



# The Application Kanban to the Management of Construction Work Packages

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# Introduction

A Kanban is a physical card used in production control systems. Originally developed by Toyota during the late 1940s and early 1950s, Kanban have now been widely adopted within the manufacturing industry as a tool of Lean Manufacturing [1]. The benefits that Kanban systems provide are well documented [2] and include reduced lead time, smoother production flow, reduced inventory volumes and simplified production signals.

In other industries, Kanban are gaining acceptance as a tool that supports work management and enables teams to achieve many of the benefits already realised within the manufacturing industry. An example outside the manufacturing industry, is the use of Kanban in Agile Software development [3]. Here small units of work (features or requirements) are pulled through the software development lifecycle with the amount of work in progress being limited and the capacity for new work being determined by the rate at which work is completed.

In the construction industry, WorkFace Planning [4] is the process of organising and delivering all the elements necessary to execute a physical package of work in a safe and efficient manner. In the same way that Lean Manufacturing processes have improved the quality and efficiency of production systems, WorkFace planning is providing similar benefits to the construction industry.

WorkFace planning is based around small, well defined field installation Work Packages which are in many ways analogous to the manufacturing or software development tasks typically represented by Kanban. This discussion paper explores the use of Kanban to support the execution of Work Packages and the potential benefits available to the construction industry. These benefits include improved efficiency and quality, minimisation of work in progress and improved accuracy in forecasting progress.

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## Lean construction

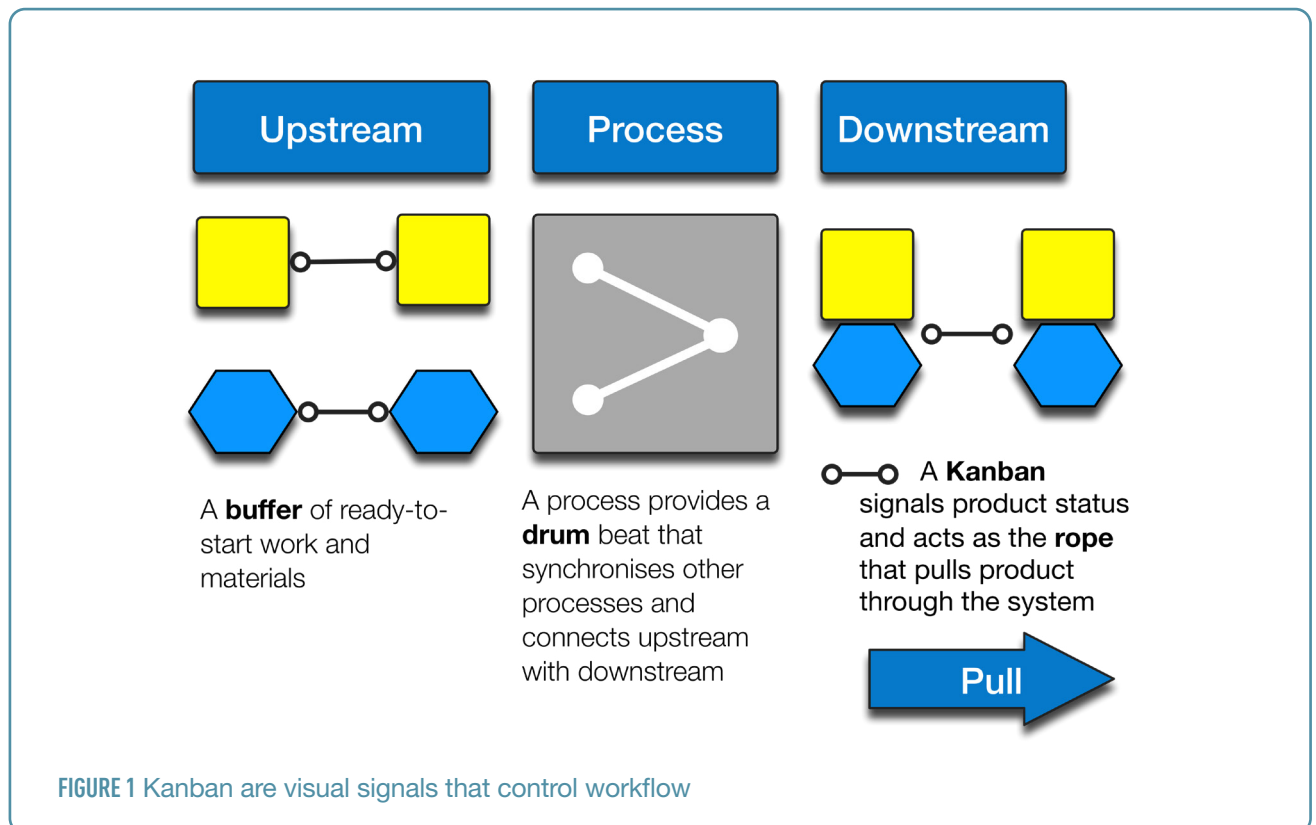
Lean Construction [5] is an adaption of Lean Manufacturing principles and practices to the design and execution of construction projects. The adaption is based around treating a construction project as a temporary production system, thereby enabling many of the Lean Manufacturing principles and practices to be applied. Lean Construction is based on the following principles and focuses on maximising value while also eliminating waste.

Lean Construction Principles	
<b>Reliable Flow of Work</b>	Work is only assigned work once all dependencies are fulfilled (Last Planner)
<b>Reduce Waste</b>	<ul style="list-style-type: none"> <li>• Construction build errors</li> <li>• Oversupply of materials</li> <li>• Unnecessary processing of materials</li> <li>• Unnecessary movement of materials</li> <li>• Unnecessary movement of people</li> <li>• Waiting between activities</li> </ul>
<b>Process Transparency</b>	Clear and accurate documentation and reporting of all work flows involved in construction process
<b>Pull</b>	Create a pull of work, materials and information through the construction process
<b>Reduce Cycle Time</b>	Minimize the time between construction steps
<b>Synchronise Processes</b>	Align timing of all steps in the construction process

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## Kanban systems

Kanban systems are an important tool of Lean Manufacturing and are based on using physical cards (Kanban) to control the flow of work and materials. In these systems the Kanban act as a visual signal to initiate work or material movement once downstream capacity becomes available within the system as illustrated in Figure 1. This has the effect of limiting the work-in-progress and creates a pull of work and materials through the system.



**Kanban systems offer benefits that include:**

- improved efficiency
- minimisation of work in progress
- improved accuracy in forecasting progress.

Improved efficiency is achieved through continuous process improvements (optimisations) that are initiated when problems are identified. Inventory reduction also helps expose problems and forces solutions to those problems.

Limiting work-in-progress creates a pull of materials and work from upstream to downstream. This equalises each process and smooths the flow of work and materials through the system. Improved progress forecasting is a result of creating a predictable work flow through the system that is based on evidence rather than an external schedule.

Characteristics of Kanban Systems	
<b>Physical</b>	Physical card that can be held in the hand, moved, and put into or onto something
<b>Limit Work-in-Progress</b>	Amount of material, product and activity process is limited
<b>Continuous Flow</b>	Signals requirement for upstream materials or work processes to start before stock completely consumed
<b>Pull</b>	Downstream process pulls items from the upstream process
<b>Self-Directing</b>	Incorporates all the information on what to do thereby allowing work to be decentralized and autonomous
<b>Visual</b>	Stacked or posted to visually show the status and progress
<b>Signal</b>	Visual status signals the next material movement or process action
<b>Kaizen</b>	Visual process flow informs and stimulates process improvement (refer to as Kaizen)
<b>Attached</b>	Attached to and moves with product

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## WorkFace planning

WorkFace Planning is an activity that involves the creation of small, well defined, field installation Work Packages that support the construction workforce. A typical Work Package supports one rotation (5 to 10 days) of a work crew and is based on activities that are extracted directly from the construction schedule/plan. Each Work Package has a standard list of requirements that must be satisfied before the work is released for execution. These requirements identify all the things that a Field Supervisor and his/her crew will need to complete the work.

Contents of a Field Installation Work Package	
1	Detailed scope of work and deliverables
2	Drawings and 3D model views
3	Safety plan - how will work be completed safely?
4	Quality plan - how will the work be approved?
5	List of trades or skills required and timing
6	List of materials - availability confirmed
7	List of plant equipment - availability confirmed
8	Personnel and equipment time/cost booking codes

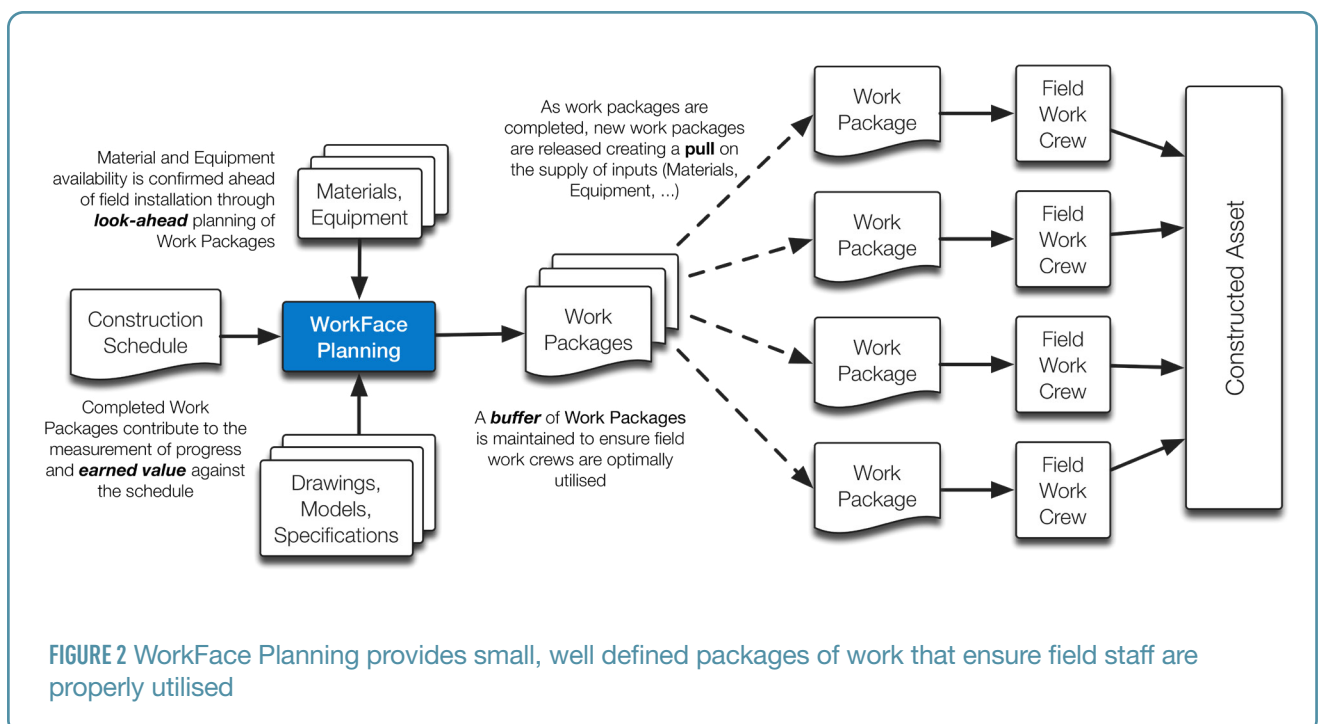
Work Packages are typically developed and managed by WorkFace Planners [4] who have prior experience as either a field or trade supervisor and are skilled in planning. This role is relatively new to the construction industry but offers a potential career path for field staff seeking skill development.

When correctly implemented, WorkFace Planning creates Work Packages ahead of the work crews. This practice ensures there is always a buffer of defined work available and allows sufficient time for missing materials, equipment or documentation to be expedited, thereby maximising the productivity of field resources.

Figure 2 illustrates the use of Work Packages for construction. Implementing WorkFace Planning will increase the indirect construction costs as a result of greater planning effort and resources. However, this investment is easily recovered through the improvements in field productivity and the reduction in equipment costs. Construction projects that implement WorkFace Planning consistently report field productivity increases of between 10% and 30% [6]. This translates to a savings between 4% and 10% of the Total-Installed-Cost (assuming labour represents 40% of Total-Installed-Cost and WorkFace Planning planning activities increases indirect labour by 2%).

Considering the above savings, WorkFace planning provides a compelling Return-On-Investment, but effective implementation requires significant operational and organisational change. Typically, these changes include:

- Creating a WorkFace Planning capability (recruitment, training, tools, processes, ...)
- Adapting project planning, scheduling and procurement practices to support WorkFace Planning (early investment in planning, material expediting, equipment ordering, ...)
- Adapting field work practices to support WorkFace Planning (crew composition, training, communication, document management, reporting, ...)





The following rules have been adapted to provide a summary guide to the implementation and execution of WorkFace Planning.

## 10 Rules for Implementation of WorkFace Planning

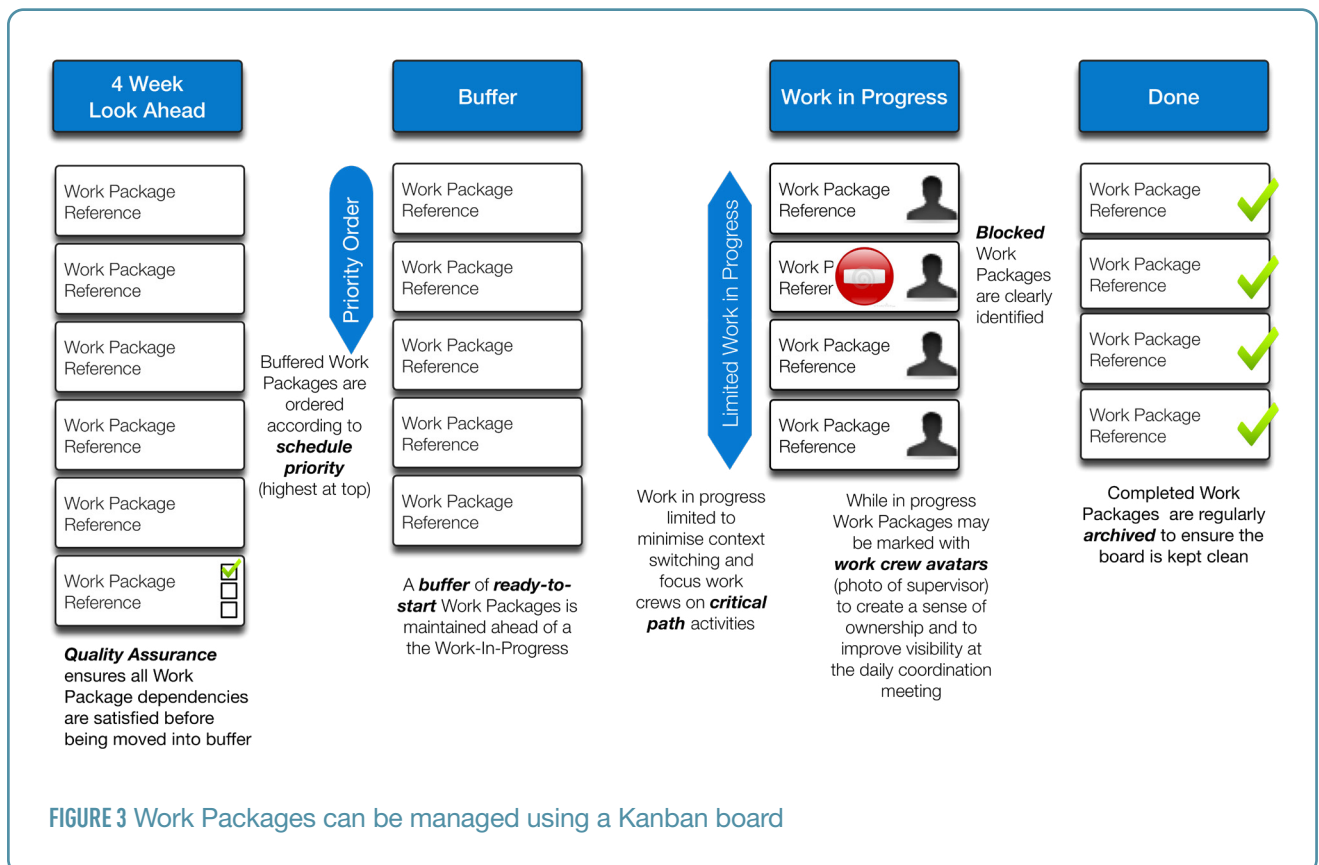
- 1** Appoint dedicated WorkFace planner(s)
- 2** Develop a construction schedule based around detailed Work Packages before field mobilisation
- 3** Verify the contents and dependencies of all Work Packages before they are executed
- 4** Create a buffer of verified Work Packages that is at least 4 weeks ahead of field execution
- 5** Setup work processes that ensure the latest project information is continuously available to all project staff and stakeholders
- 6** Assign responsibility for integration planning to resolve conflicts between Work Packages
- 7** Assign responsibility for coordination of materials, scaffolding, and plant equipment
- 8** Track completion status of each Work Package and make this visible in a daily coordination meeting
- 9** Incorporate the requirement for WorkFace Planning in all construction contracts
- 10** Initiate and coordinate management audits to ensure effective implementation

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# Kanban for construction

Just as the principles and practices of Lean Manufacturing have been adapted to construction, Kanban can be adapted to support the management of Work Packages. The adaption is based on treating Work Packages as products within a manufacturing system. This provides a lens through which the management of Work Packages can be viewed and thereby enables many of the Kanban principles to be applied.

The relationship between WorkFace Planning, Work Packages and field work crews can be described by the Drum-Buffer-Rope model [7]. The drum represents the rate at which work crews complete work packages, the buffer represents the work packages that are ready to be started and the rope represents the pull signal for releasing new work packages once in-progress Work Packages are completed.



This analogy is useful in understanding the system constraints and provides a model for optimising productivity using production planning methodologies based on Theory of Constraints [8]. Figure 3 illustrates an example Kanban style board that can be used to track the status and progress of Work Packages. Although there are many differences between manufacturing and construction, many of the principles of Kanban systems can be adapted. The table below describes how the characteristics of Kanban systems (outlined earlier) may be adapted for construction.

Kanban System Adapted for Construction	
<b>Physical Cards</b>	Physical cards are not practical in a construction environment; however, an electronic representation can be readily used for coordinating work on a daily basis. Additionally, a virtual Kanban board can be used to communicate priority (critical path), identify blocked work packages and ensure that field crews fully utilised.
<b>Limit Work-in-Progress</b>	Limiting work-in-progress is achieved by not releasing Work Packages until existing Work Packages are properly completed. This ensures construction priorities are executed and critical path activities are properly managed.
<b>Continuous Flow</b>	Continuous flow is achieved by ensuring that the requirements (materials, information, equipment, skills, ...) for all Work Packages are properly satisfied before being released to field crews. Additionally, a buffer of Work Packages that are ready to be started, should maintained to eliminate waiting and ensure optimal field crew utilisation.
<b>Pull</b>	A pull of Work Packages can be achieved by limiting work-in-progress.
<b>Self-Directing</b>	Providing work crews with all the necessary information, materials, equipment, etc ... needed to complete a Work Package encourages decentralised management and enables work crews to operate with relative autonomy.
<b>Visual</b>	An electronic display can be used to provide a virtual Kanban board that represents the status of Work Packages.
<b>Signal</b>	Kanban represent Work Packages
<b>Kaizen</b>	Continuous process improvements and optimisation are initiated by blocked Work Packages that are clearly identified on the Kanban board.
<b>Attached</b>	Attachment is not relevant, but mobile electronic access to all Work Package information is essential.

## Summary and references

Lean Manufacturing has been adapted for construction by treating construction as a temporary production system. Similarly, Kanban systems can be adapted to support the management of construction Work Packages. The benefits of combining Kanban and Work Packages are expected to include increased field productivity, improved schedule adherence, reduced rework, increased safety and better construction quality.

### References

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### About the Author

Dr Adrian Smith is an industry leader in adapting and applying Agile and Lean methods within software engineering and business technology. As a sought-after consultant, he has led and coached engineering and software development teams for major brands including Airbus, GKN Aerospace, BBC Worldwide, Suncorp, Nokia and Data#3.

Today, Adrian is Co-Founder and Head of Engineering for E7, an Australian software product development company. E7 is delivering technology advances for the construction industry, leveraging Lean and Agile methods to develop practical and innovative engineering solutions. Adrian is regularly called on for his specialist experience, which spans industries including aerospace, banking, construction, digital media, engineering, insurance, mining and public infrastructure. He is also an Agile coach and regular contributor at Australian and international conferences.



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