies" [3], "Process Optimisation and Automation" [1], Decision Support" [2], "Integration and Interoperability" [2], "Digital Alignment to Industry Needs" [3], and "Alternative Solution Generation" [2]. Where the two lowest scores of [1] rest with Design Skills" and "Process Optimisation and Automation". These are therefore seen as the weakest areas of the business, and correspondingly, one of the first two areas to investigate the reason why.

Worked Example: A Nine-Step Approach

The following worked example provides the rubrics for using this model to assess the offsite capability of an organisation. This nine-step approach is presented as a formal roadmap, highlighting each stage in the evaluation process. Perhaps more importantly, this approach provides users with structural guidance on what needs to be done at each stage [signposting position]. The challenge here is emphasise the level of investment and engagement needed at each of these stages, as each one requires considerable analysis and reflection. Moreover, each stage both naturally shapes and informs the next, so skipping stages is only advised if (and only if) users are confident from a data veracity and completeness perspective, that data is up-to-date, complete, and will not have a negative influence on any successive stage in the process.

The following flowchart (below) provides an overview of the nine-step approach. A more detailed view of this can be seen in Appendix 3.



Step 1: Users start the process by evaluating any previous Capability Maturity Model (CMM) Audit Reports from the last analysis period. The intention behind this is to tease out all

important data pertinent to action plans, resources, deliverables, performance criteria etc. Findings from this Audit Report should be used to guide the market analysis assessment in Stage 2. Should an Audit Report not be available, then users should commence this model directly at Step 2.

Step 2: Involves undertaking a full horizon scanning analysis of the offsite market and associated contextual anchors. Findings from this are used to determine a number of issues, not least: current/future client needs, market drivers, resources delivery requirements, supply chain logistics, emergent trends etc. This criterion is then used to populate business strategy templates to accommodate short, medium, and long-term need (resources, skills, automation requirements etc).

Step 3: Criterion from Step 2 is then pattern-matched to the Audit Report generated from Step 1. This typically involves undertaking the four main stages of gap analysis (or similar comparative methodologies) in order to determine the organisation's short, medium, and long-term need.

Step 4: Requires organisations to map their short, medium, and long-term goals into a formal business strategy. This should include strategic objectives and measurable (time-framed) action points with defined reflection points for interim assessment. Priorities should be highlighted to identify critical milestones.

Step 5: Users select an appropriate lens for evaluation (e.g., DESIGN, MANUFACTURING or CONSTRUCTION) – see Layer 2 (Appendix 3). Organisations are then able to undertake a detailed investigation into their offsite capability across a range of predefined areas.

Step 6: This is the main part of the model, requiring users to systematically evaluate capability need across their selected lens. For example, if DESIGN was chosen, then the first assessment box would be D6.1 [Layer 2], followed by D6.2 PE [Layer 3], D6.2 PR [Layer 3], then D6.2 PR [Layer 3]. Where PE depicts PEOPLE, PR signifies PROCESS and TE represents TECHNOLOGY. These capability assessments require users to evaluate their current maturity position using a capability maturity scale of 1-5; where 1 = low (Initial), and 5 = high (Continuous Improvement). This requires reflection across a number of areas (see Appendix 2). Nb. Appendix 2 only identifies typical assessment scores for Design:Process. Users are encouraged to develop their own bespoke organisational-specific capability criteria for all other areas of assessment. When all these areas have been completed, users then undertake the same assessment process through D6.3 [Layer 4], D6.4 [Layer 5], D6.5 [Layer 6], and D6.6 [Layer 7]. Collectively, this data is then stored in the Legacy Archive for future use. Upon completion, all scores are captured in the model (Appendix 1) for pictorial representation of both macro and micro findings.

Step 7: This requires users to reflect upon all the capability maturity scores achieved. This embraces the 36 Capability Dimension Scores [Layer 5], the 9 Combined Thematic Scores [Layer 6], and the main overall (collective) organisational capability maturity score [Layer 7].

Step 8: This step requires critical examination across all evaluated areas. Areas that scored particularly low (e.g., 1 Initial) would therefore naturally form a starting point for discussion, noting where and why these low scores were achieved. The intention here is to understand the impact of these scores on successive areas of the business, as if left unchecked, they would continue to act as anchors (barriers) to higher levels of maturity achievement. After both macro and micro analysis, an Action Plan is then produced to address areas of concern in order to support future maturity progression.

Step 9: This is the last step of the model, requiring users to generate an organisational Audit Report from this assessment process. This report acts as a formal 'checking mechanism' for future guidance. It should therefore be presented in such a way that this is able to depict all decisions, action points, resources, timescales etc. Perhaps more importantly, it should also capture the underpinning rationale supporting these decisions, as future evaluators may not always form part of the next evaluation period. Successive evaluators will need to appreciate the tacit knowledge underpinning all decisions made before they start the process again at Step 1.

Understanding the Results from the Seven-Layered Capability Assessment Model

One of the main changes organisations often face when trying to evaluate their performance is that of metrics. More specifically, how they have performed. In this respect, some organisations have a number of 'tried and tested' systems and tools that they have always used, as they are somewhat familiar with them, on how well they fit their company. Others however, adopt a more lassie faire approach, using new tools and techniques as and when they becomes available on the market. Understandably, there is no right or wrong answer here as to which tools to use - whatever works for the organisation in question. The challenge here is not whether one tool or approach is better than another, or whether hard metrics are preferred to soft; but rather, what works, given that offsite organisations tend to vary in size, type, and complexity. Given this, the decision to adopt the CMM approach was taken to showcase an 'accepted' standardised approach for showcasing evidenced-based results along with corresponding 'improvement' indicators. This standardised evaluation technique was considered a much better approach for focusing attention on offsite-specific issues - targeting specific, repeatable areas (People, Process, Technology) - to align resources and activities – in order to secure future improvement (organisational maturity). This includes short, medium, and long-term goals using a consistent evaluation technique. In doing so, this approach provides a much greater objective view of the business dynamics and organisation need (ergo capability), across five capability levels. Whilst the current capability state is presented as a number (1-5), the more important message this showcases to organisations is where the main problems are which need attention. This in itself then helps organisations establish actionable progression plans for the next evaluation period.

CONCLUSION

This report reflected on the global impact of offsite, particularly over the last 10 years since the publication of CIB's first Offsite Report (TG74 Publication 372). From purely a simple comparison perspective, it was immediately apparent how much offsite had changed over this short timescale. One of the most striking aspects was how offsite is now perceived. It is no longer seen as 'niche', nor does it play "second fiddle" to conventional approaches. Arguably, it is now leading the conversation in so many different ways as a "go-to" solution. This is due in part to a number of high-profile solutions now being showcased; including novel, highly flexible and innovative solutions with corresponding immutable advantages. In this respect, the market share of offsite continues to grow around the world, with an increasing array of bespoke solutions now being offered. This growth and impact has also been evidenced throughout the supply chain, with sector-maturity now reinforcing contractual decision making. Confidence is therefore at an all-time high. However, there is still a long way to go.

Conventional siloed thinking (procurement, design, construction, manufacturing, production etc) is still very much apparent. This not only (inter alia) acts as a barrier, but arguably stifles innovation, and most certainly influences the overall impact of the offsite value proposition. The nexus of these issues can broadly be grouped into a complex arrangement between "People, Process and Technology", and cross-correlation between "Design, Manufacturing and Construction". The corollary of this is that organisations are still faced with a number of important decisions, all of which either directly or indirectly influence the final outcome (ergo the end product). One of the main challenges noted was the way through which organisations tended to make offsite decisions; where historically, these were predominantly made though inherited tacit knowledge, or collectively though informed choice (using their internal organisational skill base).

This report provide additional clarity in the offsite decision-making process. It establishes a series of firm measures and metrics to help organisations make much clearer informed choices across a range of issues. In doing so, this new W121 Capability-Driven Research Roadmap and accompanying rubrics was developed with 'representative' offsite stakeholders to showcase new evidence. This was developed on the principles of 'capability', to offer offsite organisations with a unique opportunity of being able to assess their offsite maturity. This multi-dimensional approach is proffered as a standardised approach for managing and monitoring offsite capability. This roadmap is completely customisable to suit different organisational types and dynamics (e.g., scale, size, context etc), with flexibility in strategic choice (e.g., platforms, proprietary drivers, risk portfolios etc). It is envisaged that this new offering will provide readers with a much clearer vision of the way forward – certainly for the next ten years (at least!).

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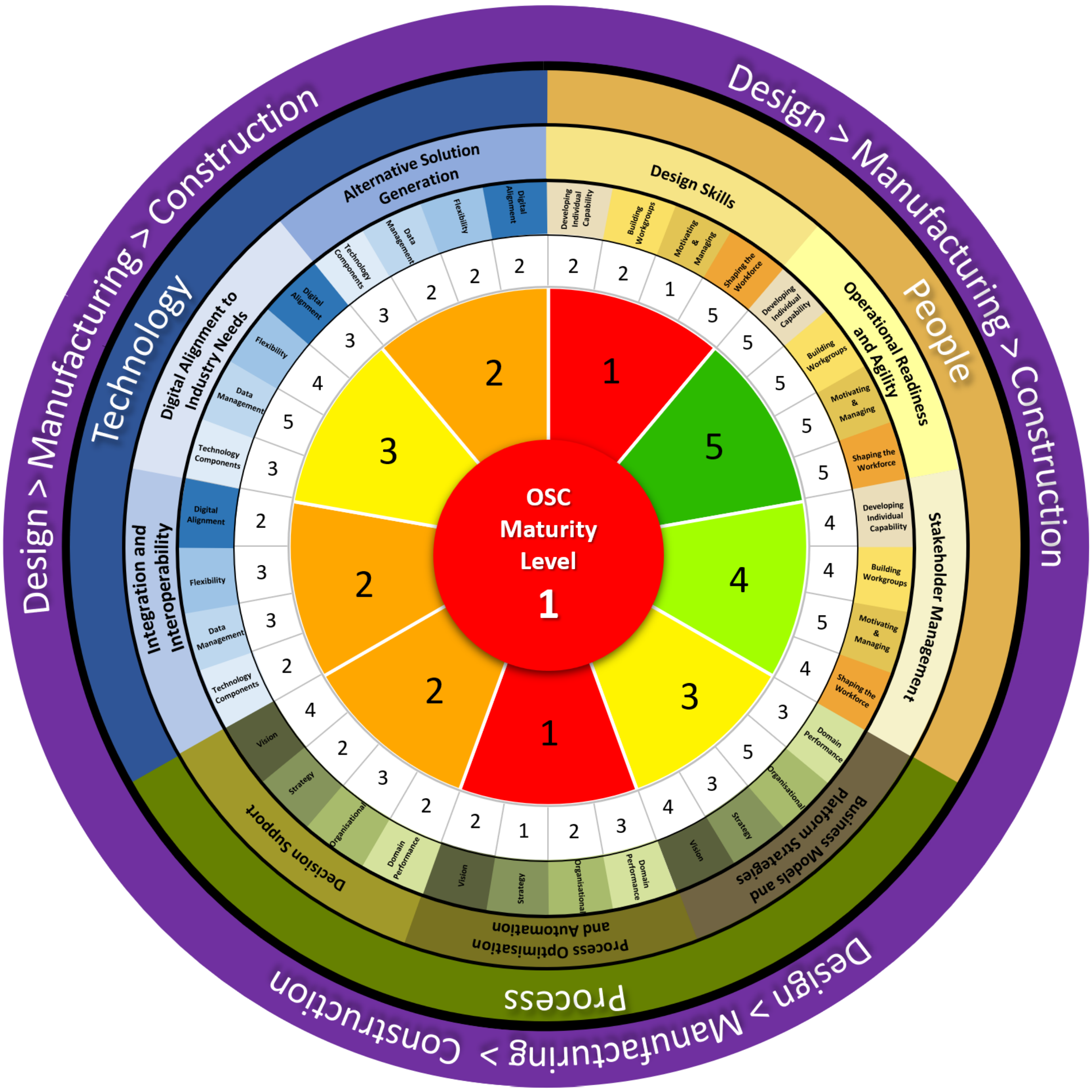
Appendix 1: W121 Roadmap Model



Appendix 2: W121 Maturity Table (Design:Process)

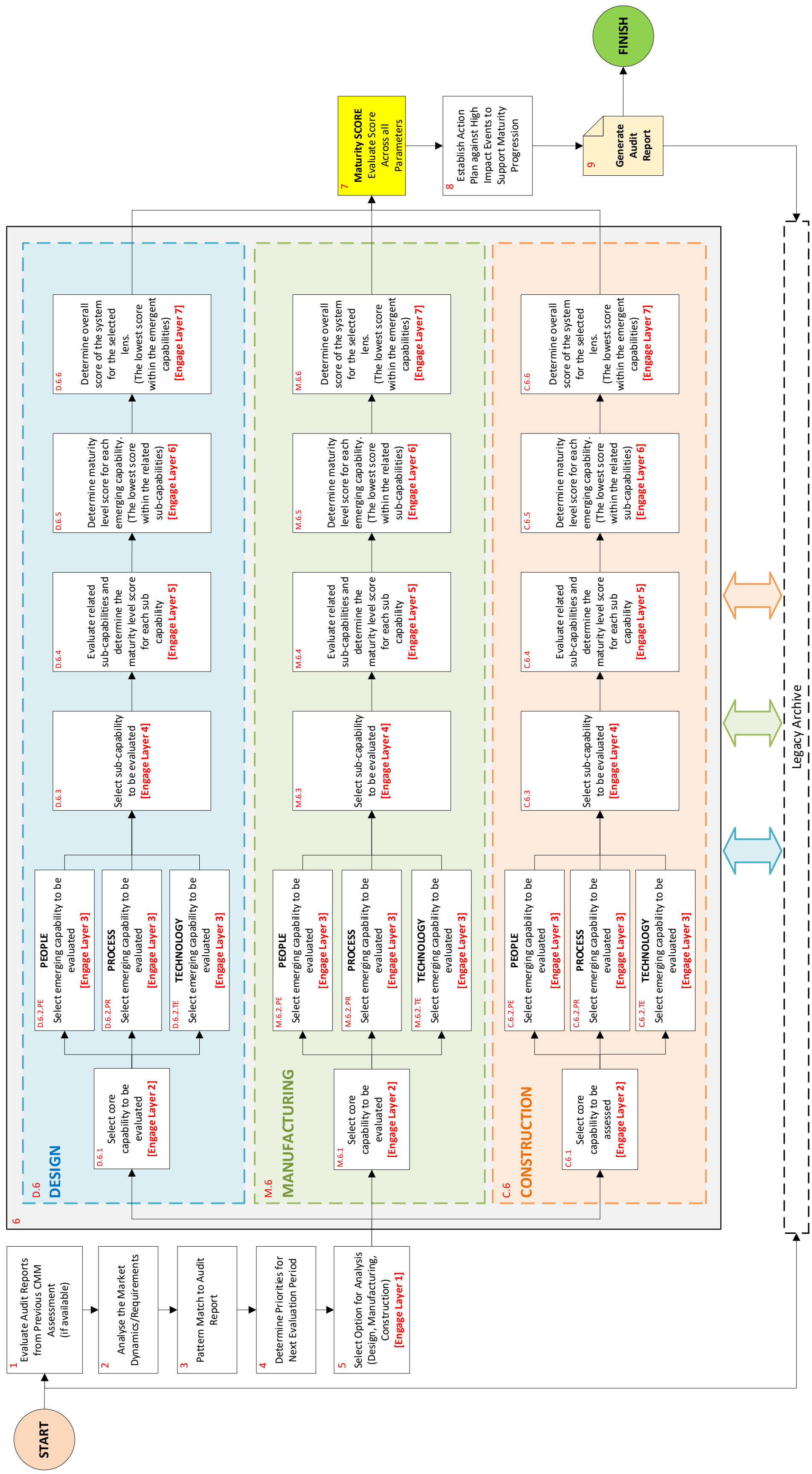
DESIGN - PROCESS

BUSINESS MODELS AND PLATFORM STRATEGIES

Development of new business models and platform strategies which purposefully encourage the uptake/use of OSC. Emphasis should be placed on leveraging corporate resources to support synergy across all provision. The underpinning rationale should be directly structured to maximise the core service offering and future exploitation opportunities (e.g. niche specialism, servitisation packages etc).

	Level 1 (Initial) *MINIMUM organisational process requirements*	Level 2 (Managed) *Establishing a structured and stable OSC working environment*	Level 3 (Standardised) *Provision of standardised processes and integrative measures*	Level 4 (Predictable) *Refinement, alignment and optimisation of processes and integrative measures*	Level 5 (Continuous Improvement) *Applied innovation measures to deliver "best in class" OSC process provision*
Vision	Intrinsic understanding of the OSC market, supply chain dependencies, and organisational direction of travel.	Good overall understanding of the OSC market, business need and direction.	Very good understanding of OSC market, strengths and weaknesses of the business model and company's market positioning.	Excellent understanding of OSC market, supported by advanced key performance indicators (KPIs) for predicting market changes and opportunities.	Sector-leading positioning in the OSC market. Continuous evaluation of OSC market dynamics, supported by agile business models and reactive platform strategies.
Vision	Intrinsic understanding of OSC business models. Some understanding of the impact of these on the design process.	Good understanding of OSC business models and potential impact on design processes.	Very good understanding of OSC business models. Some understanding platform strategies needed to maximise 'value' from OSC design processes.	Excellent understanding of OSC business models and platform strategies. Use predictive modelling to evaluate impact of new business models and platform strategies.	Clear horizon scanning measures in place to re-position goals from business models and platform strategies to exploit opportunities.
Strategy	Limited awareness and appreciation of OSC innovation opportunities.	Good awareness of the need to embed innovation into OSC business models and platform strategies.	Very good experience of deploying innovative approaches to improve OSC business models and platform strategies throughout the design process.	Advanced application of innovation opportunities to create strategic advantage. Innovation is the central tenet to the development of business models and platform strategies.	Applied innovation measures drive continuous improvement. Evidence-based indicators used to measure exploitation impact.
Strategy	Limited use of process improvement measures and strategies.	Good understanding of process improvement measures (especially design-process) including impact on business models.	Very good experience of applying process improvement measures on business model and platform strategies (as a part of the OSC design strategy).	Advanced use of process improvement measures on business model and platform strategies. Clear definable (quantifiable) metrics used to evaluate goals.	Process improvement measures are aligned to innovation strategies. Clear definable (quantifiable) metrics are dynamically evaluated against performance expectations.
Organisational	Outline understanding of business models and organisational requirements underpinning OSC design processes. Limited integration.	Good understanding of business models and requirements. Need for reengineering acknowledged (aligning design functions/divisions to maximise value).	Very good experience of business models and requirements. Clearly defined design processes evidenced, along with supportive integration measures.	Advanced application of design process KPIs underpinning business models and platform strategies. Full integration measures adopted.	Continuous analysis of design processes and KPIs underpinning business models and platform strategies. Use of alternative evaluation strategies to improve value. Seamless integration throughout.
Organisational	Outline understanding of organisational resources needed to deliver OSC design processes.	Good understanding of organisational resources supporting the delivery of OSC design processes. Evidence of monitoring/execution plans.	Very good understanding of the impact of organisational resources on OSC design processes. Evidence of monitoring/execution plans, with resources aligned to OSC business models.	Advanced use of integrative measures across a range of disciplines to maximise the impact of organisational resources on OSC design processes. Evidence of monitoring/execution plans.	Systematic continuous improvement analysis of organisational resources on OSC business models and platform strategies. Clear engagement of mitigation strategies.
Domain Performance	General understanding of design-process operational requirements needed to support the OSC product offering. Outline requirements understood (to deliver the business model).	Good understanding of design-process operational requirements supporting the OSC product offering. Requirements codified and aligned to deliver OSC design processes across some functions/divisions.	Very clear understanding of design-process operational requirements supporting the OSC product offering. OSC design processes mapped across all functions/divisions, supported by performance metrics.	Advanced understanding of design-process operational requirements supporting the OSC product offering. All OSC design processes mapped and integrated. Performance metrics used to improve operational value.	Continual evaluation of design-process operational requirements. Performance metrics dynamically monitored to improve operational value and performance. Full integration of operational OSC design processes mapped to best-in-class provision.
Domain Performance	General understanding of process performance on design criteria and product outcomes (operational level). Limited synergy/engagement of integrative measures (evidenced in the business model).	Good understanding of process performance on design criteria and product outcomes (operational level). Some synergy and integrative measures evidenced in the business model.	Very good understanding of process performance on design criteria and product outcomes (operational level). Synergy and integrative measures evidenced in the business model. Strategic performance goals aligned to customer requirements.	Advanced application of process performance on design criteria and product outcomes (operational level). Clear integrative measures used to inform performance. Performance goals monitored. Use of optimisation approaches.	Continual evaluation of process performance on design criteria and product outcomes (operational level). Full engagement of integrative measures and optimisation approaches to deliver best-in-class domain performance.

Appendix 3: W121 OSM Roadmap Nine-Step Approach



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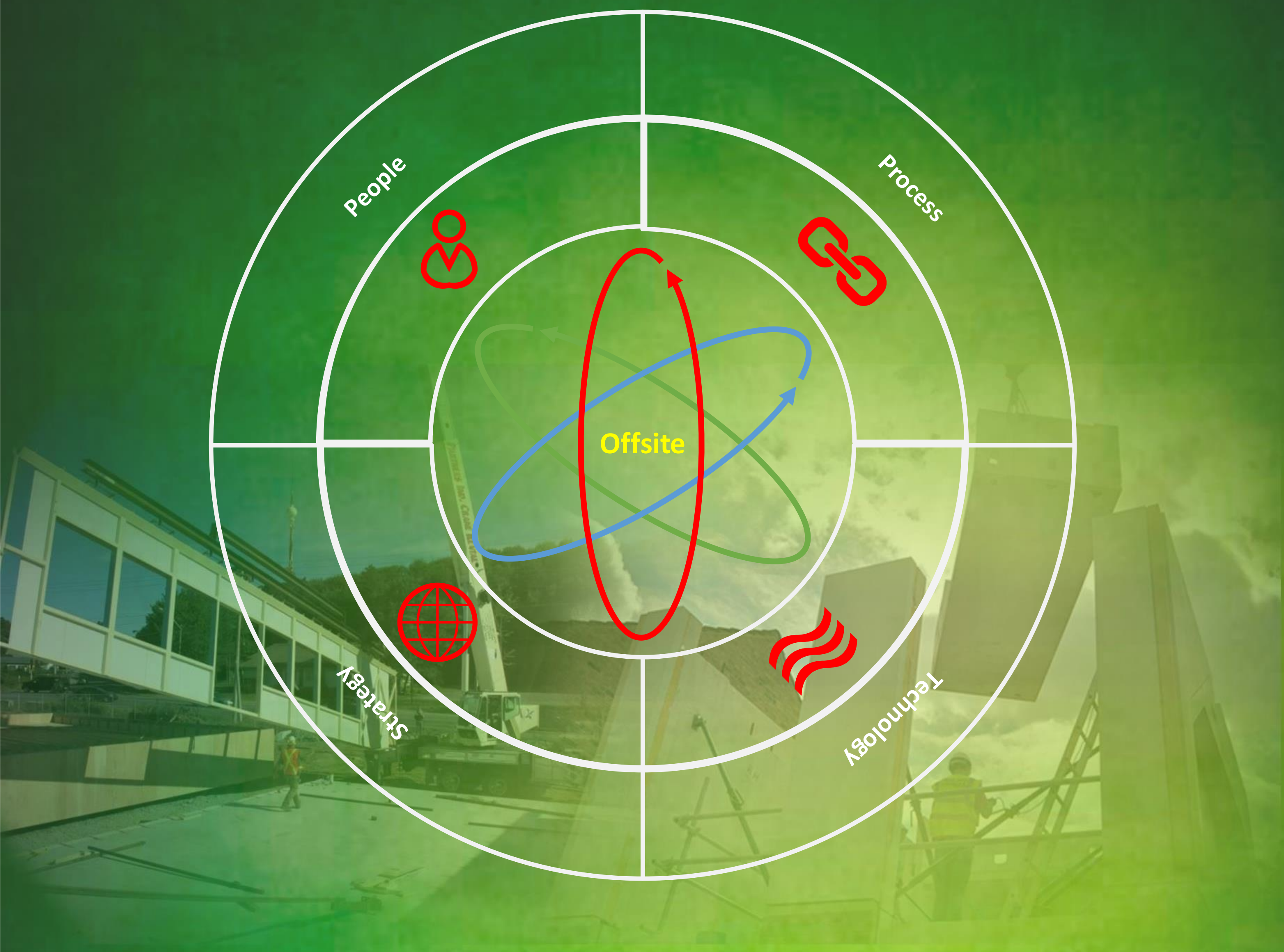

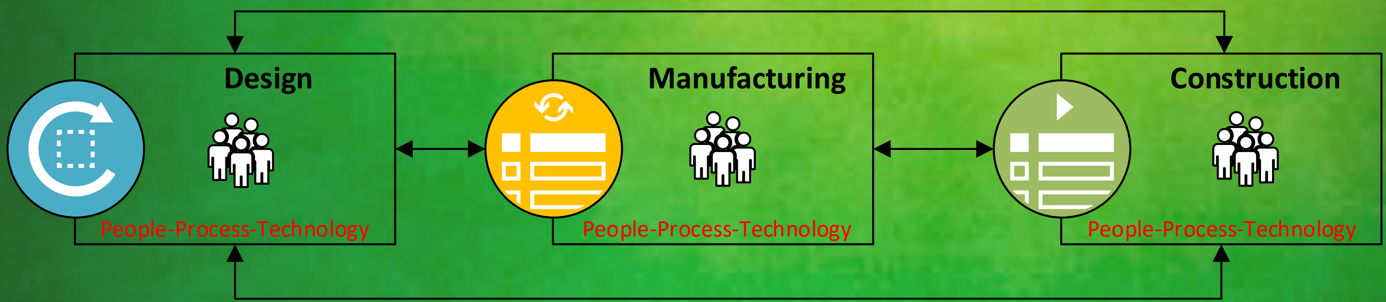

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