

# White Paper

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## Applying “Lean Thinking” to Project Delivery

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### Introduction

“Lean thinking” is a business philosophy widely used in manufacturing. Toyota pioneered the approach in its production lines in the 1970s, significantly improving its competitiveness in both the price and the quality of its vehicles and boosting its market share. By 1990 all Japanese automakers had integrated lean processes into their manufacturing. As a result, these companies took 25 percent less time and 46 percent fewer employees than U.S. auto manufacturers to develop a product. Productivity as measured in man-hours per vehicle was 33 percent higher than in the United States, and Japanese automakers had 27 percent fewer defects per vehicle.

### What is Lean Thinking?

Lean thinking focuses on simplifying processes by identifying the parts of a process that can provide greater value for the customer or client and eliminating whatever does not contribute to this goal. Lean thinking is based on the assumption that only a fraction of the total time and effort expended in an organization actually adds value to the final product or service. A lean process uses less of everything: human effort, capital investment, facilities, inventories, and time. The result is increased efficiency.

The core principles of lean thinking are:

1. **Eliminate waste.** Waste is anything that consumes resources without adding value. Waste might include mistakes, redundancies, revisions, work done out of sequence or too early or too late, or services that do not meet customer needs.
2. **Define “value” according to what the customer wants and is willing to pay for.**
3. **Use the processes that deliver what the customer values in the shortest possible time.** Processes can be streamlined by identifying the “value stream” – in lean jargon, the process that will deliver the product in the shortest time – then eliminating any step in the process that does not add value. A lean process may have as many as 60 percent fewer activities than a traditional one.
4. **Make the process flow smoothly.** This can be accomplished by managing the transition from one value-adding step to the next.
5. **“Pull, don’t push.”** This principle of lean design suggests starting with the project goal and “pulling” toward it only work needed to accomplish the goal. Accomplishing this requires planning backward from the goal to determine what each step in the process requires from the

step before it. Later steps determine what the earlier steps should be and when they should occur. Nothing should be done that is not required by a later step in the process.

6. **Pursue "perfection" by continuous improvement.** Relentless examination of each project identifies bottlenecks and their causes and ways to eliminate them in subsequent projects.

A growing movement in the construction industry, led by the Lean Construction Institute (LCI) and forward-thinking construction companies such as Boldt Construction, is encouraging the application of these principles to building projects. To facilitate discussion of how lean thinking can be applied to the design and construction process, LCI holds forums where builders, architects, and other project stakeholders meet. At these forums, builders have said construction is most adversely affected when architects leave too many decisions to the end or make changes during construction. As a result, the builders suggest, the rate of completion during the construction phase – the amount of the job that is finished by the time the contractor said it would be finished – has consistently hovered around 40 percent.

Architects can avoid this scenario by applying lean principles, which impose discipline and promote close collaboration among the owner, architect, and builder throughout the process. This continuous collaboration allows the three parties to make decisions on issues as they come up in planning and design, rather than in the field.

Design and construction companies that have applied lean principles to projects have typically improved their task completion rates from 50 percent to 70 percent and more. Instead of being caught up in minutiae, they focus on activities that add value, elevate project quality, and boost profitability.

## Lean Process Techniques

As part of its efforts to support the application of project-based production management to design and construction, the Lean Construction Institute has held forums for builders and designers. Discussions at these forums have yielded some practical ways to apply lean thinking to the industry, including the following techniques:

- Project workshops – gathering team members to make decisions collaboratively.
- Process mapping – eliminating waste in project processes and office operations.
- Target scheduling – working backward from due dates to schedule project tasks.
- Last Planner™ System – managing the delivery process and improving team effectiveness with good communication.
- Target costing – delivering projects within the client's budget through concurrent estimating.
- Computer modeling – increasing opportunities for communication and collaboration.

### Project Workshops

First and foremost, applying automotive industry experience to the design profession entails breaking down barriers that impede communication. Toyota and others have combined their design, engineering, marketing, and manufacturing staff in one location so they can share information more efficiently. In design and construction, the client, architect, engineers, and consultants work not only from different locations but from different perspectives and with different objectives. The first step in streamlining the project delivery process is to bring the project stakeholders who work in these isolated silos together into a unified team. One effective tool for accomplishing this is the project workshop.

A project workshop is a meeting or series of meetings that brings together the client, users, architects, builders, estimators, and suppliers to identify project goals, reduce them to design concepts, and fit these concepts into the client's budget and schedule. Architects lead and facilitate these workshops, which are disciplined brainstorming sessions conducted at the client's location. Input from all participants is documented (e.g., by posting it on the walls of the room) to foster discussion. The

collaboration that results from these workshops makes it possible to solve many problems early in the project delivery process. For example, on a 150,000-square-foot medical project, a rock ledge was found where a basement area for clinical use had been planned. At a project workshop, the project team explored alternatives and identified a solution before the schematic design drawings were prepared, thus avoiding costly changes.

To maximize the value of design services, architects must apply their communication skills to enable the talent within firms and that of outside consultants, clients, builders, and suppliers to arrive at a complete project definition that reconciles size, location, quality, and functional arrangement with the clients’ goals, requirements, budget, and schedule. The old notion of an architect “debriefing” a client is inadequate.

Because architects are trained to facilitate the development of program information and integrate information from all project stakeholders, they are in a good position to take the lead in such project workshops. It is at the beginning of a project that architects have the most flexibility to shape the project outcome. This is the time to engage the most experienced and talented staff to collaborate with consultants and key owner representatives. Effective collaboration in the first weeks of a project will do more to avoid problems down the line than the same effort at any other point in the process.

### **Process Mapping**

Process mapping is a management technique used to identify and evaluate each step in an existing process. A successful process mapping exercise has immediate results. Steps are eliminated, time is saved, value is created. Architects streamline operations by applying process mapping to both firm operations and project delivery. Once steps are mapped, steps can be eliminated – or combined to reduce the number of steps.

### **Target Scheduling**

Although project schedules are usually developed at the beginning of the project, they may not be actively managed to achieve the on-time completion that clients expect. Target, or “backwards pass,” scheduling can help solve this problem by defining the latest times when tasks must be started and finished if a project is not to be delayed. In this approach, planners apply the “pull” principle, working backward from major project milestones. Target scheduling works best when the entire project team collaborates in project workshops and team meetings to establish intermediate deadlines and assign responsibilities. In a workshop environment, project team members quickly discover and resolve scheduling conflicts.

### **Last Planner System**

Implementing a schedule created with the target scheduling approach requires a system that enables a team to efficiently collaborate at each step. The Last Planner system, developed by the Lean Construction Institute, is a method of project control that adds discipline and structure to team collaboration and improves coordination efforts. A project may have a two- or three-year life cycle from its inception and early planning through design and construction. As time passes, team members may forget important details about why decisions were made. Use of the Last Planner system, which involves weekly team meetings held to review progress, solve problems, and identify next steps, can help prevent this situation. Meeting discussions are centered on tasks to be completed in the coming weeks and what needs to be done to make them happen. A simple tool called a “three-week Look Ahead schedule” is used to document upcoming tasks and who is committed to accomplish them. When the target scheduling approach is applied to reviewing schedules at weekly project meetings, the team can identify and solve scheduling conflicts that jeopardize project targets. Documenting meeting decisions and the thought process behind them helps avoid unnecessary compromises, errors, and cost overruns.

A metric called the Percent Plan Complete (PPC) enables the project team to see what percentage of the prior week’s work has actually been accomplished. PPC measurements made by the Lean

Construction Institute in both the design and construction phases of projects run in the traditional manner in a number of countries have shown PPC averaging 54 percent. In other words, architects and contractors accomplish on average a little more than half of what they set out to do each week. Studies indicate that implementation of the Last Planner system can quickly raise PPC into the 70 percent range and higher. Use of the system also reduces chaos, improves teamwork, and frees time for solving difficult problems and double-checking solutions.

Projects in the United States, Denmark, the United Kingdom, Finland, Chile, Brazil, and elsewhere have benefited from the improved communications, coordination, and organization that result from use of the Last Planner system. For example, a study in Chile showed that architecture/engineering firms that applied lean concepts increased their value-adding time on projects by 53 percent, boosting productivity by 31 percent.

**Target Costing**

Architects craft their standard client-architect agreements to shield themselves from responsibility for the project budget. Clients, however, expect their architects to complete the design phases of their project on budget. When a project goes over budget, architects are caught in a cycle of redesign that eats up fees, forces late and often unwanted compromises, destroys project schedules, and strains client relationships.

Like target scheduling, target costing involves ongoing collaboration and communication among project team members. To date, this technique has been most systematically employed in consumer and industrial product development in Japan, where it is used as a way to improve profitability. In the manufacturing sector, the price for new products is based on an analysis of the market and the target profit margin. The design process is then governed by this target cost, which cannot be exceeded.

Target costing can be appropriate for application in a number of situations in the design and construction market. Clients may have a limited budget, regardless of the potential return on investment. Or, they may have a target profit margin. Real estate developers are a classic example of a product developer with a target profit margin. Designers and builders employed by developers often work for fixed fees and hope to make a profit within those fees.

**Computer Modeling**

Computer modeling applications are becoming standard in today's design office. These programs enable designers to effectively communicate designs to clients with almost "real-life" images. In addition, architects will find that building information modeling can support lean thinking. Architects must determine how to use these new capabilities to the greatest business advantage, including ways to create value for their clients.

The first step in determining how to apply computer modeling to an established project delivery process is to recognize that these tools are not the solution to every problem. Too much emphasis on whiz-bang graphics too early in the process can stifle creative thinking. The table below outlines some of the drawbacks of advanced computer modeling and possible ways to address them.

Risks of "Too Much Too Soon" in Computer Modeling	
ISSUE	SOLUTION
Too much realism too early / too much time on each option, making 3D modeling a project expense.	Keep focused on the task at hand and use computer modeling applications as appropriate. Modeling programs can be used to quickly study massing as well as blocking and stacking alternatives. These simple models can automatically generate program areas to ensure that design is on track with scope. They may also be used to evaluate alternatives and support dialogue and project definition with the client. Use rapid sketching (manual or computerized) to explore building articulation and

	character before investing the time in detailed modeling. This approach creates value for the client.
An early 3D model looks set or finished. Clients are hesitant to suggest changes.	Find tools and talented people who can work in "real time" with clients to support the design workshop.
3D images show qualities, colors, and textures of materials that can set client expectations.	Use real materials and samples to support the decisions made with 3D graphics programs.
Model-based design processes are difficult to implement. They introduce a different, more dynamic approach to design.	Start on small projects or parts of large projects where model-based 3D applications can define complex assemblies or complex system relationships. Recognize that model-based design and supporting software are evolving rapidly. Adapt accordingly.

A particular benefit of using computer modeling applications is that building information models contain information that can be useful to contractors in the construction phase. A model-based design can be handed off to builders and fabricators for detailed investigation and coordination of assemblies. A designer and contractor can use 3D models to illustrate alternatives to help the owner make informed decisions and to coordinate construction details. As well, data tables linked to these models produce fairly accurate cost estimates in real time.

Architects have a full complement of computer tools at their disposal, but in large part they treat them as expensive drafting tools. They adhere to the same processes they always have, but execute them with computers. Although the speed of the computer has somehow improved efficiency enough to justify the cost of PCs, plotters, printers, and networks, projects seem to require about the same amount of effort. Architects are forfeiting many opportunities to add value to their clients' projects.

In contrast, the manufacturing sector has gone beyond simply adding tools to developing disciplined uses for these tools, such as organizing project teams, communicating among team members, and documenting the team's progress. By forming groups that studied the number of footsteps from assembly line to parts supply point, for example, Toyota became the leader in the automotive industry. Long ago it shifted from thinking about tools to analyzing and adjusting processes with the goal of increasing the value delivered to the customer.

## Lean Thinking for Architects

The pursuit of a new lean design process for architecture requires new goals and a new vision for the design process that looks both inside the architect's office and outside to contractors, suppliers, and other essential team members who have a role in delivering value to the customer. The following process improvements are critical to moving toward the goals of delivering the project, maximizing value, and minimizing waste:

- Planning the design phase using lean practices.
- Following practices that make better use of available tools and techniques.
- Structuring work through weekly project team meetings, either in person or via the Internet.
- Increasing collaboration among the design team, builders, and suppliers.

Inside the architect's office, these process improvements remove the architect from the role of traffic cop, chasing information and responding to crises. Instead, the architect can focus on elegant, cost-effective solutions to a client's problems within the framework of a disciplined management model. Outside the architect's office, effective application of lean practices has the potential to foster better understanding and collaboration among the design team, client, contractors, and major vendors, and to increase profitability by eliminating waste.

Ultimately, lean thinking breaks down barriers among design, construction, and supply. If architects can assemble the right personnel from builders and vendors at the right points in the design process, they can specify products that will meet the project delivery times and construction budget.

## Applications of Lean Thinking

Architects are beginning to apply lean principles (e.g. target costing, project workshops, Last Planner system) to their projects. The brief case study that follows describes a project where lean principles were successfully implemented, resulting in an increase in the productivity of the architects and qualitative improvements in the project delivery process – streamlined communications, collaboration, and decision making.



### Carnegie Mellon Science Labs – An Example of Lean Thinking

In the design of the undergraduate science teaching labs at Carnegie Mellon University, a combined project workshop/Last Planner process facilitated by the architects gave project stakeholders – faculty members and students, facility management staff, and university administrators – opportunities to provide input and feedback throughout the project. The architects led intensive stakeholder kickoff meetings, weekly user group meetings, monthly executive committee meetings, and design review committee meetings at critical stages in the design. This collaborative process often led to innovation, as stakeholders pooled their experience and ideas to solve problems. The process also created stakeholder buy-in, ensuring high levels of user satisfaction.

The design team on this project relied on Internet-based tools to automate calculation of the Percentage Plan Complete (PPC) metric. Using a Web workplace, the design team accessed the Look Ahead schedules and recorded task assignments. Project tracking tools automatically recalculated the weekly PPC. These tools enable team members to access all information about a project through a single interface. Project managers review budgets and schedules, and designers post their latest design. On this and other pilot projects for which Burt Hill has used the PPC process, it significantly improved organization and boosted the architects' productivity by about 30 percent.

## Time to Move Outside the Comfort Zone

Architects must continuously question their creative processes to keep their work fresh. Using innovative management techniques will allow them to improve their project delivery processes to the clients' benefit. Adapting techniques from other industries and disciplines can be an effective way to accomplish this, as demonstrated by the lean process.

Lean thinking is still relatively new in architecture and construction. Few clients are familiar enough with it to ask for it, but that is expected to change. As clients to the process see its value, they will expect lean thinking to become part of design practice.

Within individual firms, lean thinking has the potential to eliminate waste in both project delivery and management. Techniques such as project mapping can be applied as successfully to marketing and finance as to building design. Lean thinking can bring about obvious improvements as firms

consolidate processes and streamline workflow. A more cohesive effort, more profit, and designs that are more thoughtful and creative can result.

Making changes of this nature may be outside the comfort zone of the traditional architecture practice. Architects often prefer to focus on the creativity of design rather than promoting a better delivery process. However, if architects do not improve their management of the delivery process, clients may assign others to manage the process for them. The application of lean approaches and lean thinking in design practice is an opportunity for architects to facilitate a more efficient and value-driven delivery process.

## For More Information

The following organizations have pioneered lean thinking and are excellent sources of information on the theory and practical application of lean concepts.

1. The Lean Construction Institute (LCI) is the only research organization in the United States focusing on lean construction in theory and practice. Its regular seminars gather practitioners to share experiences and sharpen their skills at applying lean concepts to construction. A number of presentations made at these gatherings are available on the LCI website [www.leanconstruction.org](http://www.leanconstruction.org).
2. The International Group for Lean Construction (IGLC) focuses on expanding the theory of lean construction through research and white papers delivered at annual conferences. Many of the papers are available on the group's website [www.iglc.net](http://www.iglc.net).
3. The Lean Enterprise Institute (LEI) promotes lean principles in every aspect of business and across a range of industries. Visit the website at [www.lean.org](http://www.lean.org).

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