THE CHALLENGE: THE IMPETUS FOR CHANGE TO LEAN PROJECT DELIVERY

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ABSTRACT

A challenge from a customer to use "Lean" in our business and production processes caused a significant change in thinking and review of "Best Practices" to deliver projects better, cheaper and faster. Our research has shown that for select construction activities the valued added portion is about 5% and the remaining 95% is both necessary non-valued added and non-value added activities, also known as "waste". The conclusion was obvious, in that, we needed to focus on reducing the non-valued activities rather than reduce margin to stay competitive. This paper presents the efforts undertaken by Walbridge Aldinger (WA) in response to a challenge from Ford Motor Company to utilize "Lean" production principles in WA's construction delivery process. These efforts resulted in the identification and implementation of lean tools and methods that comprise a set of "Lean Construction Best Practices". Deployment of "Lean Construction Best Practices" will reduce the waste in our processes and reduce the cost of capital facilities. Implementing lean in our businesses will be a matter of survival.

KEY WORDS

Lean Construction, Implementation, Organizational Change, Value Stream Mapping, Logistics Planning, Visual Management, 5S, Last Planner System®

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INTRODUCTION

Owners of capital projects are increasing their expectations in how a project is delivered and its final outcome. Owners are now looking for contractors or teams that provide the best business solution including, but not limited to, bringing the project in faster, better, cheaper, safer and adding value. Conventional project management techniques provide structure and rules of engagement but it currently does not promote removal of waste in design and construction processes and focus on adding true value. Lean Project delivery can augment conventional methods to include what the owner wants while improving the bottom line for the stakeholders involved (Koskela 1992, Howell and Ballard 1994).

Lean production evolved over many years at Toyota Motor Company. Lean production is a system of production management that was conceived by Toyota Motor Company in the 1950s. In the early 80s, this system has attracted the attention of researchers in production and operations management and numerous studies have been undertaken to unearth its mysteries. In 1990, after a five-year five-million-dollar study of the auto-indurtsy, the principles and tools of lean production were popularized by the book *The Machine That Changed The World* (Womack et al. 1990).

The architect of Toyota's lean system is engineer Taiichi Ohno. His focus was on continuous incremental improvement of processes through relentless elimination of waste. This focus on waste removal gave rise to many techniques and tools such as mistake-proofing (poke-yoke), total productive maintenance (TPM), production smoothing (Heijunka), cycle time reduction, and inventory reductions using the now-famous Just-In-Time (Womack and Jones 1996). A major source of inspiration for Toyota's lean system the Ford Motor Company Rouge Plant in Dearborn, MI which Henry Ford built in the '20s. In the Rouge, Ford implemented numerous lean-based tools and methods to reduce inventory, recycle by-products from processes, and reduce or eliminate different forms of waste. The Rouge model and Ford's use of continuous flow are probably why some authors have considered Henry Ford as the "Father of Lean" (Hounshell 1984). However, Ford's name has become more synonymous with "Mass Production" because he, unlike Ohno[3], continued to operate with large batch sizes that limited product variety and required dedicated rework areas to fix quality problems.

Walbridge Aldinger was challenged by its customer Ford Motor Company to utilize Lean Manufacturing concepts for construction of capital facilities. The rest is history. Walbridge Aldinger (WA) was confused at first as to how a manufacturing technique could be applied to construction. To help WA with the process of understanding "Lean", Ford Motor Company held two workshops and provided "lean" facilitators to value stream map a miscellaneous metal doorjamb fabrication and a concrete wall foundation installation. The workshops were very informative and we realized that both processes were, respectively, about 5% value added (that which changes the shape, form, or function of the product) and 95 % non-value added (which is categorized as either necessary non-valued added (Type I muda), such as, support functions or pure non-value added (also known as waste or Type II

[3] Ohno also embraced the concept of flow but he reduced batch size significantly. This resulted in less stocking of inventories, increased quality, and the ability to produce a variety of products.

muda)). Cyert and March (1963) were the first American economists to describe waste and dubbed it as a form of "organizational slack". In the lean lexicon, waste has been described as anything that takes time, resources or space but does not add value to the product or service delivered to the Customer (Womack and Jones 1996). Even then we did not realize what this really meant. WA's executives attended a Ford sponsored Lean Executive training which resulted in the decision to integrate "Lean" into its business. It became very apparent that in order to stay competitive that the opportunity was in the elimination of waste and adding value.

The purpose of this paper is to discuss some of the tools and methods or "Best Practices" that are shaping the Lean Project delivery approach to reduce waste and add value in the delivery of capital projects at Walbridge Aldinger. Some of them may seem like "common sense" but they are easier said than done. The reader will realize the importance of lean tools and methods as a matter of survival in the 21st Century.

VALUE STREAM MAPPING

Value stream mapping (VSM) is a tool that can be used to look at a process to reduce or eliminate waste in that process. The workshops that Ford Motor Company facilitated helped WA understand that value stream mapping is a powerful tool. WA piloted this tool for several administrative internal problems to test its effectiveness to improve processes. The result was timesavings and cost savings.

The VSM process identifies all the steps in a process showing how the product or service is being changed from activity to activity. All the actual time durations are recorded (snap shots in time). Time delay between activities as well as how data and information are transmitted is identified. When the value stream map is developed based on current information, it's usually referred to as the current state map. This initial pass will identify value added time vs. non-valued added time. The reader is referred to Hines and Rich (1997), and Rother and Shook (1998) for more details on VSM.

After creating the current state map (CSM), the next step is to look for opportunities to reduce or eliminate waste in the process. A skilled facilitator who probes and asks the question "Why do we do it this way?" can uncover some real opportunities. Usually it becomes apparent where the quick returns will be. At times a few activities can be combined or eliminated. The group decides to make changes to the current state to define how they want to operate in the future. This is the process of defining the future state map (FSM). A work plan is developed to get to the future state map. A measurable is defined to help understand when the future state is attained. Cost savings are analyzed between the CSM and FSM using conservative numbers. In general, the steps involved in a VSM include the following:

1. Current State Map
2. Opportunities for Improvement
3. Future State Map
4. Work Plan to the Future State

5. Define Measurable(s) to gage performance
6. Analyse Cost Savings

An example of the second step in the process is shown below in Figure 1. The VSM was used to improve the billing and progress payment process. The opportunities for improvement are highlighted by the starbursts. In this particular case, subcontractor invoices were sent to accounting, of which, 43% had some type of deficiency. Measures were put into place and reduced the deficiencies to below 5%.

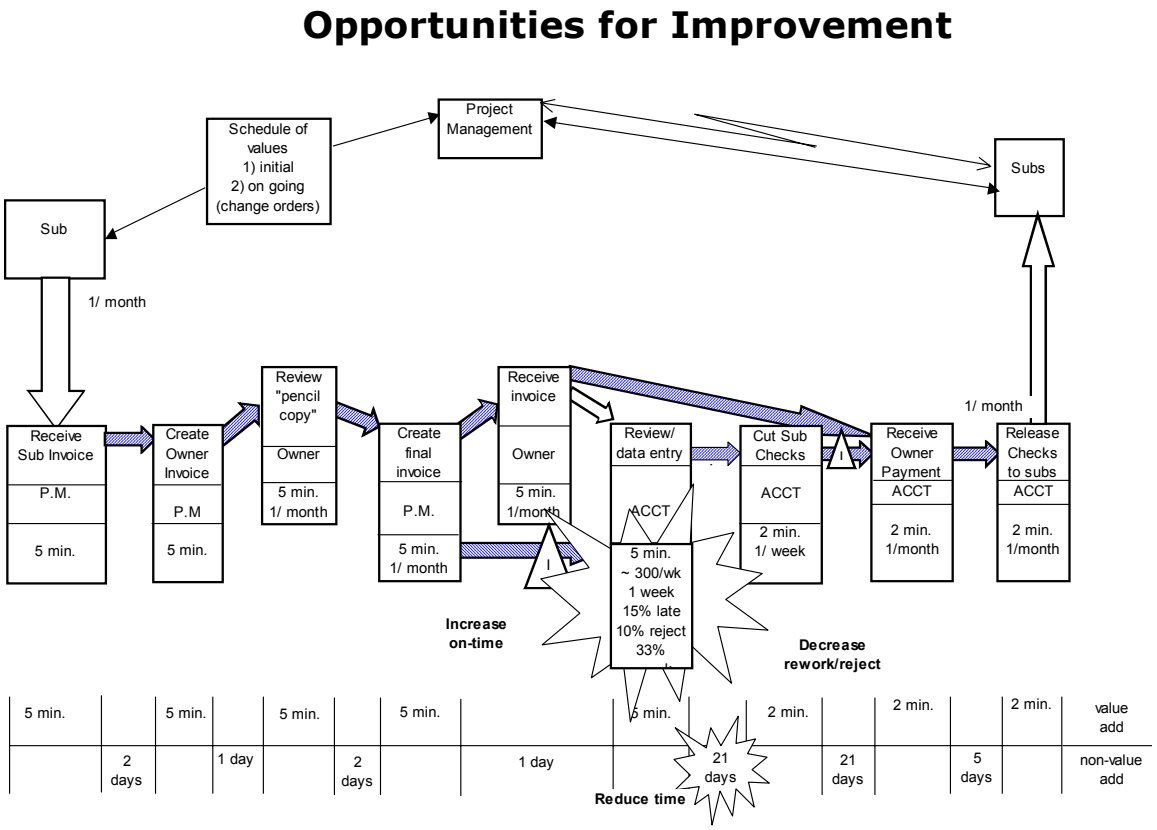

Figure 1: Value Stream Mapping - Opportunity for Improvement Step

The point of VSM is not to come up with a precise number for added value, for example, 5% of the process is value added, rather it is looking for opportunities to reduce the 95% of necessary non-value added and non value added activities – the focus is reducing or eliminating waste where there is more opportunity.

FORMS OF WASTE

In today's construction market most companies are cutting corners and margin in order to get work rather than seeking out waste in their processes. WA believes that reduction and elimination of waste (non-value-added activities) is a key part of the Lean Project delivery process. Seeking out waste is a change in focus and will require behavioral change.

One form of waste can cause another form of waste to occur. Waste occurs in administrative/yard activities, design, procurement, fabrication and installation (which includes start-up and commissioning). The question is why are the processes we have in place letting the waste occur? Communication, understanding, planning and accountability could be some of the answers.

To make the principle of waste more accessible to WA employees and business partners, WA defined 8 forms of construction waste by using and adding to Ohno's famous seven (Womack and Jones 1996). The eight forms of waste are shown in Table 1.

Table 1: The 8 forms of waste adopted by WA

	Form of Waste	**Example**
1	**Over-Production:** Producing over the customer requirements, producing unnecessary materials/products	Producing more pipe spools than required
2	**Inventory:** Holding or purchasing unnecessary raw supplies, work-in-progress inventory, finishing goods	Stockpiling too much dry wall in area well before it is needed and in the way of other trades
3	**Transportation:** Multiple handling, delay in material handling, unnecessary handling	Locating materials to far from the point of installation
4	**Waiting:** Time delays, idle time	Crew B waiting for an activity to be completed as promised by Crew A
5	**Motion:** Actions of people or equipment that do not add value to the product	Double and triple handling of material when planning could have reduced it to one move
6	**Over Processing:** Unnecessary processing steps or work elements	Rubbing a concrete foundation wall to well when it will be backfilled or covered
7	**Correction:** Producing a part that is scrapped or requires rework /procedures	Punchlist items or items of work that are deficient and do not meet requirements which require rework
8	**Not Utilizing Human Resources:** Not following-up/implementing ideas/suggestions	Not considering someone's idea to improve a process or work task particularly if that person performs that work

PROJECT LOGISTICS PLAN

Unfortunately, we do not always have direct control over the root cause of waste, such as, from a contractor's perspective if the waste is generated in the design process. WA decided to work on the processes it had control over to begin the lean journey and gradually begin to affect other stakeholders that touch the project (the outer circles) - evolutionary change as opposed to revolutionary change. WA began a company wide internal initiative to eliminate

reoccurring problems that it faced on a regular basis in the construction process. One of the tools developed to eliminate reoccurring waste was the development of a project logistics plan, which is WA's unique approach to accomplish what the Lean Construction Institute calls 'Lean Work Structuring' (Howell and Ballard 1999). The project logistics plan addresses site logistics, 5S audits and visual management. The plan is communicated to the subcontractors at bid and throughout the construction process. A few major issues that the plan addresses are:

- Organization and scheduling of material and equipment
- Movement of human resources, material and equipment
- Management of site water
- Generation of physical waste and clean up

Establishing guidelines for material and equipment storage reduces waste, such as, lay down space, searching time, transportation and double handling of material. Diverting or managing site water (rain or snow) can greatly improve efficiency with respect to transportation, material handling and movement of people. The project logistics plan lays out the expectations for the subcontractors in words and as site layout drawings. These plans can then be posted (visual management) and referred to communicate the standard of performance.

This tool has been very effective at the Ford Motor Company Heritage 2000 Project, at the Rouge Plant in Dearborn, MI (See Wright and Gonchar (2002) for more information). Site Logistics plans are updated weekly showing changes to the site, access to the site, specific subcontractor work areas, material lay down areas, toilet facilities, trash receptacles, trash that needs to be removed and recycling dumpsters. In this case, the owner was very appreciative that this tool was put in place and managed well. Ford used these plans in its monthly communications to employees at the Rouge to describe progress and how the site was changing and what roads to use for access. The old adage 'A picture is worth a thousand words' was exactly what these site plans did, and the communication process between stakeholders was significantly enhanced. The site logistics plans were a great time saver in communicating information and setting expectations. An example of a generic Site Logistics plan is shown in Figure 2.

THE 5S PROCESS

5S was originally developed by Toyota to eliminate hidden factory waste by describing a set of actions to maintain an organized work place (Monden 1998). The following are the Japanese words that describe those actions – **S**eiri (Sort), **S**eiton (Set in Order), **S**eiso (Shine), **S**eiketsu (Standardize), **S**hitsuka (Sustain). Hirano (1996) states that application of 5S should not be circumscribed to the plant floor and that it could be used in areas such as sales and accounting. 5S provides the structure and discipline for organization of a work area as aptly summarized by this statement:

> "A place for everything and everything in its place" (author unknown).

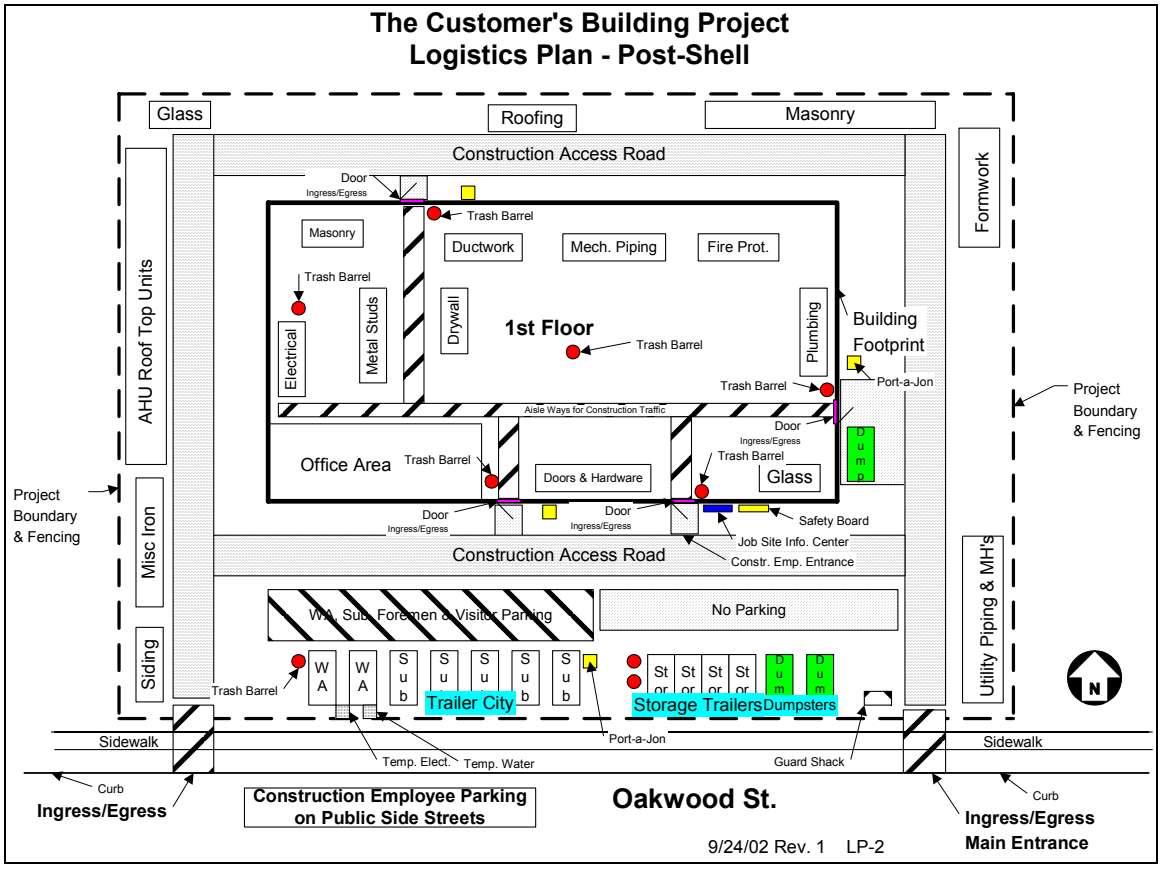

Figure 2: Site Logistics Plan

WA tailored the 'Manufacturing' version of 5S to its construction operations. A 5S audit plan was also integrated into WA's project logistics plan. This had a significant impact on the success of the site logistics plan. Again, 5S is one of those tools that may seem simple to implement but WA's experience indicates that without commitment and discipline, a 5S plan becomes useless. . The 5S words that WA has used to describe the process are shown in Table 2:

Table 2: Construction 5S as adopted by WA

	5S Description	5S Example
1	**S**eparate/Scrap	Separate like materials and equipment and remove or dispose of that which is no longer needed.
2	**S**traighten	Put material into bundles or racks so there is order. Equipment locations can be outlined to show where it is to be stored.
3	**S**crub	Broom swept areas. Put trash in designated trash bins. Clean equipment.
4	**S**ustain/Standardize	Develop standards for 5S expectations and audit those standards on a weekly basis.

	5S Description	5S Example
5	**S**ystematize	A system is in place to communicate the 5S expectations on a regular basis. The 5S audit process is done regularly. The labor forces understand the expectations and follow them. The system goes into "autopilot".

These seem like common sense actions (except perhaps systematize) but we find that labor force behavior is not consistent with how materials are organized and work areas maintained. The site logistics plan and establishing the site cleanliness standard defines the expectations or standard for 5S to be effective. As the first three S's are easy to do but sustaining the effort is the challenge. Systematize refers to the communication of the standard and adherence to the standard, hopefully with the least amount of effort, to produce an autopilot condition where every worker knows where to put things and when to do clean up and where to put trash.

VISUAL MANAGEMENT

Visual management, another lean tool, can be used to improve awareness and change behavior through visual displays and visual controls (Monden 1998). Visual displays convey information and visual controls force an action or a response. Visual displays are used to further reinforce the project logistics plan with regard to the 5S process. There are a number of simple displays that can used to help improve awareness and standards. This can be done easily by labeling trash containers or stripping an area for material placement. WA has developed a standardized method of communicating project information, which is called the Job Site Information Center. The information center is located at the work place to communicate the overall project site plan, site logistics plans, schedule status, 5S audits and safety along with other information. The information center is used to help create awareness and communicate job site standards to those working at the site. It is also communicates to visitors what is going on at the site.

LAST PLANNER SYSTEM®

Dealing with the basics was a major step in eliminating waste through site logistics, 5S and visual management. The next major step was to improve workflow of construction activities as there is waste generated when promises are not kept between stakeholders (owner, A/E, construction manager, subcontractors and suppliers). Most projects require that schedules be submitted and meetings are held to projected progress. Most of the time promises made at these meetings are met about 50% of the time. To work on this problem we employed a lean method developed by the Lean Construction Institute (LCI) called the Last Planner System® (Ballard 1997, and Ballard 2000). The Last Planner System® involves the following steps:

- Developing the overall planning sequence and milestones (Master and Phase plans).
- Six Week Look Ahead Planning to support the overall plan (continuous six week rolling schedule tied to milestones)

- Constraint Removal, such as, making sure engineering is ready and resources are available
- Weekly Work Planning (weekly work schedule). At this point activities are unconstrained.
- Measuring Planned Percent Complete (PPC) (measures how effective the plan was for the week, e.g., seven out ten items completed is a PPC = 70%)
- Identifying Reasons for Plan Failure, which is recorded for each activity not 100% completed.

To a practitioner, developing master, phase, and look-ahead (short-interval) plans included in the Last Planner System® are nothing new. However, what is novel and significant in the process is that assignments identified for the weekly plan must be constrain-free. Neat idea, although hard to perfect if all the parties involved do not communicate and understand each other's expectations.

To test the waters, WA piloted the Last Planner System® on a number of projects with its subcontractors. Some of the subcontractors took to the process quickly understanding its benefits as a way to improve productivity and to show management their ability to get the job done. The Last Planner System® promotes accountability that is sorely lacking in this industry, and more so accountability of all parties involved.

Some problems did arise for subcontractors who had several subcontractors working for them (second tier subcontractors). The difficulty for the prime subcontractor was in retrieving timely information from their subcontractors. Some of the second tier subcontractors were in and out (not consistently on site) which made it difficult to get representatives to participate at the subcontractor meetings. We do not at this time have an answer to this problem. Perhaps when second tier subcontractors become more sophisticated, an Internet solution may be the answer, whereby weekly work plans are shared immediately.

If nothing else, a significant gain from the Last Planner System® is that it establishes a two-way rather than one-way communication process and it promotes accountability of those involved. A stable overall plan has to be communicated in general terms; with the subcontractors adding the detail planning with six-week look-ahead schedules in order that constraints can be identified early enough so that weekly work plans are unencumbered.

OTHER TOOLS

DAILY WORK CREW HUDDLES

A 5 to 10 minute meeting at the beginning of a shift to focus the crew on that day's expectation for safety and work to be accomplished. This is done to create a forum to develop a team and to have the team members feel like they part of something through the sharing of information. These huddles can also focus on successes and areas for improvement.

PREVENTIVE MAINTENANCE

We all know too well that we need to do preventive maintenance but most trades people will tell you they don't have time, they are too busy trying to get work done, or its not in the budget. Although, we somehow always have time to wait for a new piece of equipment or for when one breaks down to wait for repairs. Preventive maintenance has to be assigned to someone or it will not get done. We have to communicate our expectations and then follow through.

YARD/SHOP DELIVERIES

Optimize yard/shop deliveries so that deliveries support a delivery route and having a load that is worth sending a truck and driver for. Too often requests from the job site to the yard say 'ASAP'[4] for a delivery. That type of request is unclear and creates waste. WA set up a problem solving team to focus on this issue, which resulted in procedural changes. Accuracy of delivers went up and cost of deliveries went down.

IDENTICAL TOOL TRAILERS/TOOL BOXES

Tool trailers/boxes are labeled and are identical so that trades people from one site can go to another and know where they can find tools, materials and equipment.

KANBAN

Kanban is a Japanese word to describe a signal to do something (Monden 1998). Using a signal, typically a card with information, to get a reorder of deliveries to occur with the least amount of effort. This could be used with bins so that when stock gets down to a certain point a kanban card can be given to the appropriate person for reorder. WA has used this for its yard-stocked items. WA plans to use this for material stored in tool trailers.

PREFABRICATION

Assembling portions of the work in a shop environment in order to reduce parts and pieces sent to the job site for assembly. A number of wastes are reduced or eliminated, for example, time spent in the field for assembly and installation, reduces the transport of multiple parts bins and associated stock management. Quality is improved and inspections can happen at the shop. Deliveries have to be planned with regard to size, weight and connection points. A word of caution, make sure trades unions are aware and willing to accept prefabricated assemblies for the site location. Make sure the fabrication shop is qualified and understands and can meet the requirements.

3D DRAWINGS

Accurate 3D drawings from the architect engineer will reduce approval times, reduce shop drawing development time, reduce material ordering time, improve project visualization, and

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[4] ASAP = As Soon As Possible

can be used to simulate the installation process as in 4D. This currently is being researched for additional cost savings.

BEHAVIORAL CHANGES

Lean is about using several common sense tools and methods to eliminate waste and improve production. Unfortunately, we have developed behaviors over time that is no longer acceptable today. The greatest challenge we have is that we have to change thousands of people's behaviors at just one project for example. WA has been training its subcontractors in the use of some of the tools that are being used on its projects, so they will in turn train their people. Bringing everyone on board will take time possibly ten years. Incentives can be used but should be well thought out and done consistently or it will lose its affect. Praise and recognition will also go a long way to help promote behavioral change. Constant communication of expectations will be required until it becomes a habit (systematize).

WA has developed Lean Tool Box Talks to help promote awareness of lean concepts and tools much like safety toolbox talks. These talks are done once a month with crews to begin getting the trades people exposed to lean. Signage and visual management is also used to communicate relevant project information and expectations.

CONCLUSION

In this paper WA has identified a number of tools and methods that we call our "Lean Construction Best Practices" that is beginning to shape the Lean Project Delivery system as we see it. Lean Construction or the Lean Project Delivery system is evolving. We believe that we have to take a holistic approach with all stakeholder participation to make it a reality. Lean is not one tool, but rather a set of tools and methods. WA in its short journey has tested these tools and we know they work. Changing our behaviors to think lean will be the key to survival in an industry where margins are getting too small to make a mistake or to stay in business. Customer focus and eliminating waste will help improve margins and will improve competitiveness in the market place. For this WA is grateful to its customer, Ford Motor Company, for the challenge to use lean in our project delivery (Lean Project Delivery).

REFERENCE

Ballard, G (2000). *The Last Planner System of Production Control.* PhD dissertation, University of Birmingham, UK.

Ballard, G. (1997). "Improving Work Flow Reliability". *Proceedings of the 7th Annual Conference of International Group of Lean Construction,* Berkeley, CA, July 26-28, 1999.

Cyert, R.M., and March, J.C. (1963). *A behavioral theory of the firm.* Prentice Hall, Englewood Cliffs, N. J.

Hines, P., and Rich, N. (1997). "The seven value stream mapping tools". *International Journal of Operations & Production Management*, 17(1), 46-64

Hiraon, H. (1996). *5 Pillars of the Visual Workplace: The Sourcebook for 5S Implementation.* Productivity Press, Portland, OR.

Hounshell, D.A. (1984). *From the American System to Mass Production, 1800-1932.* The John Hopkins University Press, Baltimore, MD.

Howell, G., and Ballard, G. (1994). "Lean production theory: Moving beyond 'Can-Do'". *Proceedings of the 2nd Annual Conference of International Group of Lean Construction*, 1994.

Howell, G., and Ballard, G. (1999). "Design of Construction Operations". Lean Construction Institute White Paper #4. Available at http://www.leanconstruction.org/.

Koskela, L. (1992). "Application of the New Production Philosophy to Construction". *Technical Report # 72*, Center for Integrated Facility Engineering, Department of Civil Engineering, Stanford University, CA.

Monden, Y. (1998). *Toyota Production System: An Integrated Approach to Just-In_Time.* Engineering and Management Press, IEE, Norcross, GA.

Oglesby, C.H., Parker, H., and Howell, G. (1989). *Productivity Improvement Studies in Construction.* McGraw Hill Book Company, New York, N.Y.

Rother, M., and Shook, J. (1998). *Learning to See: Value Stream Mapping to Create Value and Eliminate Muda.* v.1.1, Oct., The Lean Enterprise Inst., Brookline, Mass.

Womack, J.P., and Jones, D.T. (1996). *Lean Thinking.* Simon and Schuster, New York, NY.

Womack, J.P., Jones, D.T., and Roos, D. (1990). *The Machine That Changed the World: The Story of Lean Production.* MacMillan Publishing, New York, NY.

Wright, A.G., and Gonchar, J. (2002). "Ford's Rouge Plant Rehab Charts Automaking for the 21st Century: $2-billion job is Template for Sustainable Manufacturing". *ENR*, 249(20), 36-38.