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Discussion Paper:
The Application of Kanban to the Management of Construction Work Packages

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Introduction

A **Kanban**[1] 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.

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	
Reliable Flow of Work	Work is only assigned work once all dependencies are fulfilled (Last Planner)
Reduce Waste	• Construction build errors • Oversupply of materials • Unnecessary processing of materials • Unnecessary movement of materials • Unnecessary movement of people • Waiting between activities
Process Transparency	Clear and accurate documentation and reporting of all work flows involved in construction process
Pull	Create a pull of work, materials and information through the construction process
Reduce Cycle Time	Minimize the time between construction steps
Synchronise Processes	Align timing of all steps in the construction process

[1] The word '*kanban*' is derived from the Japanese words '*kan*' meaning visual and '*ban*' meaning board or card.

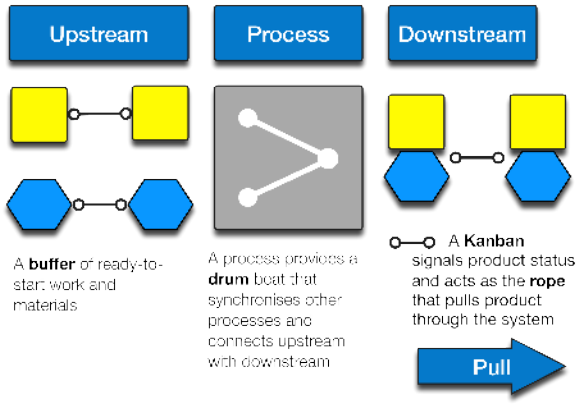
Kanban Systems

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.

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

Kanban systems offer benefits that include: (a) improved efficiency, (b) minimisation of work in progress and (c) 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 that an external schedule.

Figure 1 Kanban are visual signals that control workflow.



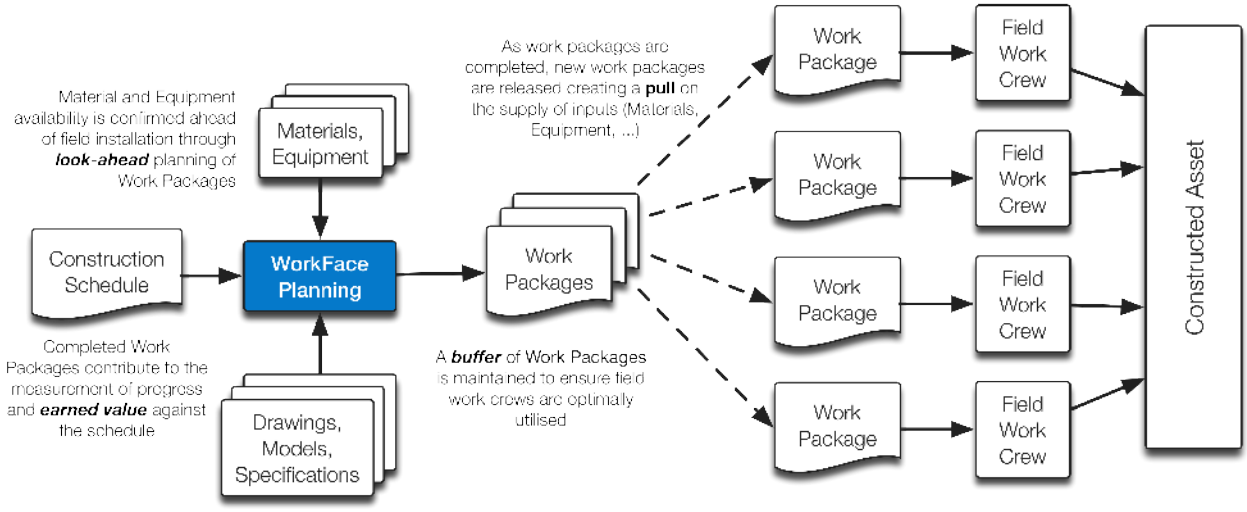
WorkFace Planning

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.

Figure 2 WorkFace Planning provides small, well defined packages of work that ensure field staff are properly utilised.



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**[2] increases of between **10% and 30%** [6].

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[3] 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

[2] 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%).

[3] Rules for WorkFace Planning are identified in Reference [6].

10 Rules for Implementation of WorkFace Planning	
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

Adapting Kanban to 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**[4] 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.

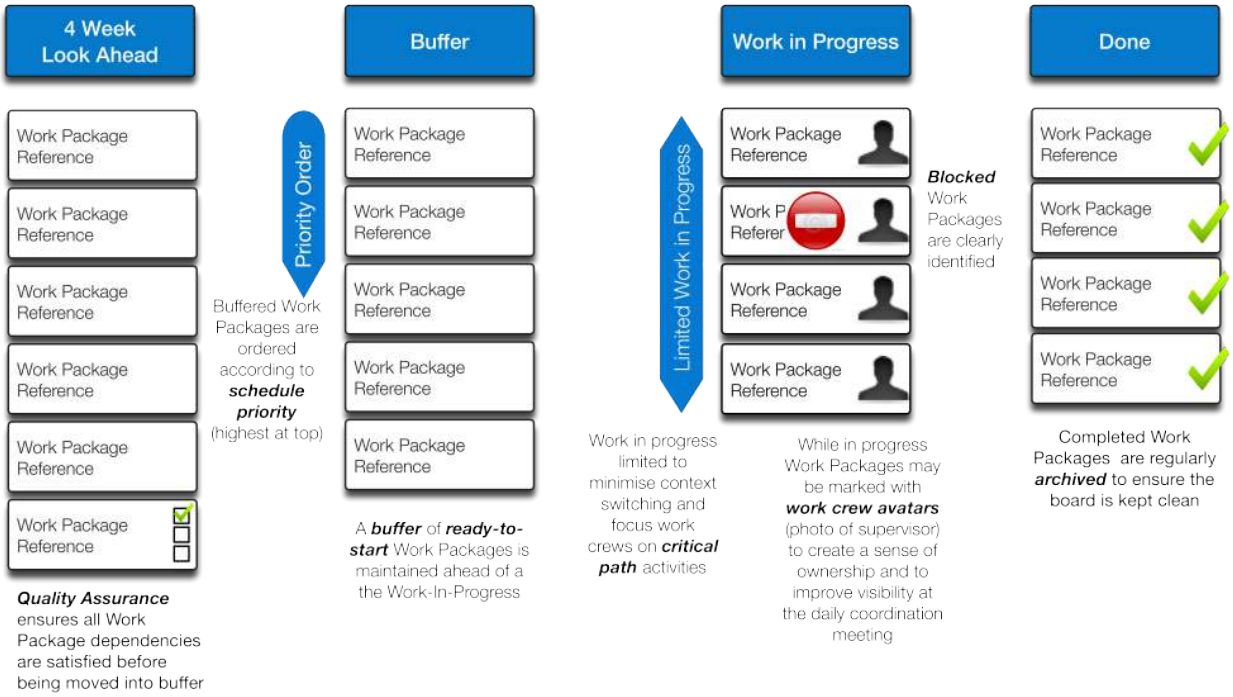


Figure 3 Work Packages can be managed using a Kanban board.

[4] Drum-Buffer-Rope is a production scheduling methodology based on the Theory of Constraints that improves system throughput, reduced work-in-progress and increase quality.

Kanban System Adapted For Construction	
Physical Cards	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.
Limit Work-in-Progress	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.
Continuous Flow	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**.
Pull	A pull of Work Packages can be achieved by limiting work-in-progress.
Self-Directing	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.
Visual	An electronic display can be used to provide a **virtual Kanban board** that represents the status of Work Packages.
Signal	Kanban represent Work Packages
Kaizen	**Continuous process improvements** and **optimisation** are initiated by blocked Work Packages that are clearly identified on the Kanban board.
Attached	Attachment is not relevant, but **mobile electronic** access to all Work Package information is essential.

Summary

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

[1] *Lean Manufacturing*, Wikipedia viewed Oct 2010

[2] *Kanban*, Wikipedia viewed Oct 2010

[3] Kniberg, H and Skarin, M 2009, *Kanban and Scrum*, *InfoQ*

[4] Ryan, G 2009, *Schedule for Sale - WorkFace Planning for Construction Projects*, *AuthorHouse*

[5] Howell, G 1999, *What is Lean Construction?* Proceedings IGLC-7, Berkeley, USA

[6] Slootman, T 2007, *Planning of Mega-Projects*, PhD Thesis, University of Twente, Netherlands

[7] *Drum-Buffer Rope*, Wikipedia viewed Oct 2010

[8] *Theory of Constraints*, Wikipedia viewed Oct 2010

About the Author

Dr Adrian Smith is a software engineering and technology consultant who specialises in Agile and Lean methods. His experience spans a variety of industries that include Mining, Aerospace, Public Infrastructure, Digital Media, Banking and Insurance.

Adrian has led and coached engineering and software development teams for organisations that include Airbus, GKN Aerospace, BBC Worldwide and Suncorp. He has also proposed and supervised research projects with RMIT, UNSW and the CRC for Advanced Composite Structures.

Adrian is the Director of Technology for Ennova and regularly shares his experiences online at AgileEngineeringDesign.com. Ennova is an engineering software company focused on construction. Ennova has implemented a Kanban style approach to Work Package management as part of the Envision system (contact Ennova for further details).