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Lean production theory: Moving beyond “Can-Do”*

GREG HOWELL

Department of Civil Engineering, University of New Mexico, Albuquerque, NM 87131

GLENN BALLARD

Department of Civil Engineering, University of California, Berkeley, CA 94720

1 INTRODUCTION

Lauri Koskela (1992) identified the first task for academics “is to explain the new philosophy in the context of construction” and this is the first objective here. The second is to provide a foundation to understand the contributions of Glenn Ballard which follow. The paper first discusses changes in the construction industry to suggest why a new (or for that matter any) production theory is required. The extent of the uncertainty experienced on projects leads to yet another comparison between manufacturing and construction. A new understanding of the construction process is offered. Next the concepts of flows and the role of Lean Production Theory (LPT) is examined. The paper closes with a reflection on the mental models which support current thinking.

One caution, our perspective is drawn from experience in petrochemical and process piping projects. While there appear to be many parallels with experience in other project types, the specific thinking and applications occurred primarily in this industry segment.

2 UNDERSTANDING THE CONSTRUCTION CONTEXT FOR LPT

Significant gains in manufacturing are reported from implementation of LPT in industry. Koskela (1992) identifies the overwhelming dominance of conversion thinking in construction and argues for replacing the conversion model with a flow/conversion model in order to reduce waste. Unfortunately, the foundations of conversion thinking are not clearly explained so its nature must be derived from the tools, techniques, contracts and organizational forms in use. Perhaps the heavy emphasis on the Critical Path Method (CPM) as beginning and ending of planning best exemplifies the conversion theory in practice. Designed for relatively slow, simple and certain projects, these tools, techniques, contracts and organizational forms are inadequate to manage let alone improve practice on quick, complex, and uncertain projects (Laufer et al. unpubl. paper). A trend toward complex, uncertain and quick projects is obvious in the petrochemical business and apparent in other segments.

Competition is becoming intense as constructors try to find new ways to reduce costs even as projects become more difficult. Experiments with various forms of TQM, partnering, and constructability provide some improvements but no consistent pattern or theory has yet emerged.

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The development of LPT in manufacturing appears related to changes in the competitive environment which are similar to those being experienced in construction. In construction, as in manufacturing, the changed project environment is the driving force behind the need for new understanding. We should not forget that the impact of LPT in manufacturing extended well beyond the shop floor.

There must be many partial explanations for the persistence of conversion thinking if it is as inadequate as we suggest. Let us offer a few. It is relatively easy to contract for the purchase of a thing and relatively difficult to contract for behavior (MacNeil 1974). Commercial contract law for the purchase of goods tends to govern the rules applied to construction. Hence we have a continuing focus on contract while projects fail because of lack of teamwork - a behavior issue.

A second reason may be the apparent efficiency of using a single set of tools for a number of functions. Wouldn't it be wonderful if work could be completely coordinated by a schedule which also provided updated forecasts for senior management, limited claims, and could be broken into smaller plans to direct specific activities? It would be wonderful but no such tool exists - despite the claims of CPM software salesmen. In our experience, it is impossible to show all of the logic constraints with CPM. Further CPM is inadequate in the face of complex resource constraints as Professor Fondahl himself noted in his early work.

A third set of reasons is suggested by what happens when conversion thinking represented by CPM doesn't work. The typical response in the face of inadequate performance has been to blame the problem on unmotivated or untrained users. To even suggest inadequacy is to provoke strong emotional reactions. After they subside, the problem remains that conversion thinking is inadequate in the face of quick uncertain and complex projects.

Finally, perhaps conversion thinking persists because no adequate alternative has been proposed and the environment of construction projects really has changed, that is, the pressure for completion on uncertain projects has increased dramatically in the last few years.

Current thinking, resting on the needs of a different era, is both unable to deliver significant breakthroughs, and is itself far more damaging than previously understood.

3 THE SITUATION AND ITS IMPLICATIONS

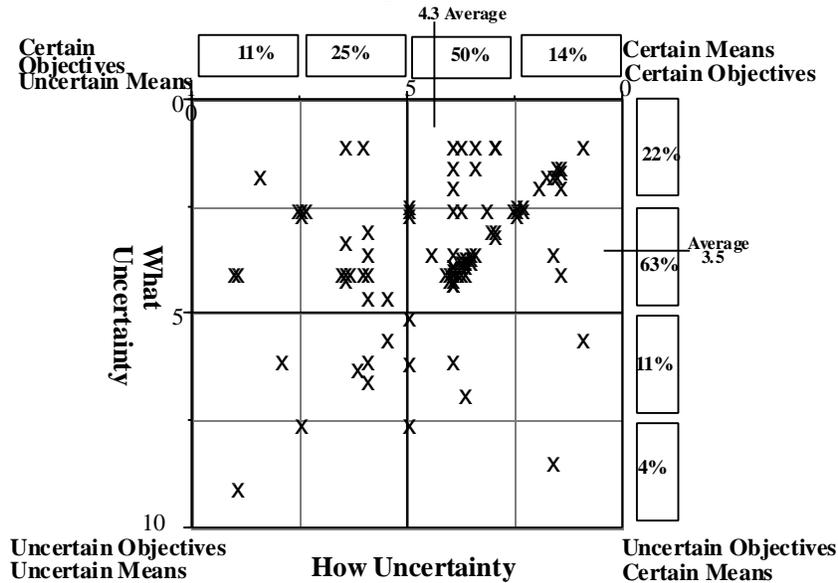
A review of data on the state of uncertainty at the beginning of the construction phase is instructive. Data in figure one shows the state of uncertainty at the beginning of typical construction projects as reported by about 175 project managers representing a broad spectrum of project sizes and types. The data confirms that significant uncertainty is to be expected even as late as the start of construction (Howell and Laufer 1993).

Data in Figure 2 was collected from managers of similar projects. Here the managers reported on their most recent projects as opposed to their "typical" projects as in Figure 1. The managers were asked to use a "T" to locate where they thought the project was when construction began and an "R" where it really was once they understood the situation.

This pattern is even more disturbing and compelling. In 85% of the projects, the manager underestimated the extent of uncertainty. The problems they didn't know about were bigger than the problems they knew about.

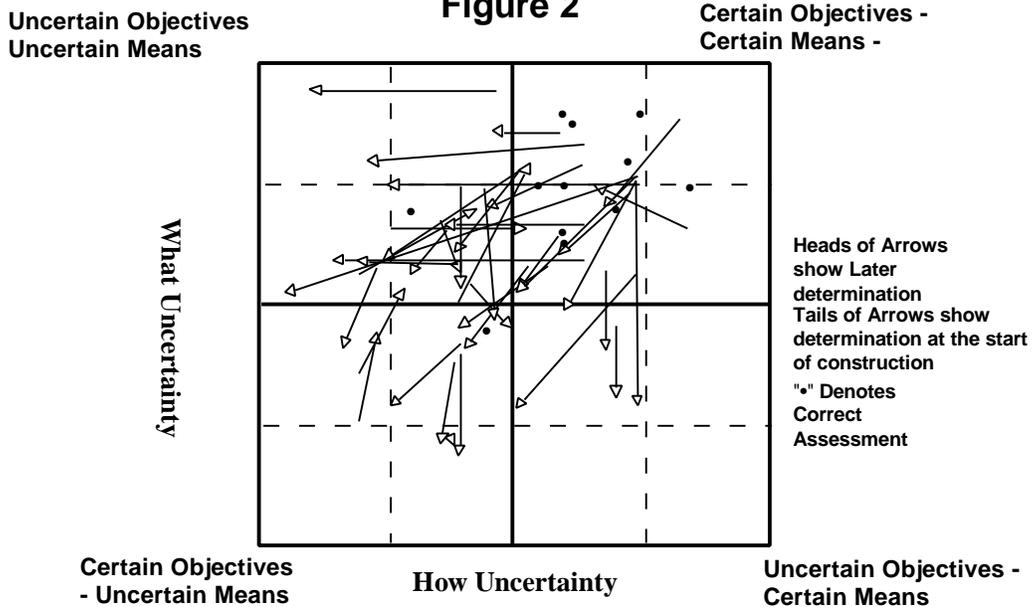
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Figure 1



Assesment of Uncertainty at the Start of Construction - Typical Projects -

Figure 2



Assesment of Uncertainty at the Start of Construction - Most Recent Project

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Consider the waste of proceeding with detailed planning and mobilization on such an unstable basis. If project management accepts real responsibility for project success, the misperception must be rooted in the way planning is conducted. The degree of instability suggests an overwhelming tendency to optimistic evaluations of project circumstance. These evaluations drive managers to plan in greater detail than supported by their information. This persistent optimism suggests either a genetic predisposition on the part of construction planners or a defect in current design of planning systems. Whatever the cause, managers are tending to focus on planning to a fine level of detail far too soon. Focus on technique without an accurate diagnosis of the situation doesn't make much sense. Information must be collected and verified.

In addition to the data on uncertainty, the pressure to reduce project durations is clear. The CII is conducting research in the area and the need for faster completion is widely reported. Recent interviews with superintendents leave little doubt about the increased urgency and complexity of projects in their charge.

LPT in construction must come to grips with the entire design and construction process because increasingly complex projects are being urgently pressed forward under greater uncertainty. Field operations can be improved using LPT principles but even they occur in a different context from manufacturing production. A comparison with manufacturing shows the key feature which distinguishes construction from manufacturing is the extent of uncertainty evident throughout the phase (Table 1).

Table 1. Context of manufacturing and construction production.

	Start of Manufacturing Production	Start of Construction in the Field
What	Highly Defined	Evolving as means refines ends.
How	Highly defined. Operations plan is in great detail based many trials. Primary sequence of major tasks is inflexible, interdependencies are documented and analyzed. Positions in process determine required skills.	Partly defined but details un-examined. Extensive planning remains as situation evolves. Primary sequence only partly determined by hard logic but may change. Interdependencies due to conflicting measurements, shared resources, and intermediate products only partly understood. General craft skills to be applied in a variety of positions.
Assembly Objectives	Produce one of a finite set of objects where the details of What and How are known at the beginning of assembly.	Make the only one. The details of What and How are not completely known at the beginning of assembly.
Improvement Strategy	Rapid learning during the first units preparing for production runs.	Rapid learning during both planning and early sub-assembly cycles.

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In important ways, the life of a construction project is similar to the product development stage in manufacturing.

Because a construction project is analogous to the preparation of a prototype, completing the construction phase is better understood as one of the preliminary steps leading to the "production" which occurs once the facility is completed rather than as manufacturing production exposed to the elements. Reducing uncertainty related to What and How defines the process of "building a prototype in place". The challenge for LPT is to reduce waste through bringing stability to the planning process as What and How are refined.

Stability is a key aspect of LPT in manufacturing. There the idea is to minimize input variations so non-value adding steps or flow related activities could be eliminated from the process. Managing flows in construction is more difficult than in the production phase of manufacturing because there is uncertainty both in what is to be accomplished and in the provision of requirements for assembly.

Current construction thinking tends to deny the existence of uncertainty or to suggest it is some sort of moral failure.

"If the owner would make up their mind - once and for all, we could do our job."

or

"If the process design engineers would" and on down the chain.

Once the reality of uncertainty is accepted, a construction project becomes less the transmission of unambiguous orders from the owner to the worker and more a series of negotiations. The object of these negotiations is the rapid reduction of uncertainty. Anything which inhibits these negotiations adds waste. This is true whether the negotiation is between project objectives and means during project definition and design or the more constrained negotiation between shoulds and cans which occurs as foremen prepare weekly work plans.

It is time to examine the concept of flows in relation to the reduction of uncertainty.

4 FLOWS RECONSIDERED

The idea of flows of materials and information from one conversion process to another is quick to grasp. Work in a factory or on a site can be thought of in terms of the movement of materials and information (Stuff) through "Input - Process - Output/Input - Process - Output" chains. Stabilizing work in these chains reduces waste. It requires managing the timing and sequence of the flow of Stuff, and assuring it meets downstream requirements.

This simple I/O model is adequate for field assembly operations but is not sufficient for understanding the flows involved in the planning process. Minimizing uncertainty in the flow of decisions and information required in planning is as important as minimizing uncertainty in the flow of Stuff. To visualize the flows associated with planning, we propose to expand the horizontal I/O model to include the concepts of directives, i.e., the vertical flow of instructions or standards, the Plans for the process at hand. Similar ideas have been expressed by IDEF₀ and Sanvido (various papers) but have been thoroughly developed by Talley and Ballard (1990).

In a sense, Plans are directives produced by a planning process. They tell the next level what "Should" take place. Inputs such as materials to the work processes determine what "Can" be done. Thus there are two different kinds of flows - one of the Plans which become more narrow

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as the assembly process nears, and Stuff which is used in the assembly process. Uncertainty may be transmitted to the work site through either flow. Stabilizing work flow, the subject of the following paper, proposes a technique for shielding the workers from uncertainty in both Plans and Stuff. This is the first step in waste reduction and it provides a basis for further improvements.

Reducing the waste occasioned by the flow of Stuff is closely tied to the development of plans. Stable plans both rest on firm upstream assumptions (or premises) and have been tested against the availability of resources. Reducing the variation in the flow of both Plans and Stuff is the topic of the third paper.

LPT, as we understand it, reduces waste by rapidly reducing uncertainty. The implementation strategy is to stabilize work flow by shielding, reduce in-flow variation, then better match labor to available work, and finally improve downstream performance. This strategy both solves problems on projects and clarifies our understanding of LPT. Once this approach is adopted it becomes clear that current management techniques inject uncertainty into the project. Examples will be offered as time permits.

The immediate goal of LPT should be to bring stability to the process by more efficient "negotiations" between ends and means at every level. Activities such as partnering and constructability which are considered partial implementations of LPT exemplify the negotiation aspect of construction. Important work remains in learning to package and planning to the right level of detail so plans remain in force and stable despite environmental changes. Conversion thinking offers little advice on how to package work so that activities may proceed independently.

5 MOVING BEYOND "CAN DO"

"Can do" the slogan of the SeaBees of the US Navy summarizes the underlying mental model of most constructors. Ambiguous as it may be, Can Do is an answer to an assignment. It means, "No matter what the problem or situation, you can count on me to get the job done." (No wonder they chose "Can do".)

A new answer, "Won't Do" is possible under LPT because it makes explicit the criteria for decision making. As we develop our understanding of LPT in construction we will confront the underlying thinking of an industry built on "Can Do". Real information on the performance of planning and resource systems can only be available when those charged with planning and doing the work can say "Won't Do." Having the right to say "no" makes real commitment possible. I am not saying people are allowed to say no on a whim, rather that they are **required** to say no when asked to act beyond the limits of established criteria. This sounds a lot like Ohno's radical decision to allow workers to stop the production lines.

Current management planning and controls systems rely on two unspoken assumptions; 1) The last planner (who you will meet shortly) will always select work in the "correct" order to achieve project objectives, and 2) Last planners lack the intelligence to manipulate the cost/schedule system for their own short term ends. In effect we believe they do not know how to protect themselves by selecting the easy work when pressed to increase productivity or production or lose their job.

In short, current management approaches are built on and entice dishonesty. We cannot improve performance unless new thinking exposes the contradictions and weaknesses in our underlying mental models and injects certainty and honesty into the management of projects. It is simple in concept and not hard in execution once we take the challenge of no longer accepting

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“Can Do” when “Won’t Do” is appropriate. Only then will we have the consistent feedback needed for rapid learning.

6 WHERE DO WE GO FROM HERE?

Simple, certain and slow jobs hardly pose a challenge. Those best able to manage complex uncertain and quick projects will claim the future. Tools developed to enhance performance on these projects will prove useful on all projects but the aim of LPT should be to help those managing in turbulent situations. Since construction projects are really vast product development processes seldom repeated by the same group of people, and there are so many of these projects, LPT drawn from construction should prove useful across the spectrum of product development efforts.

The idea that LPT ideas drawn from construction could be valuable in other arenas is at first surprising - we tend to think of ourselves as primitive compared to manufacturing. Perhaps our field operations are primitive in comparison with the auto factory of today. This paper has argued that this is an incorrect comparison. The better comparison is with the product development phase. Here we may not look so bad. It is worth noting that Gilbreth and Ohno, two seminal thinkers in industrial or manufacturing engineering began their careers working in construction.

One caution. We must avoid the tendency (particularly among academics) to deny the nasty uncertainty of the real world. We must avoid the temptation to becoming manufacturing engineers who attempt to change circumstance to fit a theory which is useful in a more stable arena. Rather we must develop our own unique approach to managing all of the flows occasioned by the complex negotiation between ends and means. Once we bring stability to the work environment through better planning, we can turn to the details of methods analysis and there utilize similar principles to those applied at the project level.

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