MAXIMIZING VALUE & MINIMIZING WASTE:
VALUE ENGINEERING & LEAN CONSTRUCTION

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BIOGRAPHY

Theresa Lehman has earned recognition by SAVE International as an Associate Value Specialist. She is an honor graduate of Milwaukee School of Engineering with a Bachelor of Science in Construction Management. Theresa is a full time value specialist and has co-facilitated Module I training sessions. Theresa has earned recognition by the USGBC as a LEED Accredited Professional, by AIC as an Associate Constructor, and has had training in Lean Construction by the Lean Construction Institute. Theresa is a member of CSI (Construction Specifications Institute), AIC (American Institute of Constructors), AGC (Associated General Contractors), and SAVE International.

BIOGRAPHY

Paul Reiser is the Corporate Vice President – Productivity and Quality. Paul has more than 20 years of construction experience including construction and project management, project controls and estimating. Paul's involvement in the development and implementation of project controls has resulted in highly reliable systems for planning, monitoring, and controlling projects. Paul's training in Value Management and his work in developing Boldt's Value Services have gained him significant insight into customer value. With his insight into customer value, and his passion for the continuous improvement of the project delivery process, Paul's work has helped to guarantee project success. He is a graduate of the University of Wisconsin, a trained Value Management facilitator, and a Director of the Lean Construction Institute.

ABSTRACT
So what is the key to reducing cost, or more importantly increasing value for the customer? The Lean Construction Institute defines *Lean Construction* as, "a production management-based approach to project delivery -- a new way to design and build capital facilities. Lean production management has caused a revolution in manufacturing design, supply and assembly. Applied to construction, Lean changes the way work is done throughout the delivery process. Lean Construction extends from the objectives of a lean production system - maximize value and minimize waste - to specific techniques and applies them in a new project delivery process." [1] Lean Construction challenges the belief that there must always be a trade between time, cost, and quality.

Projects are becoming more complex and customers are requesting that they be built faster, less expensive, and with higher quality standards. Customers are requesting value. As value service providers, we need to deliver projects that meet, or exceed, the customers' expectations: maximizing value and minimizing waste through strategies and techniques that enhance value.

INTRODUCTION
Lean Construction is a project delivery system based on the Lean Production Management process, originally developed by the Toyota Motor Company, that is aimed at improving value by satisfying customer needs and improving performance. The Lean Production Management process moved away from mass production and found the key to drastically reduce cost yet provide increased value to the customer.

The ideal in both Value Engineering and Lean Construction is to maximize value and minimize waste by systematically applying a method to a process or service to provide the customer with an enhanced product or service that fulfills their needs in a cost effective and timely manner. Lean Construction practices do not compete with value engineering; it is intended to complement value engineering. Although there are many similarities, especially regarding measurable results and benefits in terms of resources, dollars, and time, Lean Construction has its own set of specific project tasks intended to maximize value and minimize waste.

THE LEAN CONSTRUCTION IDEAL
The Lean Construction Ideal is "a custom product, delivered instantly, without waste." Lean Construction practices utilize the knowledge of all field personnel to assist in the planning of projects, especially in regard to the identification and execution of field labor tasks. It integrates the tasks of each trade to create a realistic schedule that is used by the project managers, superintendents, trade foremen, owners, facility maintenance personnel, and facility users that result in increased reliability.

Lean Construction practices transform the long-range, master schedule planning tools, into reliable project tasks broken down into weekly, bi-weekly, or six-week look-ahead work plans that clearly identify project tasks, constraints and the people responsible for task

completion through the use of a common language and collaboration. This results in an incremental, up-to-date, continuous, effective workflow plan. Lean Construction practices should be supplemented by the master schedule, the productivity report, and the budget.

Boldt is a Charter Member of the Lean Construction Institute.[2] Together with the Lean Construction Institute, and a select group of contractors around the world, Boldt is advancing Lean Construction through implementation and research dedicated to improving project delivery. Boldt has implemented Lean Production Management processes on nearly 200 projects in the past 4 years, and currently utilizes the Lean techniques on almost all of their projects.

In many ways the Lean process systematically applies, and improves on, the best practices of the past. More significantly, Lean fundamentally changes the way work is done throughout the project delivery process. Lean Construction principles are applied to capital projects to reduce cost, accelerate delivery, and improve both quality and safety. The following sections detail the phases, features and benefits of Lean project delivery.

HISTORY OF LEAN (PRODUCTION) CONSTRUCTION

Eiji Toyoda and Taiichi Ohno pioneered the concept of lean production at the Toyota Motor Company in Toyota City, Japan after World War II. Lean production quickly became the strength of the Japanese motor-vehicle industry because it was able to eliminate waste: half of the resources, half of the manufacturing space, half of the investment tools, half of the engineering hours, and half of the new product development time than that of mass production.

Lean production caused Toyota to gain market share and revitalize the automotive industry. This revitalization and increased market share caused other automobile manufactures around the world to become interested in Toyota's methods. They wanted to learn their techniques, thus the International Motor Vehicle Program (IMVP) at Massachusetts Institute of Technology (MIT) was created in 1985 and the research and learning of the fundamentals of lean production techniques began. John Krafcik, a factory specialists on the IMVP research team, coined the term "lean" because it consumed less of everything and eliminated waste. Lean principles incorporate teamwork, communication, efficient use of resources, elimination of waste, and stressed the importance of continuous improvement.

As the principles of Lean were studied, the IMVP team incorporated other value improving principles such kaizen (a continuous, incremental improvement process) and value engineering (VE) techniques to achieve target costing, statistical process control (SPC), total quality control (TQC), and computer aided design (CAD).

After years of collaborative research and learning, it was concluded that the fundamental ideas of lean are universal and lean production can be applied equally to every industry where cost, quality, and resource allocation matter. Lean production focuses on the pursuit of perfection, creating reliability, and eliminating anything that does not add value to meet

or exceed customer expectations. It changes how people think and how people make choices.[1]

Lean Construction was created as a result of the research of Glenn Ballard, a Lecturer at University of California Berkeley, and Greg Howell, an Adjunct Professor at Boise State and Virginia Tech. It was described in a paper entitled, *What is Lean Construction – 1999,* written by Greg Howell.

Lean Construction embraces the principles and ideas of lean production. It optimizes the project value activity by activity by continuously monitoring and improving project flow. These principles reveal the waste generated from the disruption of activity flow, non-release of the "right" work, and the misallocation of resources. Lean Construction is a different project management approach because it;

- has a clear set of objectives for the delivery process,
- is aimed at maximizing performance for the customer at the project level,
- designs concurrently product and process, and
- applies production control thought the life of the project.[2]

LEAN CONSTRUCTION GOALS

- Deliver products or services that enable customers to better accomplish their goals,
- Deliver products or services on time and within budget,
- Minimize direct costs through effective project delivery management,
- Make well-informed business decisions at all project levels,
- Minimize risk and maximize opportunity,
- Inject reliability, accountability, certainty, and honesty into the project environment,
- Reduce system noise,
- Improve project delivery methods,
- Promote continuous improvement in project delivery methods through lessons learned,
- "Deliver a custom product, instantly, without waste."

OPTIMIZING VALUE THROUGH LEAN CONSTRUCTION

The Boldt Company has grown their services from a successful construction company that is 115 years old, to offer total project management, design/build capabilities, architectural and engineering services, and consulting services for a wide portfolio of industries and clients world-wide. It will continue to evolve and develop as the industry changes and grows. One thing that has remained consistent is Boldt's philosophy of giving customers exactly what they need, no more, no less, without delay, and at a fair cost that reflects effective, high value solutions.

Boldt's Lean Construction practices are modeled after that of the Lean Construction Institute. We are proud to be leaders in the construction industry practicing the LCI techniques and contributing to the research to continuously refine the Lean Project Delivery System theory through it's application in our practice.

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[1] Womack, James P., Jones, Daniel T., and Roos, Daniel. 1991. *The Machine That Changed the World*. Harper Perennial.

[2] Howell, Gregory. *What is Lean Construction – 1999*. Berkeley, California: University of California.

Like any successful project delivery method, Lean Construction needs to be supported by upper management. Someone must be committed to success of the method, the project management team and field personnel must embrace the method, and the results must be monitored and reviewed. Without these things, improved value will not be realized.

Boldt's Lean Construction program is conducted under the sponsorship of The Boldt Company and is supported by Vice-President, Paul Reiser.

Training and software has been provided and implemented, and Boldt employs the Lean Construction practices on all of their major projects. Their efforts have proven time and time again that Lean Construction is essential to project success and therefore, is evolving as one of the most significant value-adding project delivery methods.

Each person involved has recognized the benefits of Lean Construction. These include direct impact on their individual involvement, increased safety awareness, improved project schedule, leveling of resources, reduced the negative impacts on current customer operations, better defines project scope which eases construction, increased productivity, ensured on-time material deliveries, creation a team atmosphere, achievement of productivity goals, and most importantly, satisfaction of customer expectations. The construction personnel are more motivated to collaboratively work toward the common goal: to deliver value.

I have learned through my own personal experience that the field foreman, superintendents, project managers, architects, engineers, material suppliers, owners, facility maintenance personal, and facility users. consider Lean Construction to be a significant value-added service that enhances project delivery performance and ensures project success.

Lean Construction has taught people to see "the big picture" and not be focused solely on their window of work. It was a tool that brought people to the table to share a common language and focus on achieving common goals. The integration of tradesmen's daily construction activities has taught the importance of communication, sharing and teamwork.

Boldt and others have seen improved jobsite productivity, highly reliable task completion, shortened overall project schedules, elimination of redundant activities, preservation of project contingency, and quality improvement. Together they result in improved value for the client. "If you improve the reliability of planning, projects get done sooner, for less cost."

LEAN CONSTRUCTION STRATEGIES

When the strategies of lean construction are employed, it connects strategy of the management level to execution at the project level, resulting in a collaborative effort that encourages teamwork and removes many of the barriers and unknowns creating a safer, more efficient and effective worksites.

Identifying the project tasks that need to be complete and the issues surrounding the success of the task completion is the first step; in other words, identify the facts, unknowns, and

assumptions. The next step is to identify the tasks that are major milestones or critical path tasks, similar to identifying the higher order objectives because sometimes, "not all of the work is the right work."

1. Organize
    a. The superintendent and project manager must establish a plan and identify roles and responsibilities of all of the stakeholders.
    b. Identify the overall project schedule.
    c. Identify project objectives, constraints.
    d. Establish resources (people, place, time)
    e. Provide documentation, reporting procedures, decision and auditing procedures
    f. Identify and list jobsite-oriented goals regarding space required for basic equipment, material lay-down and staging, utility access, office and subcontractor trailers, tool cribs, toilets, crew sizes, hours of operation, parking, trash removal, office location, environmental requirements, safety requirements, etc.
    g. Identify measurable goals such as productivity
    h. Discuss construction conditions and potential details
    i. Discuss schedule impact

2. Weekly On-Site Project Meetings
    a. Determine existing information (facts, unknowns, & assumptions)
    b. Determine information desired including constraints
    c. Document information sources
    d. List possible alternative tasks (secondary items that could be accomplished)
    e. Review current schedule
    f. Identify future suppliers and subcontractors
    g. Identify and list potential concerns.
    h. Compare to business objectives. List reasons for variances.
    i. As a team, prioritize conditions affecting constructability.
3. Validate
    a. Compare sub-schedules with master schedule
    b. Evaluate productivity
    c. Evaluate planned percent of work complete.
    d. Discuss benefit to project in total
    e. Test feasibility by identifying whether benefits, constructability, safety, cost, schedule and other issues will achieve expectations
4. Report
    a. Report the planned percent complete
    b. Report the labor productivity
    c. Update the master schedule
    d. List potential areas of concern
    e. Review with proper authority
    f. Determine means to achieve planned percent complete and labor productivity goals.

LEAN CONSTRUCTION TECHNIQUES & APPLICATIONS

If it is intended to deliver value to the client and fulfill their expectations, today's project team simply cannot do "business as usual" and be successful. Implementation of Lean Construction techniques and applications is imperative. Lean Construction delivery methods includes the following applications:

- Co-located project teams.
- Detailed design by specialty contractors and vendors.
- Simultaneous design of product and process.
- Last Planner production management for design, supply, and construction.
- Shared 3D design, modeling, and prototyping.
- Kanban System for material and inventory control - just in time delivery of materials.
- Lean 5S practices setting the workplace in order.
- Logistics centers managing the delivery of materials and consolidating everything needed for site assembly.

Lean Construction strategies and techniques including the following:

- **Last Planner**
  The Last Planner production management system allows decentralized planning and control, and promotes high reliability in the commitment and performance of work. The Last Planner is a systematic applied process that:
  - Guarantees collaborative planning at the production level.
  - Releases the right work, to the right people, at the right time.
  - Promotes continuous improvement through accountability and learning.

- **Engineering**
  In Lean project delivery, designers and installers are co-located, simultaneously designing the product (what is to be built), and the process (how it will be built). 3D modeling can assist in evaluating and optimizing the product and the process.

- **Establish cross-functional teams of engineers, suppliers, constructors, and operators to simultaneously develop what is going to be built and how it will be built.**
  Cross Functional Teams are the organizational unit for all phases of the Lean Project Delivery System. Team members are physically co-located in design offices or on jobsites. When teams cannot be physically co-located, they are virtually co-located through web meetings and on project websites.

- **Standardize components to facilitate fabrication, installation and maintenance.**
  Design product standards that minimize on site labor effort. Labor productivity improves when what is to be manufactured and installed is standardized in configuration and composition.

- **Apply Target Costing and Value Engineering to lower costs and increase value.**
  Establish a target costing process from the start to ensure the budget is an influence on design and decision-making, rather than an outcome of design. Use the value engineering methodology to cause high value design rather than cut cost and create wasteful rework after design.

- **Apply 3D CADD as the integrated design tool that models the product, and the manufacturing, logistics, assembly, commissioning, and operations of that product.**
  Use 3D CADD to display alternative concepts, and ensure interface of systems, subsystems, and components. Allow installers to design the assembly process, and allow operators to design operations needs and support systems well in advance of construction.

- **Supply**
  In Lean Project Delivery, detailed design is shifted to vendors and specialty contractors. Modularization and pre-assembly are used to shift labor offsite. Supply chains are structured to reduce lead times of materials, components and equipment.

- **Use modularization and pre-assembly to reduce on site labor cost and compress project duration.**
  Labor productivity improves in the controlled conditions of the manufacturing shop. Jigs and other labor saving devices become possible and we take full advantage of the learning curve. Product is delivered in modules or work packages to optimize assembly on site. Work packages include everything that is required to perform the work thereby reducing craft delays.

- **Structure supply chains to enable just-in-time delivery and reduce on-site inventories and costs.**
  Costs are reduced when suppliers have an assured and reliable demand. Pricing can be based on volume purchases even though deliveries and inventories on site are based on small batches. Product is delivered just when needed to minimize accumulation of inventories on site, and avoid re-handling.

- **Reduce lead times for engineered products by eliminating delays, rework and unnecessary reviews and inspections.**
  Engineered products such as switchgears, pumps, fans and fabricated piping can be delivered late or wrong. Application of Lean techniques such as co-located teams, 3D design, value stream mapping and other supply chain management methods can reduce the lead times for engineered products enabling scheduling compression, and avoiding premature design decisions.

- **Take advantage of supplier and specialty contractors capabilities for detailed engineering.**
  Designers often create detailed design. Later, vendors and specialty contractors are typically required to produce detailed design and instructions for fabrication and

installation of materials and components. A simple waste reduction strategy is to stop having design specialists produce detailed design and shift detailed engineering to fabricators and installers.

- **Installation**
  The key issue in production control is to match load and capacity. Lean production management is used to avoid workers waiting on work, as well as work waiting on workers. Lean techniques such as the Last Planner system of production control and interactive team scheduling are used to increase the reliability and performance of on site production.

- **Pull planning and scheduling**
  Pull planning and scheduling advance work only when the next station needs it. Pull techniques result in higher productivity due to consistent crew flow and reliable workflow.

- **Apply a formal process of designing installation methods to assure optimum performance.**
  First run studies are used as a Lean tool to design installation methods that meet safety, time, quality, and cost criteria. A practice of mock-ups is a version of a first run study. A detailed level of collaborative planning among those responsible for the work develops best practices and assures continuous improvement.

CONCLUSION

As a result of Lean Construction, customers are benefiting from increased value through reduced labor costs, increased quality, and improved project schedule. It is not uncommon for projects applying Lean Construction principles to experience performance improvements in productivity and schedule acceleration in ranges of 10 to 20%.

On Boldt projects, and isolated Lean projects throughout the world, customers, subcontractors, architects, engineers, and Boldt employees attest to higher levels of planning, control, communication, work-flow reliability, quality and safety. Other results include:

- Workflow becomes more reliable and efficient as the waste of waiting, redundancy, and over-processing are eliminated, consequently resulting in increased work structure and flow and increased quality of workmanship,
- Releases the right work at the right time to the right people,
- Communication is improved; systematic lying is reduced or eliminated,
- Resource disruption is minimized,
- Increases leveling of resources,
- Increases on-time, just-in-time, and scheduled material and equipment deliveries,
- Creates a backlog of make-ready work,
- Improved quality reduces rework and inspection time,
- Eliminates unnecessary spending,
- Guarantees collaborative planning and promotes teamwork,
- Achieves productivity goals,
- Increased safety awareness,

- Raises the visibility of project performance from the field level up,
- The ultimate result is the ability to deliver a high value product, as defined by the customer.

Lean Construction is dedicated to developing increased reliability and improving trends in the project delivery process including: improved productivity, highly reliable and shortened schedules, elimination of wasteful redundant activities, and preservation of project contingencies, all resulting in savings and increased value for customers. Increased reliability is translating into improved productivity and therefore improved customer satisfaction by providing value-enhanced products and services that fulfill their expectations in a cost effective and timely fashion and eliminates waste in terms of resources, dollars, and time.

Lean Construction works to focus master schedules and long-range planning tools into reliable tasks that clearly identify constraints and the people responsible for the execution of the tasks. Lean Construction is a successful tool because of the common language that it establishes and the collaborative environment it creates that provide for the continuous flow of work, which ultimately lends itself to giving customers exactly what they need reflecting effective, high value solutions.

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[1] ©Lean Construction Institute, 2000. All Rights Reserved.
[2] http://www.leanconstruction.org/