WORKING THROUGH UNFORSEEN UNCERTAINITES USING THE OODA LOOP: AN APPROACH FOR SELF-MANAGED CONSTRUCTION TEAMS

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ABSTRACT

Construction operations are dynamic and time sensitive. The management response to issues on site is typically a consequence of and the response to an event that has already taken place. Decisions and actions that are delayed are often rendered ineffective because of the constantly changing site conditions. The sudden emergence of the situation and the dynamic nature of its evolution needs to be addressed with flexibility and fluidity based on an appropriate assessment of the issues at hand. The need to increase the effectiveness with which self-managed teams perform under such conditions cannot be overstated and clearly requires a theoretical framework that can provide an interpretation of the underlying cognitive processes and selected responses in the face of dynamically evolving environments, and the intricate interrelationships among all constituents of the process. This paper presents the Observe-Orient-Decide-Act (OODA) loop as the theoretical interpretation by which to understand, influence, and predict the performance of self-managed construction teams. The paper begins by introducing the constructs of the OODA loop, followed by exploring its application to understand and evaluate the performance of self-managed teams in construction. The paper then posits that the effectiveness of self-managed teams found in construction is a function of the collective OODA loop speed of the group. The paper concludes with research possibilities associated with the OODA Loop, and develops guidelines for embracing uncertainty in the project, and production management phases.

KEY WORDS

Lean construction, OODA loop, last planner system, self-organizing teams.

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INTRODUCTION

A definition of Lean Construction states that it is: "A holistic facility design and delivery philosophy with an overarching aim of maximizing value to all stakeholders through systematic, synergistic, and continuous improvements in the contractual arrangements, the product design, the construction process design and methods selection, the supply chain, and the workflow reliability of site operations," (Abdelhamid et al 2009). The Lean paradigm is heavily invested in planning upcoming work. However, no amount of planning can foresee every potential circumstance (nor, as we argue later, should it) that may arise on a construction project. The OODA Loop approach is presented here as a means for front line decision makers to fill the gaps that planners didn't (or couldn't) anticipate.

Lookahead planning facilitates onsite production assignments. These are established based on the ability to complete weekly work assignments. To measure the effectiveness of the site crew and management to carryout assignments (commitments) the Percent Plan Complete (PPC) is calculated. The PPC metric is found by dividing the number of actual completions by the number of planned completions. The PPC ranges from 0 to 100% and reflects both the effectiveness of production planning and the reliability of workflow from one trade to another (Ballard & Howell 1994a; Ballard & Howell, 1994b; and Salem et. al, 2005). Under the Lean Construction paradigm, increasing planning reliability increases system throughput, which is the rate of production or output. PPC is considered the critical performance measure of a production system as opposed to the focus on point speed in conventional construction management where point speed is typically increased by maximizing capacity utilization.

Using the Last Planner System (LPS®) as a planning tool uncovers a myriad of constraints that threatens the execution of assignments as well as production progress. By removing these constraints, Last Planners are more confident in making and keeping their commitments (Jayaraman et al 2008).

In spite of the best intentions and efforts, problems will still occur a week before work is scheduled or during the week work is being executed. The LPS® is designed to encourage engagement in conversations about production, but the mechanism of addressing constraints and solving problems is not explicitly included. We don't advocate including specific mechanisms, but constructs should be suggested such as the use of PDCA (Plan, DO, Check and Act), six sigma, 5-whys, etc. Therefore, this paper considers a very basic question: "what construct should construction teams use to systematically overcome constraints that arise, in spite of efforts to preempt them, during the course of construction?"

Pondering and attempting to address this question is critical to enabling construction teams to increase their effectiveness in dealing with expected and unexpected conditions on site. It is plausible to suggest that addressing this question requires a conceptual framework that can provide an interpretation of the underlying cognitive processes and selected responses in the face of dynamically evolving environments, and the intricate interrelationships among all workers involved in the process. This paper presents the Observe-Orient-Decide-Action (OODA) loop, which was developed by military strategist extraordinaire Col John Boyd (USAF, Ret). Boyd developed the OODA loop to aid in combat situations. The need for prompt decision making in such conditions is similar to what self-managed construction teams face. We argue that the OODA loop could serve as the conceptual construct that can aid self-managed construction teams facing unexpected or developing constraints.

The remainder of this paper introduces the OODA loop and then explores its applicability as an aid to self-managed teams in construction. The paper then posits that the effectiveness of self-managed teams found in construction is a function of the collective OODA loop speed of the group. The paper concludes with research possibilities associated with the OODA Loop, and develops guidelines for embracing uncertainty in the project, and production management phases.

OODA LOOP

Col John Boyd, USAF (Ret), coined the term and developed the concept of the "OODA Loop." Boyd was instrumental in explaining the concept of agility (fast cycle time) in both decision-making by individuals/organizations and performance of physical systems. The OODA loop, shown in Figure 1 as originally depicted by Boyd, is structured in a sequential and non-sequential fashion. The OODA loop concept has been used to describe people's reaction to unexpected events. It has also been used in describing, and perhaps defining, performance characteristics of engineered systems.

Boyd extensively studied the Toyota Production System and considered it as an implementation of ideas similar to his own, and as an exemplar of his OODA loop. Richards (2004) states that the self-organized, multifunctional teams at Toyota developed products and manufacturing processes in response to demand, turning out new models in just three years compared with Detroit's cycle of four or five years. Boyd felt that systems like Toyota's worked so well, because of *schwerpunkt*, a German term meaning organizational focus. That is, employees decide and act locally, but they are guided by a keen understanding of the bigger picture. It is important to note that the Toyota production system inspired the birth of Lean Construction.

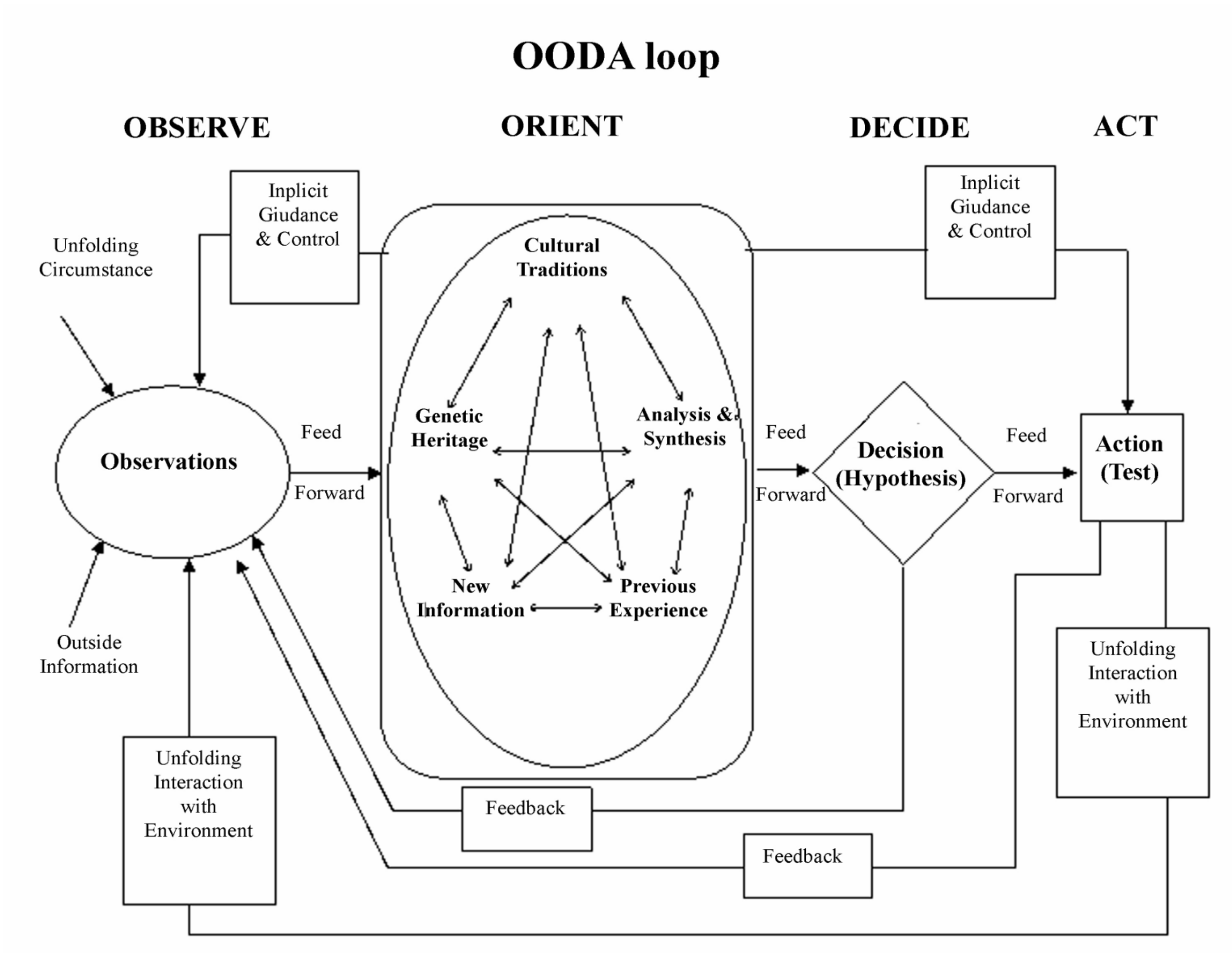

Figure 1: OODA Loop (Richards 2004)

Although the OODA model was created for military purposes, it can also be applied to business strategy. A construction company can be abstractly compared to an F-16 or an Aeroflot turboprop. In general, success in business isn't simply a matter of being quickest to market, spending the most, or selling the highest-quality products. Success can be tasted by using any of these methods but only if you do one thing more: Outmaneuver the uncertainties. A company has to decode the environment (observe and orient) before their competitors do, act decisively (decide), and then capitalize on it (act). This is a "sustainable success" of sorts, where even if one is 1st to market and successful, sustaining that requires developing abilities to embrace (and beat) uncertainty.

Understanding the OODA Loop

In the "The Essence of Winning and Losing," Boyd writes: "Note how orientation shapes observation, shapes decision, shapes action, and in turn is shaped by the feedback and other phenomena coming into our sensing or observing window. Also note how the entire "loop" (not just orientation) is an ongoing many-sided implicit cross-referencing process of projection, empathy, correlation, and rejection."

In the OODA loop, knowledge of the strategic environment is the first priority. Hence the first step is to observe, in order to acquire sufficient knowledge for making a decision. This step requires recognition of unfolding events and feedbacks from the various other stages namely – orient, decide and act. This makes the OODA loop non-sequential at times.

The second step is to ***orient*** the information. This step involves utilizing previous experience, waiting for all new information to arrive, cultural traditions of the organization, collecting information about the genetic heritage of the problem and analyzing the problem. This is perhaps the most intriguing and complex part of the OODA loop this is often overlooked and least appreciated. In fact, the underlying constructs that govern how orientation to information collected or received from the world around us could easily be the subject of many papers.

This leads us to the hypothesis stage where a decision is made on how the problem can be approached. Depending on the decision made considering all the information received, an appropriate action would be taken. However, it is to be noted that this is a continuous monitoring process where once the action is taken; observation starts again to look for any new problems. This is an effective way to detect any unforeseen uncertainties, as it is a very vigilant process where there is constant monitoring of the environment.

It is important to note that the 'decide' node is needed only when we are not sure what to do or there is no plausible action that can be inferred from the implicit guidance and controls link (going from orient to act). This is the case when we are training or experimenting with something truly new to us. Going through the decide node and reorientation (learning) always take time, and will slow the process down. In addition, actions will still be influenced by previously learned "implicit guidance and controls" until these are reset by new learning.

Competitive advantage comes from quickness over the entire "loop," not just or even primarily from the O-to-O-to-D-to-A sequence." The key to quickness over the entire OODA loop turns out to be the two "implicit guidance and control" arrows shown at the top of Figure 1, both leaving from the orient section. These arrows are capturing the fact that a person (or group) does not always go through the loop in a sequential O-to-O-to-D-to-A fashion, but rather they simply observe and act (Richards 2004).

By observing then acting, we in fact collect information about whether our assumptions for acting are correct, and if they are not we have to change our orientation – and this is where the implicit guidance and control arrow flowing from orient back to observe is meant to symbolize, as well as the feedback loop between observe and act. It can be concluded then that quick execution of the OODA loop, as Boyd envisioned it, is depending on the speed with which we reorient ourselves in response to changing external and internal conditions that we observe.

On the face of it, Boyd's loop is a simple (not simplistic) reckoning of how human beings make tactical decisions under stressful situations. However, it's also an elegant framework for creating competitive advantage. Managers must be able to observe and orient themselves in such a way that they can survive and prosper by shaping the environment where ever possible and by adapting to it where they must.

The ability to observe and orient oneself to decide and act in such a way to survive and prosper by shaping the environment where ever possible and by adapting to it is a priceless attribute that should be sought, developed, and perfected. According to Hammonds (2002), doing so requires a complex set of relationships that involve both isolation and interaction. Knowing when each is appropriate is critical to success in developing the agility manifested in the OODA loop. This is done through a combination of: Rapidity; Variety; Harmony; and Initiative.

Rapidity of action or reaction is required to maintain or regain initiative. Variety or variability (not variation) is required to make the organization unpredictable, so that there are no patterns to recognize their plans in advance. Harmony is the fit with the environment and others operating in it. Initiative is required so that someone or a group in the system can take charge of their own destiny and master circumstances rather than being mastered by them.

AN OODA-LOOP FRAMEWORK TO MANAGE UNCERTAINTY IN CONSTRUCTION

Construction personnel need to learn how to embrace and outmaneuver the uncertainties inherent in projects. We propose a framework in this section to manage uncertainty based on a literature review of the model designed by Clampitt and DeKoch (2001) and research results found in Jayaraman (2006) and Jayaraman et al (2008). The main conclusion from the aforementioned studies is that those who embrace uncertainty see it as a challenge and do not try to artificially drive out the ambiguities. If construction teams (organizations) also work with this same perspective, then we believe it will further enhance workflow reliability by encouraging meaningful discussions and fostering innovations. Another major finding is that construction professionals surveyed (48 out of 60) indicated that training on ways to embrace uncertainty was needed as well as a demand for a positive working environment where people get more latitude to make decisions. This implies that the respondents wanted the organization to embrace uncertainty and provide the employees the opportunity to do so. Better planning and need for adopting various lean principles were some of the other comments that were prominently found in these responses. These views were considered in the development of the framework.

Foreseen uncertainties have a low probability of occurrence. These are generally managed by contingency planning. A framework is needed such that construction teams can embrace the unforeseen uncertainties for which no *prior* contingency planning can be made. Effective handling of these uncertainties would directly impact workflow reliability and improve project success.

Planning projects in Lean Construction is an outcome of a process called Lean Work Structuring (LWS). LWS is a term created by the Lean Construction Institute to underscore the necessity to deliberately consider operations and process design concurrently with product design, the structure of supply chains, the allocation of resources, and design-for-assembly efforts, with the goal of making “work flow more reliable and quick while delivering value to the customer” (Ballard 2000). In essence, works structuring entails considering the production process during product design. LWS may utilize a myriad of tools such as BIM, Target Costing (Target Value Delivery), set-based design, CPM, and simulation. The spirit of LWS is to think about production during design. LWS efforts results in a master and phase plan that gives confidence to the construction team that the project can be constructed in the contract duration.

Initial master and phase plans do not account for all the constraints which will surface during the project because uncertainty exists both in the higher corporate goals and in the un-examined means of accomplishing the project itself. However, identifying a stable plan is a pre-requisite to identifying stable production objectives, which is difficult due to the high level of uncertainty that surrounds the project. It is at this time that examination of the means will help. Testing the objectives against means would also help in identifying and minimizing the potential damage that could be caused due to impact of unforeseen changes late in a project. However, addressing and tackling unforeseen uncertainties will have to wait until new information arises to formulate new solutions.

At this point, a choice has to be made of whether to refine the existing plan or using it as a springboard to explore other plans. Once the critical stage is reached where no further exploration is possible, it must give way to consolidation. Consolidation in the case of construction would mean the phase where the project goals and objectives are fixed. However, it is important to note that this critical stage should be encountered only at the last responsible moment – the underlying thinking here is similar to the set-based design concept. Until then the exploration phase should be active. Moreover, the experiences should be recorded as feedback for future reference. These feedback loops could be useful at a later stage in the same project or for new projects later on.

The emphasis thus far has been on keeping the initial goals and objectives flexible and testing them against the means before fixing the objectives eventually at the last responsible moment. Matching objectives to means can be applied to the principle of matching "Should" with "Can" as practiced in the Last Planner System.

The following section outlines a 2-step framework for embracing uncertainty in a construction setting. The framework is founded on the Last Planner System® with an OODA loop overlay so that a construction team continually observes, orients, decides and acts in order to achieve and maintain reliable workflow for site operations. This continuous monitoring would help the construction team act decisively and correctly at uncertain times during the production phase.

STEP 1: Monitoring the EnvironmentIin the Production Phase

In project-based production environments, the OODA loop should be directed towards creating an environment of trust that permits explicit communication amongst team members. This is one possible reason why lean companies (e.g., Toyota) have a faster OODA loop (Richards 2004). A rapidly executed OODA loop is essential for maintaining reliable workflow of site operations, which ensures the success of the overall project.

It should be noted that a more rapidly executed OODA loop is not the same as the speed with which we take actions – we want to act in a decisive and correct manner. In other words, speeding the OODA loop by going faster from O to O to D to A is the incorrect use of the OODA loop, and may yield negative outcomes since the speed and accuracy of decisions will be traded-off because going faster through one step will only happen by shortchanging the other steps.

To deal with unforeseen uncertainty, construction teams must embrace uncertainty and move from troubleshooting to reactive consolidation of what the team has achieved so far. Monitoring (observing) the production phase is very critical because it is this phase that suffers the first effect of any problem occurring due to the occurrence of an unforeseen and uncertain event. We suggest the OODA loop as a conceptualization of how environment monitoring and decisive and correct action can be undertaken during uncertain times. Specifically, we advocate the formal use of the OODA loop during the Weekly Work Planning phase of the Last Planner System. To explain this, it is essential to graphically depict the project and production planning process utilized in Lean Construction, under the LWS and LPS processes. Figure 2 illustrates this, as well as where the OODA loop can be implemented in the production process.

The OODA loop meshes well with the weekly work planning process. Only the activities that are free from foreseen uncertainties will be carried forward to next week's work plan. In spite of these rigorous screening steps, something unexpected may occur that can derail the progress and workflow. Faced with unforeseen uncertainties, the construction team can use the OODA loop to address the situation.

The process will begin with observing and acquiring sufficient knowledge of external and internal conditions. At this point, the team may will re-orient itself and make an action if there is a previously learned "implicit guidance and control" schema. If not, the team will need to make a decision on action (experiment) and then take the action. The results of the actions will form our new observations which will in turn restart the loop. By documenting the procedures adopted and learning at every instance where uncertainties are dealt with using the OODA loop, a resourceful database can be created.

STEP 2: Learning the OODA Loop by Introducing Perturbations Into the System to Avoid Complacency

As mentioned in step 1, learning to think in an OODA-loop fashion is a process and not just a training session that is attended by the construction team. Hence, occasionally challenging the plan that the construction team is very comfortable with, will serve as a drill for both the organization and the team to embrace uncertainty. This means that even on occasions when there are no problems due to uncertainties the team should be exposed to uncertainties by artificially simulating such situations.

Given that unforeseen uncertainties are totally unexpected, simulations cannot replicate all the situations that a team may encounter. Still, the team will be ready to embraces uncertainty by cultivating situations where the use of the OODA loop is triggered. The following is suggested to engage team members in OODA-loop cycles:

- Asking penetrating questions, to make the team think deeper. One way to do that is by using the "5-Whys" approach – used by Toyota to uncover the root cause of the problem.
- Challenging the existing heuristics, or rules of thumb, to break the spell of overconfidence in estimating their accuracy of judgment.
- Make performance expectations broad, general, and fuzzy such that local decision making is the norm and not the exception. ("Don't tell people how to do things. Tell them what to do and let them surprise you with their results"-- George S. Patton)
- Mark correspondences with an "information perish date". This gets people accustomed to seek new and fresh information and not depend on outdated facts.

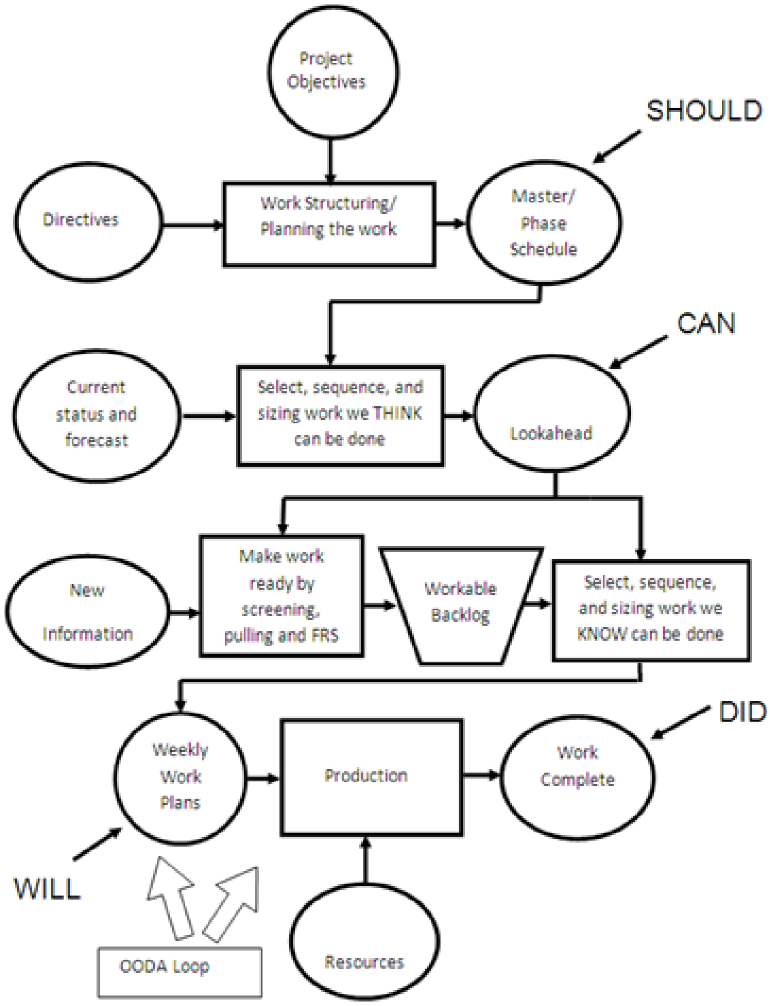

Figure 2. Project and Production Management Under Lean Construction (LCI 2001)

CONCLUSIONS

The goal of this paper was to propose the use of the OODA loop in assisting construction teams towards managing and embracing uncertainty in the production-management phase. It is also suggested that the OODA Loop should used by construction teams in tandem with the Last Planner System®, specifically during weekly work planning and work monitoring to continually observe, orient, decide and act in order to achieve and maintain freedom of action and maximize the chances for maintaining reliable workflow on the site.

Advancing the performance of production planning and control is one of the key enablers in achieving the lean construction vision of completing projects with minimum waste and maximum value. Additional research is needed to understand how to integrate OODA-loop thinking as part of a construction teams daily activities. Other researchers may choose to further develop/validate the suggested 2-step framework or find other methods for addressing unforeseen uncertainties.

REFERENCES

Abdelhamid, T.S., El-Gafy, M., and Salem, O. (2009). "Lean Construction: Fundamentals and Principles." The American Professional Constructor journal.

Ballard, Glenn (1994). "The Last Planner." Northern California Construction Institute Spring Conference, Monterey, CA, April, 1994.

Ballard, G. and Howell, G. (1994b). "Implementing Lean Construction: Improving Performance Behind the Shield." Proceedings of the 2nd Annual Meeting of the International Group for Lean Construction, Santiago, Chile.

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.

Ballard, G. and Howell, G. (1998). "Shielding Production: Essential Step in Production Control". Journal of Construction Engineering and Project Management, Vol. 124, No. 1, pp. 11 - 17.

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

Ballard, G. (2000). Lean Project Delivery System. White Paper #8, Lean Construction Institute (www.leanconstruction.org).

Ballard, G., and Howell, G. A. (2003). "Competing Construction Management Paradigms." Proceedings of the 2003 ASCE Construction Research Congress, 19-21 March 2003, Honolulu, Hawaii.

Salem, O., Solomon, J., Genaidy, A., and M. Luegring (2005). "Site Implementation and Assessment of Lean Construction Techniques". Lean Construction Journal, Lean Construction Institute, Vol 2, No. 2.

Hammonds, H. K. (2002). "The Strategy of the Fighter Pilot" http://www.fastcompany.com/online/59/pilot.html , (Feb 21, 2009).

Richards W. C. (2004), "Certain to Win: The strategy of John Boyd, Applied to Business" Xlibris Corporation, Philadelphia, PA, ISBN: 1413453767.

Clampitt, G. P. and DeKoch, J. R. (2001). "Embracing Uncertainty: The Essence of Leadership", M. E. Sharp Inc., New York, NY.

Clampitt, G. P., Williams, M. L. and Korenak, A. (2000). "Managing organizational Uncertainty: Conceptualization and Measurement" – Paper presented at the International Communication Association, Acapulco.

Jayaraman, V. (2006). Assessment of Uncertainty Management Approaches In Construction Organizations". Masters Thesis, Michigan State University, East Lansing, MI.

Jayaraman, V., Abdelhamid, T. S., and Ilozor, B. D (2008). "Assessment Of Uncertainty Management Approaches In Construction Organizations." Proceedings of the 16th Annual Conference of the International Group for Lean Construction, 16-18 July 2008, Manchester, United Kingdom.

Cleland, I. D. (1990). "Project Management: Strategic Design and Implementation", Tab Books Inc., Blue Ridge Summit, PA.

Howell, G., Laufer, A., and Ballard, G. (1993). "Uncertainty and Project Objectives" Project Appraisal Journal, 8, pp. 37-43. Guildford, England

Hopkins, P. K. (2005). "Value opportunity three: Improving the ability to fulfill demand", http://www.businessweek.com (Aug. 18,2005).