

building
4.0 crc

PROJECT #10: PRODUCT PLATFORMS FOR VOLUMETRIC CONSTRUCTION

FINAL REPORT



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Preface

Researching industrialised construction at the Future Building Initiative, we often look abroad for case studies of best practice examples. Countries such as Sweden, Japan, and Germany have had a long history of implementing and refining prefabrication as an alternative to traditional construction. Consequently, those contexts have provided fertile ground for construction innovation (digital technologies, streamlined supply chain management, product platform implementation, refined production strategy). These countries also benefit from a well-established culture of collaboration between academia and industry that has fueled these commercial developments, establishing the benefits of applied research interpretation and analysis.

Australia, historically, has not had the manufacturing capacity or scale observed in Sweden, Japan, or Germany, nor has Australian prefabrication been associated with the delivery of desirable or high quality building stock as seen overseas. For these reasons, and many more, implementing a sophisticated industrialised construction approach in this context can be challenging at best. Research programs, such as the Building 4.0 CRC, demonstrate industry interest in developing more innovative and complex methods of building, and align research to this end.

In Australia, there have not yet been many known local examples of advanced product platforms in use by industrialised building companies. This is why CRC#10 has been such an interesting and important project to be involved in. While Fleetwood Building Solutions has some way to go in establishing its own platform approach, the current initiatives within the company, and the evident desire to be leading industry change are exciting. As researchers, we are thrilled to be able to follow, provide input to, and document the early stages of this journey.

Acknowledgements

It has been a great pleasure to spend the last 12 months getting to know the people and practices of Fleetwood Building Solutions. Specifically, we would like to extend our gratitude to Brendan Pope (FBS Head of Design and Innovation) and Stuart Waters (FBS Virtual Design and Construction Manager) for their invaluable input to the project. Our regular Tuesday morning catch-ups provided an opportunity to reflect on, verify, and contextualise the insights of the research, guiding the project trajectory.

We also would like to thank all of the Fleetwood Building Solutions staff who participated in the interviews and workshops, and generously hosted factory and site visits. These engagements were instrumental in providing a window to the company philosophy and operations, and allowed us to uncover some of the promising initiatives towards platform-thinking already underway within FBS.

We hope that the research findings presented in this report generate some robust internal conversations, and provide a framework through which to consider a future company state.

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01

// Introduction

This report summarises the research activity conducted by the Future Building Initiative in Phase 2 of the Building 4.0 CRC's Project #10 (CRC#10) Product Platform for Volumetric Building, as well as the overall findings of the project. The 12-month study aimed to investigate the potential of a product platform approach for volumetric building in the Australian context, specifically in response to the operations of Fleetwood Building Solutions.

Product platforms seek to standardise products, processes, company knowledge, and supply chain to drive efficiency, unlock design variability, and enable continual improvement in response to market conditions. Originating in the manufacturing industry, product platforms have recently shown utility in construction through commercial implementation by a number of Swedish prefabricated builders (refer to Interim Report: Case Studies in Appendix A). Product platforms deliver commonality in 'assets' that are defined as: physical components; business processes; knowledge management; and stakeholder interactions. Defining common approaches to these assets allows variety to emerge through configuration while focusing resources on each asset to monitor performance and target continual improvement.

Fleetwood Building Solutions (FBS) is a large, volumetric construction company currently servicing the education, resources, and housing sectors through multiple operations across the five mainland states of Australia. The basic FBS module consists of a mild steel structural chassis and frame with light-gauge steel framed walls. The majority of designs are unique and construction is offsite, but both processes remain largely traditional in execution. In recent decades, the company has grown through mergers and acquisitions, leaving legacy processes, structures, and 'path dependencies' in each operation. FBS now has a desire to realign its existing business model that relies on uniquely tendered, state-based projects, to also develop pre-defined product offerings and in doing so, support a national design-build strategy through a clear FBS product platform.

Project Objectives and Methods

The objectives of CRC#10 are as follows:

Phase 1 (captured in the Interim Report, see Appendix A)

- Demonstration of the value of a product platform approach by communication and analysis of best-practice case studies, which includes commercialisation successes that have transferability to the Australian market.
- Value stream mapping of FBS' existing design, manufacture, and assembly systems.

- Identification of ‘pain points’ in the value stream and opportunities for commonality of parts and processes.

Phase 2

- Development of an outline FBS product platform framework—the base elements for future development.
- Roadmap for full platform development.
- Identification of future research opportunities that will be addressed iteratively in the first half of the research period and formalised in the quarterly research updates.

The research design of the project is illustrated in Figure 01.

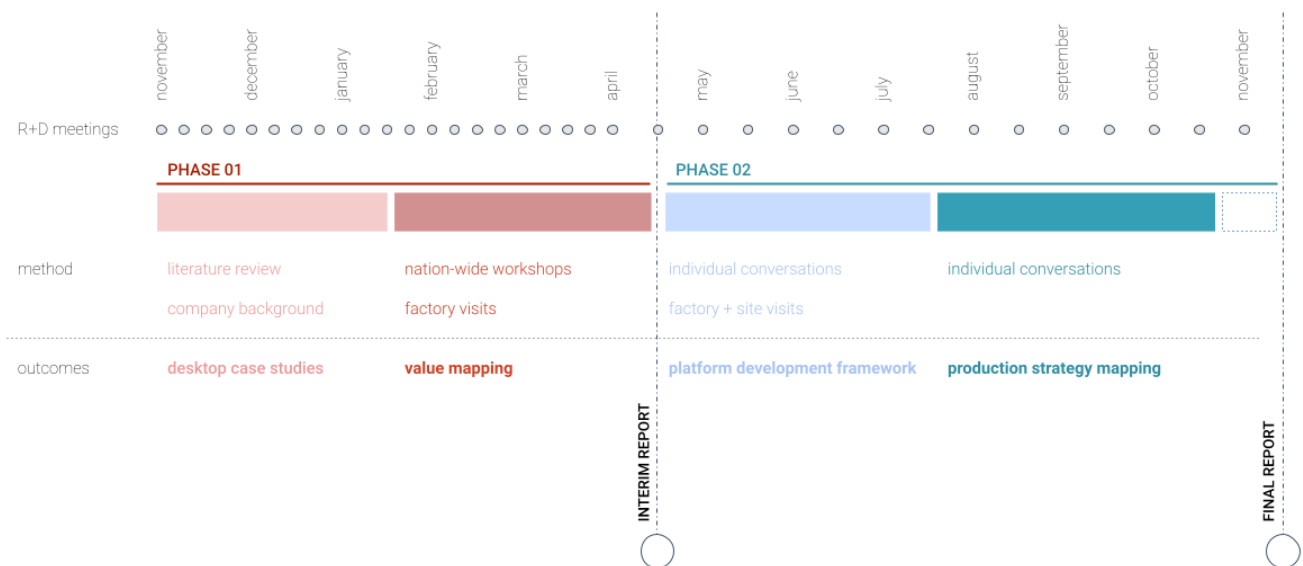


Figure 01. CRC#10 research design.

Phase 1 Research Findings

In Phase 1 of the project, a series of value stream mapping workshops were conducted across all state operations to document and understand the company structure, project and information flows, current challenges, and pain points across the value chain. A summary of the general observations and key issues relevant to the platform development discussion identified through this early research is provided here as context for Phase 2 research activities.

General observations

- All state branches follow a similar sales and design handover process. At the other end of the value chain, delivery and install processes also share many similarities across all states.
- The sales team is the primary point of contact with the client in a project’s early phase, and therefore plays a significant role in determining and establishing design constraints, and managing client expectations.

- From a design perspective there are 2 types of projects: (1) externally designed/specified and value engineered to suit FBS production system, and (2) internally designed.
- Each branch (1) delivers bespoke projects, and (2) services standard offer agreements for which streamlined systems exist within all departments.
- The ambition for product offering diversification is apparent, with all teams seeking internal efficiencies to allow greater design flexibility.
- All production facilities use a static build methodology.
- Some states have production lines, but these lines are only used for 'standardised' projects with high volume and repetition.
- Factory workforce is outsourced to subcontractors (to varying degrees), typically on repeat jobs throughout long term engagements. Contractual arrangements with subcontractors vary state to state.
- Most site activities are outsourced, except in VIC, where the in-house transportation team delivers and installs modules.
- Horizontal communication between the design, production, and site teams of the various states was largely non-existent prior to the value-stream mapping workshops (with the exception of a personal relationship between two of the Production Managers). On the other hand, horizontal communication between state Sales departments exists and is perceived to be valuable.
- Currently no standardised protocols exist for capturing, communicating, and actioning lessons from previous projects across the value chain. There is a need to develop and implement knowledge management practices to facilitate feedback channels, enabling continuous improvement of the overall approach.

Pain Points

- Design freeze. From the design perspective, the time taken to document projects is a pain point. From the production perspective, timely access to reliable design information is a key issue.
- Design changes (regulatory, compliance driven, production-focused) resulting from the low level of detail resolution at contract signing.
- Upstream flow of information from procurement and production to design.
- From the production perspective, lack of technical product knowledge in the design team.
- Long lead times on items such as windows and doors.
- Indirect costs of production/construction methodology are not accurately captured.
- Unforeseen site delays, resulting in uncertainty around module delivery (factory floor is occupied longer than anticipated). Sometimes factory trades will also complete site work, compounding issues around factory schedules when site activities are delayed.

- Transport-related challenges in any given project include: finding a suitable route; lengthy permit delays; and metropolitan road transport limitations.
- Site-related challenges such as: negotiating working hours and exclusion zones at sensitive sites such as schools, and for WA specifically, remote locations requiring additional considerations (worker camps and transport).
- Lack of post-mortem project review to identify successes and failures (this was identified by the Sales team, but also applies to the other departments).
- Lessons learned are currently not distilled into a format that is readily available and useful for future projects.

Framing Phase 2—The importance of aligning design and production

Many of the production team's challenges and pain points were related to design handover, while the site team's pain points were mostly related to contextually-derived transport issues and site constraints. This highlights the significance of aligning design and production strategies, regardless of whether a platform approach is pursued. The present report focuses on Phase 2 of the research project, during which the findings of the value mapping were further scrutinised, with specific attention paid to design and production. Follow-up discussions were held with the workshop participants individually to identify opportunities for platform development (Chapter 02) and production strategy definition (Chapter 03). The combined findings inform an implementation and future research roadmap (Chapter 04).

02

// Platform Development Matrix

a. Theoretical Framing

The literature review of platform use in construction informed the development of a framework that guided conversations with representatives from each state. These interactions provided insights to existing modes of operation within the company, and any initiatives towards rationalising, streamlining, and optimising projects and/or products towards a platform-driven approach. The framework is based on Robertson and Ulrich's four platform assets:¹

- *Components*: Physical parts of products that define product families.
- *Processes*: Key processes that can be isolated and refined.
- *Knowledge*: Storage and analysis of design, production, and assembly information.
- *Relationships*: Organisational connections internally, between team members, and externally to the supply chain.

To overcome construction's increased need for design-activity in the definition of a platform-based approach, and its use between projects, these assets require forms of design support as defined by Jansson to assist:²

- *Design Planning*: Supports the structuring and documentation of activities.
- *Collaborative Design*: Enables a collective working environment, creates a match between design-production activities: e.g. time-planning, buildability (back-end), or pull-through of client requirements (front-end).
- *Requirements Iteration (project level)*: Supports discovery of a solution, typically client-focused tasks or those that involve engineering expertise.
- *Design Optimisation (project-to-project/platform)*: Actions are focused on continuous improvement and customer satisfaction.

Building on further work by Jansson et al., the basis of the framework captured in Table 01 describes how each support method interacts with the platform assets.³ In extending this research, at each instance we have defined a series of propositions and questions to define the interactions and from there, we propose that there exists a spectrum of opportunities, that range from a platform-driven scenario, to that of the conventional, bespoke, project-led way of working. These extremes are captured in Table 02, as a way of defining the boundary limits of the spectrums.

¹ David Robertson and Karl Ulrich, "Planning for Product Platforms," *Sloan Management Review* 39, no. 4, 1998: 19.

² Gustav Jansson, "Platforms in Industrialised House-Building," PhD Thesis, Luleå Technical University, 2013.

³ Jansson, Gustav, Helena Johnsson, and Dan Engström. "Platform Use in Systems Building." *Construction Management and Economics* 32, no. 1-2 (2014): 70-82.

	Design Planning Supports documentation of activities	Collaborative Design Enables a collective working environment, creates a match between design-production activities: e.g. time-planning, buildability (back-end) or client requirements (front-end)	Requirements Iteration (project level) Supports discovery of a solution, typically client-focused tasks or those that involve engineering expertise	Design Optimisation (project-to-project / platform) Actions are focused on continuous improvement and customer satisfaction
Component Physical parts of products that underpin product families	<i>Planning and management of 'parts' design — informed by client-needs (push) or manufacturing constraints (pull).</i>	<i>From what perspective do most organisational design collaborations occur, with regards the design of the physical elements?—Buildability? Customer communication? Technical resolution?</i>	<i>How are project-based design issues resolved through components? Are physical components flexible, do they enable reconfiguration? Are there modular design principles at play?</i>	<i>How is the design of components improved over time? (with respect to client needs, production/installation process improvement, cost measures, other?)</i>
Process Key processes that can be isolated and refined	<i>Planning and structuring of activities. What level of detail is present along the value chain?</i>	<i>How does procedural value chain collaboration occur? (Daily, Weekly) What is the focus of this collaboration? Production flow, Quality?</i>	<i>Are there structures in place to enable expert participation in the process?</i>	<i>How are improvement activities undertaken? Who is involved?</i>
Knowledge Storage and analysis of design, production, and assembly information	<i>How knowledge flows and is managed between activities. Is this planned from a business or project perspective?</i>	<i>What is the focus of knowledge capture/management when team members are together? Unique, problem-solving? Search for commonality?</i>	<i>How is expert knowledge deployed in projects to satisfy project-based problems? Is this knowledge captured for future utilisation?</i>	<i>Are there structures in place to support and capture improvement?</i>
Relationships Organisational connections internally and externally from team members to the supply chain	<i>How do external participants engage with the project plan?</i>	<i>Does the structure of relationships support and facilitate effective, flexible, and easy collaboration?</i>	<i>How are stakeholders engaged when it comes to resolving complex, project-based issues?</i>	<i>Are relationships reviewed? Are there systems in place to improve stakeholder relationships?</i>

Table 01. Matrix definitions.

	Design Planning Supports documentation of activities	Collaborative Design Enables a collective working environment, creates a match between design-production activities: e.g. time-planning, buildability (back-end) or client requirements (front-end)	Requirements Iteration (project level) Supports discovery of a solution, typically client-focused tasks or those that involve engineering expertise	Design Optimisation (project-to-project / platform) Actions are focused on continuous improvement and customer satisfaction
Component Physical parts of products that underpin product families	<ol style="list-style-type: none"> 1.Component designs are ‘pulled’, being informed by production possibilities. 2.Component design is ‘pushed’, changed based on customer/project focus. 	<ol style="list-style-type: none"> 1.Open design decision-making across stakeholders. 2.Internal, closed design-team decision-making. 	<ol style="list-style-type: none"> 1.Components define iterative possibilities, resolution in the late-phase. 2.Project attributes drive design response across project phases. 	<ol style="list-style-type: none"> 1.Components gradually optimised with a view to their ongoing utility. Continuous product improvement. 2.Adhoc component design changes, project-specific.
Process Key processes that can be isolated and refined	<ol style="list-style-type: none"> 1. Defined activities with clear structure. 2. Activities are planned in bespoke relationship with project. 	<ol style="list-style-type: none"> 1. Structured, daily collaboration, informed by production. 2. Opportunistic collaboration, qualitative-focus. 	<ol style="list-style-type: none"> 1. Late-phase iteration only. 2. Iteration defines the process. 	<ol style="list-style-type: none"> 1. Established performance metrics. Performance measurement geared towards process improvement. 2. Project-based processes, rarely evaluated. Few metrics.
Knowledge Storage and analysis of design, production, and assembly information	<ol style="list-style-type: none"> 1. Design, production and assembly combine to ‘pull’ project design planning. 2. Planning is ‘pushed’, based on customer/project focus. 	<ol style="list-style-type: none"> 1. Centrally-managed. Activity-focused, sorted by commonality / distinctiveness. 2. Problem-solving, experts. 	<ol style="list-style-type: none"> 1. Expert knowledge baked into the solution. In execution, expert refinement in late-phase. 2. Experts contribute project-specific knowledge from early-phase. 	<ol style="list-style-type: none"> 1. Methods for documenting and integrating learnings. Projects benchmarked. Knowledge capture separated from design. 2. Mostly tacit knowledge brought from previous projects (if relevant).
Relationships Organisational connections internally and externally from team members to the supply chain	<ol style="list-style-type: none"> 1. Long-term relationships, stakeholders familiar with planning design. 2. Variable team between projects, unfamiliar planning structures. 	<ol style="list-style-type: none"> 1. Ongoing, long-term relationships. Collaboration is second-nature. 2. Project-based, unique teams. Collaboration requires effort. 	<ol style="list-style-type: none"> 1. Stakeholders provide continuity across decisions outside of projects. 2. Decision-making is within project-team only. 	<ol style="list-style-type: none"> 1. Measured across multiple metrics, consistently, with feedback captured at operational-level. 2. Strategic feedback only, based on ‘gut-feel’ or economic performance only.

Table 02. Spectrum extremes.

b. FBS Observations

The project team mapped the current state of FBS to understand:

- conventional project-driven modes of working
- the existence of established practices aligned with platform ways of working
- the preferred platform scenario.

Detailed information is commercial-in-confidence and is not presented in this report.

Overall, the analysis shows FBS is transitioning towards a platform-driven approach that streamlines nation-wide processes while still allowing for variations that meet different geographic and market needs.

03

// Production Mapping

a. Theoretical Framing

The importance of production strategy

Production strategy is typically guided by a company's key competitive advantage (e.g. quality, speed, cost, flexibility). Traditionally, in manufacturing, focus on one and its improvement has come at the expense of others.⁴ For industrialised building, different production systems with their varying levels of offsite manufacture have varying strengths and weaknesses that respond to market needs.⁵ Performance measurement, in the form of KPIs, are critical to understanding how overall production systems are operating such that competitive priorities can be balanced.⁶ For offsite construction, this is particularly important as many building measurement systems have utilised qualitative production estimates that are grounded in traditional construction approaches or simplified systems of quantitative measurement.⁷

KPIs are important to measure and evaluate appropriateness of production strategy in terms of an industrialised building company's product and market positioning, however reliable KPIs that are specific to construction in an offsite context have been historically lacking due to construction's tendency towards unique, project-based solutions and measurements. As such, many KPIs that are utilised by offsite construction businesses leverage consumer product manufacturing measurements (with an inappropriate scale and complexity of product) or those used by project-based construction. Recent research has sought to define KPIs that are aligned to prefabricated production.⁸ Such offsite production KPIs at first reading may appear conventional: quality, speed, cost, flexibility. However, in detail they inject more nuance to capture:

- project quality over time through the production system;

⁴ Hayes, R.H. and S.C. Wheelwright (1984), *Restoring Our Competitive Edge: Competing Through Manufacturing*, John Wiley & Sons, New York, NY.

⁵ Jonsson, Henric and Martin Rudberg (2015), "Production system classification matrix: matching product standardization and production-system design", *Journal of Construction Engineering and Management*, Vol. 141 No. 6.

⁶ Miltenburg, J. (2005), *Manufacturing Strategy – How to Formulate and Implement a Winning Plan*, Productivity Press, New York, NY.

⁷ Gibb, A.G.F. (2001), "Standardization and pre-assembly- distinguishing myth from reality using case study research", *Construction Management and Economics* 19 No. 3, pp. 307-315.

⁸ Jonsson, Henric, and Martin Rudberg. "KPIs for Measuring Performance of Production Systems for Residential Building." *Construction Innovation* 17, no. 3 (2017): 381-403.

- delivery speed that accounts for precision of time estimates and their dependability;
- cost in terms of whole project and specific to the production system phase as well as the estimate's precision and dependability; and
- production flexibility in terms of deviation between the breakeven point and production's maximum capacity.

Further research is required to refine and test offsite construction production strategies, especially as new production systems and technologies emerge, however the importance of developing a clear production strategy and its alignment of product design with market needs must not be underestimated.

Construction-specific DfMA

Construction-specific DfMA is still a relatively young field of knowledge, and there are several reasons why the tools and evaluation methods used in manufacturing are not completely appropriate for use in the design of buildings (production environment, product scale, production processes).⁹ Certainly, there are principles and generic design rules that can be taken from the manufacturing context such as:¹⁰

- Part count reduction;
- Eliminating parts whose sole function is to connect to other parts;
- Standardising materials, parts and processes;
- Modular design and product families;
- Symmetrical parts for easy orientation, otherwise obvious asymmetry is recommended (mistake-proof insertion);
- Minimising part weight;
- Self-aligning and self-locating parts;
- Provision of datum surface to assist part location;
- Provision of base part to which others can be assembled;
- Assembly about one axis, from above is recommended (use gravity);
- Ensuring adequate vision and access;
- Minimising dexterity required for assembly;
- Minimising and standardising tool requirements.

However, how and when these principles are to be applied, and importantly, which of these warrant precedence in the design and production of buildings has not been studied in detail. Certainly, no definitive design evaluation metrics have been

⁹ Ivana Kuzmanovska, "Building Design for Manufacture and Assembly: Reframing the Design-Production Relationship in Industrialised Construction", PhD Thesis, Monash University, 2020: 62.

¹⁰ K. L. Edwards, "Towards More Strategic Product Design for Manufacture and Assembly: Priorities for Concurrent Engineering," *Materials and Design* 23, no. 7 (2002): 651–56.

established, leaving space for building typology- and company-specific DfMA approaches to emerge.

High-level recommendations for implementing DfMA at the project management level exist in frameworks such as RIBA's Plan of Works overlay 2021, and Singapore's BCA BIM for DfMA guide 2016.¹¹ All of these frameworks highlight the importance of early contractor involvement and collaboration with the supply chain. In a company like FBS, this would equate to high levels of collaboration and communication between design, production, transport and site teams. Additionally, most frameworks acknowledge the importance of the design phase as a (potentially extended) time frame when production issues are properly considered and addressed.

There also exist frameworks for the development and implementation of metric-based design evaluation methods, such as those shown in Figures 02 and 03, which outline the steps taken to identify, define, and measure relevant design attributes to drive design improvements. This is aligned with the need for KPIs to evaluate appropriateness of production strategy in any given construction business setting.

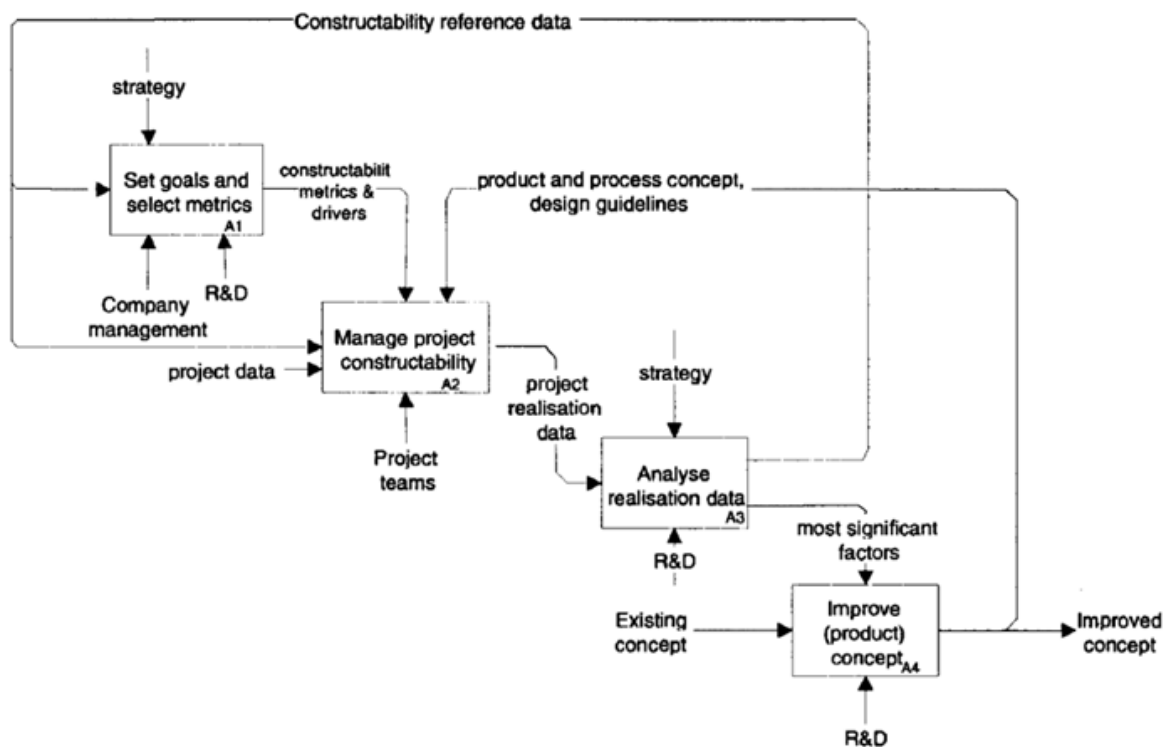


Figure 02. Design for Construction framework developed by Lautanala.¹²

¹¹ Royal Institute of British Architects, *DfMA Overlay to the RIBA Plan of Work, Mainstreaming Design for Manufacture and Assembly in Construction* (London: RIBA, 2021)., Centre for Construction IT, Building and Construction Authority, and Bryden Wood, *BIM for DfMA (Design for Manufacturing and Assembly) Essential Guide* (Singapore: BCA, 2016).

¹² Mika Lautanala, "A Process Approach to Design for Construction," in *Lean Construction*, ed. Luis Alarcón (London, New York: Taylor & Francis, 1997), 244.

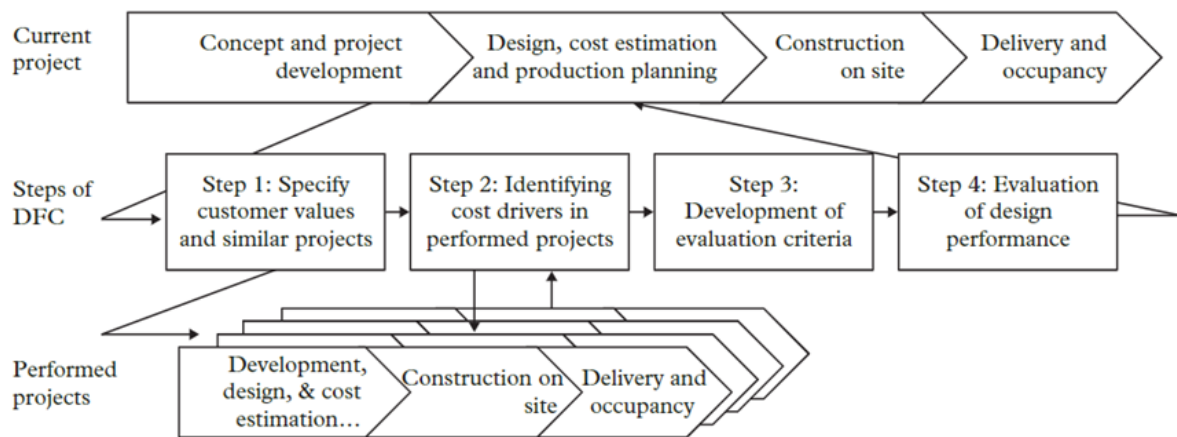


Figure 03. Design for Construction framework developed by Gerth et al.¹³

b. FBS Observations

Factory visits and production-focused conversations with the manufacturing managers of each state branch provided insights to the production strategy and how it is reflected in the factory planning.¹⁴

The factory mapping exercise was used to elicit further conversation and insight into factory processes and how they inform or impact design. Discussions with manufacturing/production managers focused primarily on the definition of production steps and the factory layout rationale. These conversations, and the resulting mapping reveal commonalities and differences in factory layout and production activities that are important to address when contemplating a company-wide platform approach.

This information is commercial-in-confidence and is not presented in this report.

¹³ Robert Gerth et al., "Design for Construction: Utilizing Production Experiences in Development," *Construction Management and Economics* 31, no. 2 (2013): 141.

¹⁴ It is worth noting that factories in only three states were visited (QLD, NSW, and the Wood St. and Kangaroo Flats facilities in VIC). The NSW facility was visited during the transition phase from the previous factory, while production was occurring in both premises, and so the final set-up of the factory was not witnessed. The WA and SA mapping is based on conversations with production personnel.

04

// Roadmap

Understanding and mapping FBS's characteristics allowed the team to identify opportunities and challenges to implementing a platform-driven approach, which they used to develop a roadmap. This roadmap recommends future development opportunities for FBS that loosely align with Robertson and Ulrich's four platform assets—components, processes, knowledge and relationships.

This roadmap is commercial-in-confidence and is not presented in this report.

// Appendix.A

Phase 1 Interim Report

CRC#10

Product Platforms for Volumetric Construction

A Building 4.0 CRC project developed in collaboration with FBS Building Solutions

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01

// Introduction

Since November 2020, Building 4.0 CRC's Project #10 (CRC#10) Scoping Study—Product Platform for Volumetric Building—has undertaken its opening phase of research activity focused on:

- literature review and construction platform implementation case studies;
- background data collection from Fleetwood Building Solutions (hereon referred to as FBS);
- two rounds of interview workshops with the design, production, installation, and sales teams; and
- value stream mapping based on this phase of data collection.

CRC#10 aims to demonstrate the potential of a product platform approach for volumetric building in the Australian context of FBS' operations. Of the agreed project objectives, this interim report provides an initial research response to the following:

- Demonstration of the value of a product platform approach by communication and analysis of best-practice case studies, which includes commercialisation successes that have transferability to the Australian market.
- Value stream mapping of FBS' existing design, manufacture, and assembly systems.
- Identification of 'pain points' in the value stream and opportunities for commonality of parts and processes.

Further, this Phase 1 report informs the research plan of Phase 2 activities, where the opportunities of a product platform approach specific to FBS will be investigated, analysed, and presented.

02

// Literature Review

Product Platforms have demonstrated impact on the volumetric building value chain, with the approach having been implemented by a select group of offsite building companies, notably in Sweden, since the early 2000s (refer Section 03—a). Further, the approach has gained traction in efforts to innovate the construction industry beyond its project-based tradition, in search of greater efficiency and productivity, particularly in Britain as seen by the UK Government’s Construction Strategy development since 2013 (refer Section 03—b) and the approach featured in a number of recent industry reviews.¹⁵

While the term ‘platform’ is used extensively in business, at times with ambiguity, product platforms specifically refer to a work approach focused on the standardisation, re-use, and continual improvement of a collection of ‘assets’ that drive product development. Companies that utilise product platforms are able to create differentiated products efficiently through the sharing of physical components and processes. Such an approach delivers flexibility and responsiveness to the market as well as production.

The assets of product platforms were defined by Alvin P. Lehnerd and Marc H. Meyer in *The Power of Product Platforms* after a period of research into manufacturing companies’ use and development of the approach during the 1990s. Lehnerd and Meyer identified platforms’ ability to seek opportunities for “commonality, compatibility, standardisation or modularization among different products and product lines”.¹⁶

Having analysed automotive industry case studies in the decades prior, Robertson and Ulrich determined product platform assets to be:

- *components* — the physical parts of products that underpin product families;
- *processes* — key processes that can be isolated and refined;
- *knowledge* — storage and analysis of design, production, and assembly information; and
- *relationships* — organisational connections internally and externally from team members to the supply chain.¹⁷

¹⁵ Mark Farmer, *Modernise or Die: The Farmer Review of the UK Construction Labour Model*. (London, UK: Construction Leadership Council, 2016).; M. Ribeirinho et al., *The next normal in construction: How disruption is reshaping the world’s largest ecosystem*, (McKinsey & Company, 2020).

¹⁶ Alvin P Lehnerd and Marc H Meyer, *The Power of Product Platforms*, (New York, NY: Simon and Schuster, 1997): 2

¹⁷ David Robertson and Karl Ulrich, “Planning for Product Platforms,” *Sloan School of Management* 39, no. 4 (July 1998): 19–31.

Product platforms had emerged in manufacturing over the preceding two decades prior to this research, evolving from the product families that had been established by Alfred P. Sloan at General Motors in the early-20th Century to drive competitive advantage against the mass production ideology pioneered by Henry Ford.¹⁸ Early product families established streams of connected car types in response to different market sectors and tastes. By the late-20th Century, product families had progressed to control the technical development of products, notably in consumer electronics.

Initial literature defining a theory of product platforms identified a strong focus on the linking of design with production to promote production efficiency and market responsiveness. Further, product platforms are considered a strategic business tool that target the improvement of technical and organisational processes to reframe product development away from one-off, individual actions.¹⁹ More recently developments have moved to consider the broader supply chain perspective.²⁰ Such a view supports and implies opportunity for the construction industry, with its complex value chain, and blurred distinction between design, production, and assembly activities.

Market Leverage

This strategic, market-focused view of product platforms determined their ability to integrate design and production in order to select and respond to market preferences while maintaining production efficiency through the alteration of product designs, combining subsystems to target market niches as a 'leveraging strategy'.²¹ Leveraging enables platforms to scale between market segments as well as customer cost profiles.

Strategic Setting

Design processes are a key aspect of product platform-based working methods and develop product platform in two ways, either *top-down* (a proactive approach where a company strategically develops product families from a defined product platform), or *bottom-up* (a reactive method where a company redesigns or consolidates groups of existing products to seek standardisation and process improvements).²² Product platform research has gradually broadened its strategic focus, initially targeting a linking of design and production to a wider focus on utilising the approach to tackle back-end issues in more recent research (refer

¹⁸ Powers, T. L. and J. L. Steward (2010). "Alfred P. Sloan's 1921 repositioning strategy." *Journal of Historical Research in Marketing* Volume 2(Issue 4): 426-442.

¹⁹ Moreno Muffatto, "Introducing a Platform Strategy in Product Development," *International Journal of Production Economics* 60-61 (1999): 145-53.

²⁰ Jianxin (Roger) Jiao, Timothy W Simpson, and Zahed Siddique, "Product Family Design and Platform-Based Product Development: a State-of-the-Art Review," *Journal of Intelligent Manufacturing* 18, no. 1 (July 2007): 5-29.

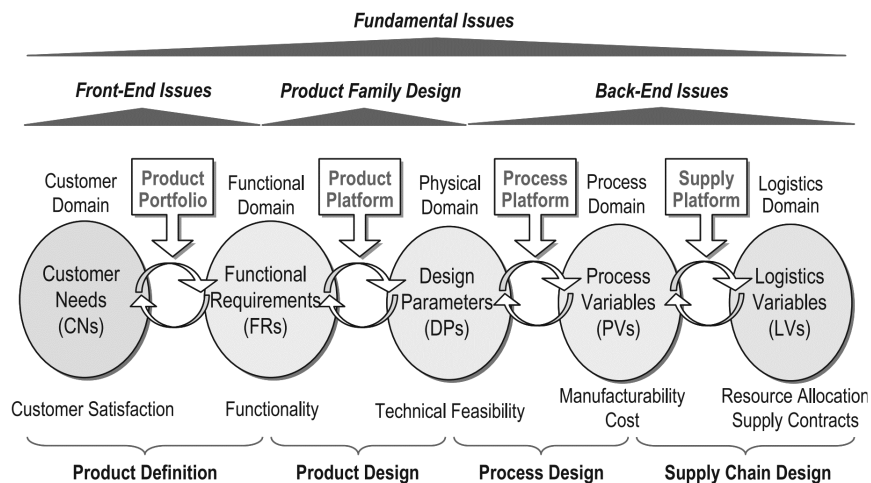
²¹ Marc H Meyer, "Revitalize Your Product Lines Through Continuous Platform Renewal," *Research-Technology Management* 40, no. 2 (Mar/Apr 1997): 17-28.

²² Timothy W Simpson, Jonathan R Maier, and Farrokh Mistree, "Product Platform Design: Method and Application," *Research in Engineering Design* 13, no. 1 (July 2001): 2- 22.

Figure A.01).²³ As yet, the majority of construction research regarding product platforms has focused on the connection of design-production, and not explored this broader perspective.

Figure A.01

Three focus areas of platform development were identified in later research that determined the platform approach to hold utility in the coordination of the supply chain and logistics.



Component Design

Product platforms are typically held to control physical component design through approaches that are either modular, scalable, or integral. These three approaches are distinct. Modular designs typically focus on interface design to ensure that parts are interchangeable, meaning that the overall design can adapt and respond to market or customer needs.²⁴ Scalable approaches feature components that are 'stretched' in order to achieve differentiation, such as airline fuselages.²⁵

Components that are integral in their design are typically aspects of designs that do not change through adaptation, featuring 'fixed' design parameters.

Application to Construction

At their core, product platforms seek to balance commonality (of parts) and distinctiveness (of the overall design).²⁶ This pursuit has led to their investigation within construction. These investigations have been led by Sweden, a country that has a strong culture of collaborative academic-industry research and development. Early research identified the concept's utility for construction, in consideration and definition of industrialised building practices.²⁷ Further development and

²³ Jianxin (Roger) Jiao, Timothy W Simpson, and Zahed Siddique, "Product Family Design and Platform-Based Product Development: a State-of-the-Art Review," *Journal of Intelligent Manufacturing* 18, no. 1 (July 2007): 5–29.

²⁴ Karl Ulrich, "The Role of Product Architecture in the Manufacturing Firm," *Research Policy* 24, no. 3 (1995): 419–40.

²⁵ Timothy W Simpson, "Product Platform Design and Customization: Status and Promise," *AI EDAM: Artificial Intelligence for Engineering Design, Analysis and Manufacturing* 18, no. 1 (December 2004): 3–20.

²⁶ Robertson and Ulrich, "Planning for Product Platforms."

²⁷ Jerker Lessing, "Industrialised House-Building: Concept and Processes" (Licentiate diss., Lund University, 2006)

investigation of platform-based working methods in construction identified that specialised contractors who integrate the supply chain towards a specific market segment benefit fully from the platform concept, while contractors with a wider scope benefit from standardisation of processes rather than product.²⁸ Bringing the concept effectively to construction relies on adaptation and tailoring of the concept for construction's unique circumstance and researcher Gustav Jansson worked with volumetric multi-residential builders to undertake this adaptation, developing 'design support methods'.²⁹ Jansson's support methods comprise design planning, collaboration, optimisation, and iteration. It has been argued that construction platforms should use these supports in order to arrange a product platform's inherent common components in ways that deliver one-off project distinctiveness, rather than being assembled into product families as is common in manufacturing.³⁰ Such a view identifies that construction projects have a unique and complex web of contextual factors that inform project outcomes that are distinct from stable manufacturing environments, therefore the resulting product platforms must be sophisticated in their development and implementation in order to sustain lasting effect.

²⁸ Helena Johnsson, "Production Strategies for Pre-Engineering in House-Building: Exploring Product Development Platforms" *Construction Management and Economics* 31, no. 9 (September 2013): 941–58.

²⁹ Gustav Jansson, "Platforms in Industrialised House-Building," (PhD diss., Luleå Technical University, 2013).

³⁰ Gustav Jansson, Helena Johnsson, and Dan Engström, "Platform Use in Systems Building," *Construction Management and Economics* 32, no. 1 (February 2014): 70–82.

03

// Case Studies

Two groupings of case studies are documented in Section 03, with analysis in terms of their relevance and applicability to volumetric construction companies operating in the Australian context, such as FBS.

The first grouping are three company studies of Swedish industrialised apartment builders. As noted in section 02, Sweden has been the focus of product platform development for construction, and these companies demonstrate the early gains that have been achieved in this translation and application. Each company is distinctly relevant to this project and will be revealed to be relevant to FBS. Beyond the companies themselves, the context features broad alignment as beyond the geographic and climatic contrast, there are contextual similarities in terms of the distances covered in logistics and delivery, the costs of labour specifically and construction generally, and a regulatory context that features a three-tiered system of government.

The second study features a discussion of recent developments in the UK, where the Government's construction strategy has driven investigation of product platforms with analysis of their utilisation for government projects. This work has furthered the development of product platforms for the building industry by presenting a combined vision for product platforms that are informed by Design for Manufacture and Assembly (DfMA).

a. Commercial Development and Innovation: The Swedish Context

While the outside view of Sweden's pursuit of prefabrication generally is often confused with its cold climate and need for high-performance built fabric, the fundamental drivers to build offsite (and subsequently seek product platform-based modes of working) are linked to Sweden's culture of manufacturing and a desire to increase efficiency and productivity in the industry.

A number of construction companies in Sweden have led the practical implementation of product platforms from the research that has identified the required adaptations to test their utilisation and implementation in market conditions. Large-scale contractors, such as Nordic Construction Company (NCC) have developed regionally-specific light-weight building platforms, such as *Folkboende* that deliver apartment buildings using traditional construction methodologies but utilising a product platform-based modular design system and process controls that respond to specific market and technical design requirements of the north of Sweden. Another of NCC's efforts was the short-lived *Komplett* building system that existed at the other end of the product platform approach spectrum, and sought a comprehensive suite of manufactured component designs, process controls, and a highly integrated view of the supply chain to deliver multi-storey apartment buildings via an onsite 'factory'.

Aspects of product platforms are also in development of Swedish institutional buildings, such as prisons, hospitals, and community/recreational centres. These recent developments have been driven by a governmental desire to seek greater efficiency of design and production, having witnessed the gains made so far by the concept. These gains are best summarised by three industry platforms, developed by the contractors: Lindbäcks, Boklok, and Peab.

i. Lindbäcks

Background

Lindbäcks are a family-owned volumetric offsite builder, based in the northern Swedish town of Piteå, 900km north of Stockholm. With origins in student and key worker accommodation, the company is now expanding their product platform to build apartments with higher design emphasis in order to gain access to more profitable sites closer to city centres. Buildings are constructed from timber-frame volumes, and are typically three to six storeys in height, though the technical platform is capable of delivering buildings up to eight storeys. Lindbäcks' two factories are closely located, the first a 19,000m² facility that produces 1,200m² of apartment building per week, the second is a recently opened 44,000m² factory that is capable of 4,000m² output per week.

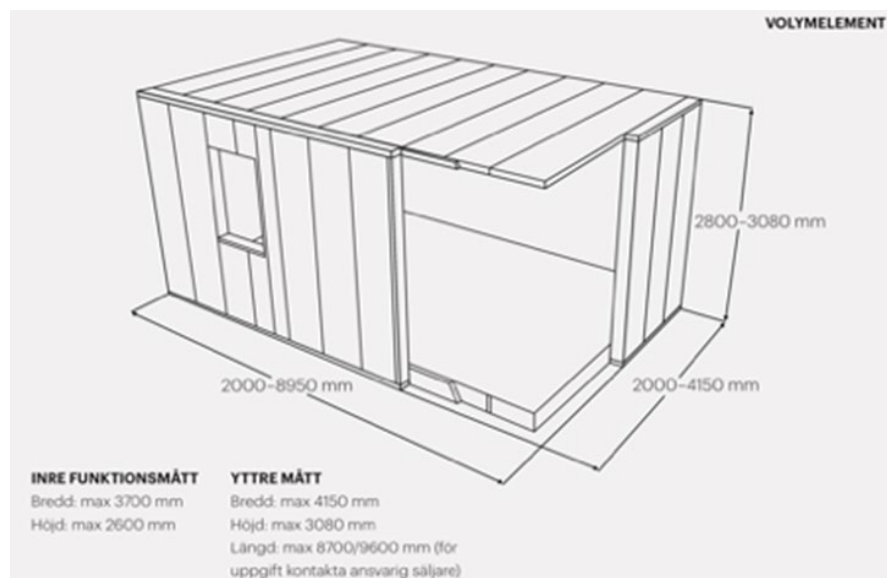


Figure A.02

Published design guidelines assist architects to design with the Lindbäcks product platform.

What is the platform?

The Lindbäcks' product platform, at the component-level is centred on the selection of wall-type components. There is a strong process emphasis with the platform being utilised to guide, manage and support the design process, with clearly established and refined knowledge management practices in place. Lindbäcks has a close working relationship with an industrialised building research group at Luleå technical University, and there is a strong organisational commitment to continual improvement through feedback and ongoing development of the platform. Further, the platform focuses on managing staff and supplier relationships, in particular those of property development companies and architects whose early-phase

designs are brought into the platform through the use of design support methods as outlined in Section 02. Designs are handled according to an adapt-to-order approach, pulling 'unique' designs into the product platform from architect-designed conceptual designs. As a consequence, the development of design processes and support methods has been a key focus at Lindbäck's.

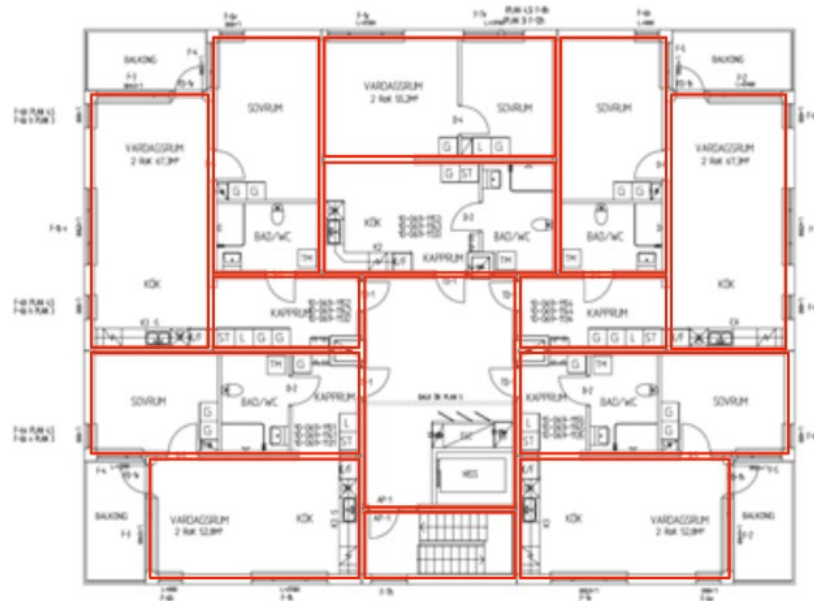


Figure A.03

A typical Lindbäck's plan, broken down into volumetric modules.

Characteristics:

- *Distance.* 70% of Lindbäck's' projects are located in Stockholm 900km south of their factories, and so the company experiences significant geographic dislocation. Logistics is a major priority with alignment of production to ensure consistent factory flow and delivery to site.
- *Adaptation of design.* In contrast to some other product platforms that have been developed by companies that are highly vertically integrated, Lindbäck's work with developers and architects to edit and adapt new, site specific designs. This mode of working is aligned with common and expected practices in Australia where companies are typically less integrated than is common in Europe.
- *Market focus shift.* Lindbäck's are increasingly moving into more prestigious sites with higher design requirements from local authorities. This shift is a trend that aligns with Australian market design expectations, and is an important factor in seeking to define product platforms for construction that can handle and deal with changing market conditions and differing local authority regulatory requirements.

ii. Boklok

Background

A joint venture between Sweden’s multinational contractor, Skanska, and homewares giant IKEA, Boklok was established during the 1990s in response to a housing affordability crisis. Boklok’s mission is to provide accessibly-priced housing to the mass market, that is well-designed and of good quality. Homes are built in a volumetric manner, delivered to site through a value chain that is tightly controlled. The target market for the builds are key workers who have limited income, and since their establishment, Boklok have undertaken detailed financial modelling of imagined end-users to drive the design work. The resulting designs are highly standardised modules that can be reconfigured in response to developer requirements. Design decisions are limited to the number of bedrooms required, roof type, and external cladding. Boklok delivers housing at 25% below the market rate by design as well as business strategy (limits are imposed by both corporate stakeholders to limit the push to drive profits higher). Completed developments are sold through a ‘lottery’ system at IKEA stores, and developments are typically over-subscribed (again limits are placed on purchaser re-selling to constrain investors). These factors allow Boklok a solid revenue stream for future development, and the ability to forecast and confidently plan innovation. Growth has been consistent, and over the past decade Boklok moved from delivering 300 apartments per year in 2010 to close to 2,000 apartments a year currently.



Figure A.04

Built example of the Boklok Flex offering.

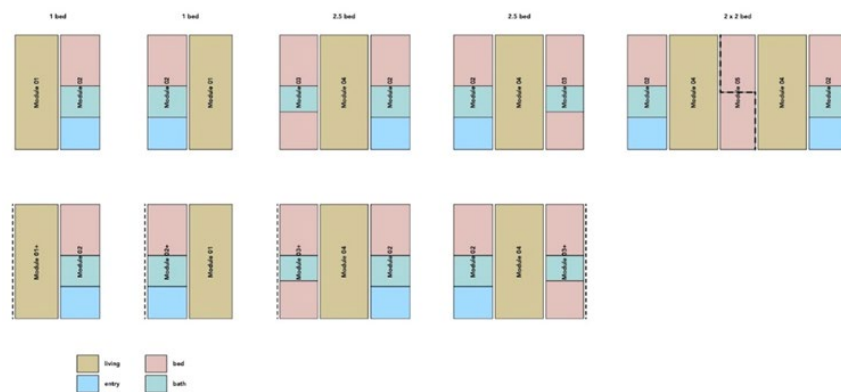
What is the platform?

The highly standardised product platform that has been developed by Boklok has a strong ‘product’ focus. Engineer-to-stock principles are used to control the design phase of the product, with three product types having emerged through generational design over the years since establishment in the 1990s. These are:

Classic (the original design), two forms of *Terrace house*, and *Flex* (a progression of the Classic design with increased design variability). Designs are managed around (1) a platform that has a component emphasis focused on the volumetric module itself, and (2) reconfiguration in response to site and required apartment mix. As with Lindbäck's, a construction methodology of timber-framed floors, walls, and ceilings come together to form these modules and allow Boklok responsiveness to the required technical differences of a varied geographic context of operation (builds occur in Sweden, Finland, Norway, and the UK). Having such a highly standardised product design means that production efficiency is high, with reliance on a strong degree of supply chain control to give predictable procurement. The level of control is possible due to the level of integration that Boklok enjoys, often controlling early-phase design and local authority liaison by building for themselves as developer, through to coordinating the end-user sales process and handover with IKEA stores.

Figure A.05

Boklok's modular configuration approach comprising standardised module layouts arranged to create a limited variety of apartment types.



Characteristics:

- Geographically disparate operations.** Despite having a highly integrated company structure and build process, Boklok have begun to outsource production from geographically disparate locations. With initial factory production only occurring in Sweden, today Boklok also produce and ship modules to the Nordic region from Estonia. A partner company in Estonia is responsible for the manufacture and shipping of Boklok's older and more standardised Classic range, while operations in Sweden build the higher tier Flex product. Further, with their expansion into the UK, Boklok have chosen to partner with a local volumetric building company in a 5-year deal. These production relationships have imposed the need for greater coordination of design, production, and procurement processes in ways that are relevant to Australian operators where geographically dispersed production facilities and build sites are common.
- Market Expectations.** Related to the above consideration are the market expectations and requirements between contexts of operation. Today Boklok delivers homes across the Nordic region of Sweden, Finland, and Norway, as well as in the UK. With a failed expansion into the UK during the 2000s, this is Boklok's second attempt at moving beyond the Nordic region, and the earlier failure highlights the challenges imposed by market alignment and adaptation that is required in terms of a hard technical

regulatory responsiveness. Softer changes to sales processes, customer involvement, and minor design adaptations cannot be underestimated. Of relevance to the Australian context, these technical and market adaptations are apparent for nationally-focused industrialised building companies that seek to implement product platforms that can standardise product or process actions, but retain flexibility in response to regional regulatory needs or customer demands.

iii. Peab PGS

Background

Peab is one of Sweden's largest contractors and has developed a specific product platform for multi-residential construction within their operations called PGS. PGS brings together Peab's construction and production capabilities from a range of divisions to deliver a building system that has a high degree of design-production flexibility. The development of PGS began in 2003 in response to Sweden's rising construction costs, time delays, labour shortages, and perceived drop in build quality. Strategic platform development began from a top-down process of market identification, customer needs analysis, and articulation and design of a product architecture that could deliver buildings aligned to this market. The PGS product has typically focused on university town developments of student housing with a product that can be up to eight storeys in height with greater design flexibility than is common of most student housing typologies, thus allowing Peab competitive advantage in the market. After a period of R&D, the platform was launched publicly in 2007. In operation, by contrast to its strategic development, PGS utilises a bottom-up approach of leveraging existing Peab production divisions to pull together a range of building components from different factories around Sweden.

What is the platform?

The PGS build system comprises a number of building components that together have been patented. By leveraging Peab's existing expertise, the platform is focused on coordination of assets. The patented component designs have focused on a common system of connection that allow parametric adaptation to drive design flexibility. As with Lindbäcks, the Peab PGS platform works with external designers to pull conceptual design proposals into the platform while also using these external engagements to receive feedback on the platform's constraints. By contrast to Lindbäcks, PGS relies on a more fragmented system of production and assembly. The technical platform comprises a range of prefabricated components: lightweight, fast-curing concrete floor slab elements; concrete stairs; a steel primary structural system; volumetric bathroom pods; light gauge steel internal walls; roof cassettes; and an external curtain wall system.

The utilisation of a bottom-up approach to production exhibits a degree of 'path dependency' in the development of the product platform as it draws on Peab's long history of experience developing and delivering steel and concrete buildings. This approach reveals a difference to both Lindbäcks and Boklok whose platforms have emerged in a top-down manner, leveraging new approaches and regulatory changes in recent years for timber construction.

Figure A.06

Graphic breakdown of the Peab PGS platform.



Characteristics:

- *Production coordination.* With multiple internal suppliers and production facilities around Sweden, the PGS approach pulls together a collection of products in a mode that emphasises the need for control of design, production, and logistics delivery. Such an approach holds potential implications for the development of the PGS platform, giving flexibility in the generation of new product types and market responses. This approach holds relevance for Australian companies seeking to coordinate and standardise approaches from operations across the country, potentially unlocking new markets or typologies.
- *Leveraging existing expertise.* Peab's expertise in steel and concrete highlights the opportunities that are presented to companies with existing competence and knowledge of particular building methodologies. FBS has significant understanding of steel structures, processes of design for steel, its production and delivery. As such, like Peab, this knowledge and experience can be leveraged for competitive advantage.

b. Governmental exploration and moves towards a whole of industry approach: The UK Context

In the UK, the British Government has driven a number of investigations of platform-based working approaches. Guided by 2013's 'Industrial Strategy' for construction, a number of exploratory initiatives have been undertaken to examine platform-based modes of working. A key outcome was a 'sectoral deal' in 2018, promising to drive construction innovation and transformation with regards to issues of digital technologies, offsite manufacturing, and whole-of-life asset performance. Product platform explorations by consultants (such as Bryden Wood, described in Section b.i.) provided input to this sectoral deal, leading to discussions around how offsite construction performance improvement is measured, and the role that platform-based methodologies play (discussed at Section b.ii.). These relatively recent explorations of an expanded product platform role in construction in some ways build on the private-sector development work witnessed in Sweden, and move the concept towards an industry-wide procurement approach. To this end, the Construction Innovation Hub's *Platform Design Programme* has established a stream of research investigation into how to articulate and define the need and utility of product platforms, such that the private sector will be able to respond most appropriately. These positions, and direction of R&D work, responds directly to the trajectory of research within manufacturing product platforms that initially emerged as tools to link design and production, but that later broadened their position to include wider supply chain implications (as per Simpson et al., noted in Section 02). When coupled with understanding of DfMA, building industry product platforms are similarly positioned for rapid future development, therefore potentially overcoming blockages to the concept that have historically held due to construction's complex supply chain and unique products/sites.

i. Bryden Wood

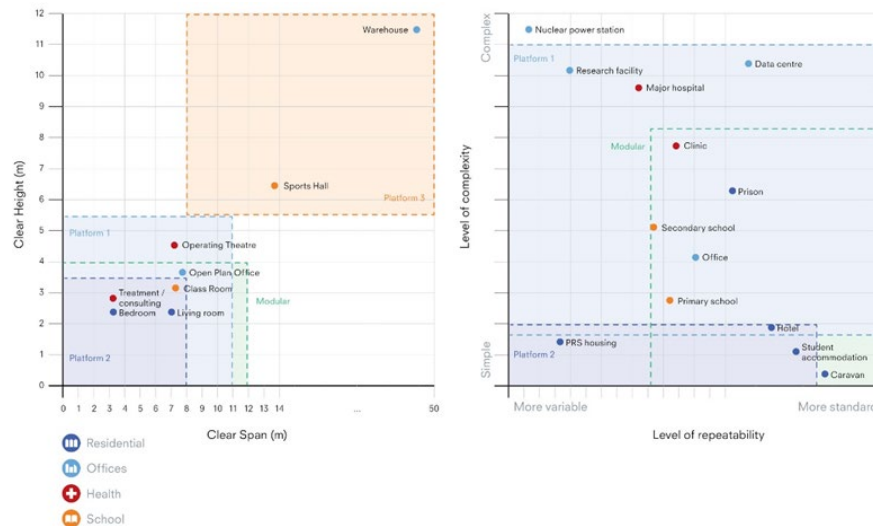
Bryden Wood is a large architecture and engineering firm (250+) operating out of the UK, and is a key proponent of manufacturing principles such as product platforms and Design for Manufacture and Assembly (DfMA) as applied to the construction industry. Bryden Wood is developing their platform approach to DfMA (P-DfMA): an open kit-of-parts product platform for public sector construction projects.³¹ The idea behind P-DfMA is to leverage the scale of demand generated by the UK government construction portfolio to develop a product platform that various manufacturing and construction suppliers can plug in to. These suppliers would not only provide the necessary building parts but also invest energy in iteratively improving and refining products and processes (with the promise of more work to come as a result). The aim is to, where appropriate, (1) rationalise, (2) standardise, and (3) optimise the processes of design, procurement, manufacture and assembly, thereby contributing to a paradigm shift within the fragmented construction industry.

³¹ Bryden Wood, *Delivery Platforms for Government Assets, Creating a Marketplace for Manufactured Spaces* (London: Bryden Wood Technology Limited, 2017).

In 2017, Bryden Wood was appointed as a designer for the UK prison estate transformation programme, for which two product platforms were developed.³² As can be seen in Figure A.07 (which also shows two additional platforms developed for P-DfMA), the P-DfMA platforms are defined around four key characteristics:

- Span
- Height
- Complexity
- Repeatability

Figure A.07
P-DfMA product platforms mapped according to span, height, level of complexity and level of repeatability.



Platform 1 addresses the requirements of accommodation structures in the prison, which contain low complexity and high repeatability, with smaller spans. Platform 2 caters for the more varied communal spaces that tend to require larger spans and more flexibility in arrangement. It is interesting to note that using these four criteria, classrooms and prisons (two of FBS's standard product types) are contained within the same, modular platform in P-DfMA.

The P-DfMA approach to product rationalisation involves three categories of product complexity to facilitate flexibility in design (assemblies, sub-assemblies, and components). For the prison project, DfMA principles were used to develop 30 standard connection details for the structural elements (which could vary in length), and pilot assembly tests were run.

The initial plan was to deliver 10 prisons using these two platforms. In the end, this was scaled back to only one, which significantly affected the viability of production using the platforms. Consequently, the project was realised using a traditional precast concrete system instead. This outcome speaks to the potential misalignment between current procurement and risk allocation models, and the nature of a platform approach in construction. While P-DfMA remains a theoretical concept for now, the approach can offer insights to the implementation of construction-specific platforms locally, especially as the market sectors targeted in

³² Kevin Masters and Jaimie Johnston, 'Automated Construction: Boosting on-Site Productivity Using a Platform-Based Approach', *Proceedings of the Institution of Civil Engineers-Civil Engineering* 172, no. 6 (2019): 23–28.

P-DfMA bear similarity to those serviced by FBS' core business. The criteria of span, height, complexity and repeatability offer a potential framework around which FBS' current standard offerings might be organised in the development of a platform approach.

ii. Platform Design Programme

The work that Bryden Wood undertook to define and explore the potential of product platforms for the UK construction sector has been progressed and developed through a stream of funded research enabled by 2018's 'sector deal' for the construction industry, and coordinated by the Construction Innovation Hub (a granting body similar to the role of Building 4.0 CRC). One aspect of research has been the Platform Design Programme (PDP), a stream of research to identify, refine, and develop platform-based solutions for new buildings such as schools, hospitals, and social housing. Early research has sought to define the need for platform-based solutions by analysing project-based criteria in the British Government's built environment public spending. Factors considered include the areas of spaces procured annually by government departments and the frequency of such spaces, in an attempt to identify initial areas for commonality and standardisation between project typologies.

The PDP seeks to define:

- a rulebook that establishes rules and interface standards for the interface of building components;
- the value proposition of a platform-based approach to building that articulates the benefits, competitive differentiation, cost structure, and life cycle of the platform;
- a kit-of-parts that maps the designs of the physical components that comprise the platform; and
- the resources and enablers supporting the implementation and adoption of product platforms in industry, and addressing the business-level implications of a new way of working.

The broad purpose of the PDP acknowledges that significant effort is required to articulate the roles, responsibilities and processes of a product platform, as much as is required to design the physical kits of parts.

Recent projects within the PDP have made progress to now deliver on these aims. An initial activity has been to seek response from industry as to how best articulate the benefits of a platform-based approach to construction. Further, the definition of a 'Construction Playbook' has sought to map contemporary best practice for the sector, and the PDP has informed this report from a whole of value chain perspective.

Ultimately, the PDP is trending towards the definition of a high-level whole of industry product platform marketplace. This work highlights the potential for product platforms to emerge through government efforts to improve construction productivity and supply chain efficiency, as well as standardised approaches to public spending. Further, the programme and its associated initiatives also demonstrate the link between typologically-based, technically focused product

platforms and the wider potential for platform-based means of working in consideration of construction's business model.

c. From Sweden to the UK – the trend of platform research, implementation, and implications for the future of building

Initial efforts to define product platforms for the building industry have had a strong design-production emphasis, with a focused view of an individual company's operations, as revealed by the case studies of companies in Sweden. Recent developments in the UK suggest the benefit that is promised by a broader view of product platforms' engagement with construction's wider value chain. By seeking platform-based working opportunities from this holistic perspective, there is the possibility to extend and broaden these initial construction product platforms to also include delivery and assembly activities, as initially outlined by the Bryden Wood P-DfMA concept. Such an approach would not only establish a product platform's benefit for market orientation, design effectiveness, and production optimisation, but would also link these approaches with the successful delivery strategy and assembly methods, capturing data from customer approach to building handover.

Looking towards Phase 2 of CRC#10, the research team contend that not only is there benefit in defining a product platform that is suited to the Australian context through the design support methods defined from Swedish R&D, but also that this approach can be linked to the P-DfMA perspective that has emerged recently in the UK Accounting for the specific context of operations that FBS deals with, Phase 2 will seek to define the platform-based opportunities that exist from its current operations, now described in section 04.

04

// FBS Context

a. Project types

FBS is a large Australian modular building company, delivering steel-framed, volumetric modules for a range of different building types:

- Educational facilities (government tenders and private schools)
- Sports and recreational facilities
- Custodial facilities
- Hospitality
- Mining camps and Non-Process Infrastructure
- Residential
- Commercial
- Hire buildings

The basic FBS module consists of a mild steel structural frame and light-gauge steel framed walls. Modules are completed to varying degrees of finish within a factory environment, prior to delivery and crane installation on site. In some building types, for example mining camps and correctional facilities, the module also contains a concrete floor.

FBS currently offer a number of standard products, delivered through standard offer agreements, such as 4- or 5-module classroom buildings, hire buildings (for example site offices and amenities structures), and mining camp accommodation. In most cases, these standard designs are manipulated according to clients' specific needs, and site requirements. For example, the hire buildings may have windows, doors and interior fitouts relocated within the plan. However, the structural design of the module is maintained. The standard educational building designs have been developed according to the specifications provided by the Department of Education in each state. These designs are agreed upon at the commencement of the contract, and do not vary significantly from year to year.

b. State branches + facilities

FBS is a nation-wide company, operating out of branches in five of Australia's mainland states:

- *Queensland*
- *New South Wales*
- *Victoria*
- *South Australia*

- *Western Australia.*

Other information about the company's operating systems is commercial-in-confidence and is not presented in this report.

c. Platform developments

FBS has undertaken several initiatives to introduce a product platform approach to its operations. This information is commercial-in-confidence and is not presented in this report.

05

// Semi-structured Interview Summaries




To gain insights to FBS' processes across the value chain, two rounds of semi-structured interviews were conducted. This information is commercial-in-confidence and is not presented in this report.

06

// Value Map

The project team created a value map that documents the project flows and value chain interactions in each of the FBS State operations. This information is commercial-in-confidence and is not presented in this report.



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