

Managing Sustainability Value in Design: A Systems Approach

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Environmental Design and Planning

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## ABSTRACT

The aim of the research is to identify core conditions that support increased delivery of sustainability in the built environment. The selected methodology is constructive research, which is distinguished by the dual focus on practical industry perspectives and theoretical knowledge. The first research question examines how Target Value Design (TVD), an integrated design management process, can elicit better delivery of sustainability values. This is developed through case study research of an exemplary design team and project. The findings identify a gap in the capability of the team to adopt a whole systems approach in order to make explicit the values of sustainable prosperity and develop a unified vision. This provides the basis for the second research question - how can design teams gain an understanding of the systemic nature of sustainability, and how can this understanding impact the design process? The research proposes an intervention method that aligns learning models from the disciplines of experiential learning cycles, design thinking, behavior modeling, systems thinking and unified vision. This integrated approach leverages creative design activities to capture the learning potential for individual skills and team building. While the research acknowledges the limitations from the testing of a single workshop experiment, post-workshop data suggests the intervention framework is sufficiently robust and versatile enough to adapt to individual workshop circumstances. The key research outcome is the importance of the people in the process of collaborative design, in their ability to envision a future state of sustainable prosperity and articulate explicit actionable values.

## Preface

---

*“Reading maketh a full man,  
conference a ready man,  
and writing an exact man.”*

Sir Francis Bacon

Never did the words of Sir Francis Bacon ring truer than in the work of a dissertation. I soon discovered that immersing myself in reading, conferences and lectures was only the first step, albeit a very important one. The final step was the writing, but the most critical aspect of shaping thought was the “conferencing,” or the dialogues with colleagues who provided a critical audience, sometimes a sparring partner, and often a source of inspiration.

I would like to thank my partners in this process. The students who helped shape the nascent concepts: Chris Strock, Chris Henry, Brendon Johnston. My friends who fielded frenzied phone calls when I needed help articulating the germs of ideas, or obsessing with exacting vocabulary: Janet Embry, Amber Dalley, Dr. Toni Thiriot and Judy Hopkins. My good friend Julie Easton and her son Dylan provided the initial concept of Dragonfly Pond, an eco-system workshop, which eventually metamorphosed into the intervention method that is the key outcome of this research.

A special thanks to my mother, who listened patiently as I gained understanding through the explaining of my latest, greatest break-through idea. She has suffered through many a vacation looking at vernacular building materials or designs, and has served as my primary workforce on more than one remodel project. It is thanks to her unconditional support and belief in me that I had the courage to return to academia and undertake this venture.

My early academic progress was supported by several of the professors at Virginia Tech. Dr. Yvan Beliveau was a fellow believer in integrated design practice, and sponsored my first meeting with the International Group for Lean Construction. Dr. Andrew McCoy proved to be a man of wide ranging talents, as he initially provided me with the tools to organize my research and later stretched the limits of my pragmatic thinking to more esoteric thoughts. Dr. Annie Pearce provided the early guidance in the research of sustainability topics and served on my Masters Committee. Dr. Robert Schumann extended an open door to my initial foray into the understanding of A/E/C collaboration, and served as an early committee member. Work on the First Year Experience freshman program with Professor Mills presented an opportunity for research and the means of travelling to England to meet with colleagues in lean construction.

The academic community of lean construction authored has much of the literature that formed my background research, and they have continued to inspire me through their unique approach to

distributed self-governance. I would like to give special thanks to Dr. Lauri Koskela and Dr. Carlos T. Formosa for hosting the IGLC20 summer session on design science, the “Women of Lean” for creating a personal and academic community, and the European “lean” academics for welcoming me as one of their own. As the work progressed, I have been fortunate enough to rely on the considerable academic prowess of Dr. Felix Schmid for honest critique, and Professor Christopher Monson for training in design thinking and countless hours of spirited discussion.

None of this work is accomplished without a great support system. Many thanks to our department librarian Patrick Tomlin, who was willing to augment the library as appropriate and the team at the Interlibrary Loan, who have been a lifeline in tracking down endless requests in all languages. This was an invaluable service for my research, which took on an increasingly international flavor. I also met on several occasions with Jonathan Stalling at LISA, who advised me through the several iterations of my research approach, and coach me through the statistical significance of the final data. Within our department, a warm thanks for the friendship and support of our team: Stephanie Randel and Amanda Lucas, Lisa Cash, and Renee Ryan, who helped to navigate the bureaucratic quagmire of the degree paperwork.

And finally, I wish to express my appreciation for the committee members who have been through this journey with me. Dr. Georg Reichard, who guided the committee through the Master’s degree, and supported the academic and funding process as my initial advisor. Dr. Michael Garvin, co-chair, who provided guidance through the case study methodology, and along with Dr. Ted Koebel, helped to shape the final document. Greg Howell, from the Lean Construction Institute, who has provided guidance since December of 2009, when I tracked him down to learn about this new idea of “lean” construction. Conversations with Greg are generally followed by an e-mail with reading lists that keep me busy for weeks.

I’ve reserved the greatest heartfelt gratitude to Dr. Christine Fiori, who was the first to welcome me to the department and assumed the committee leadership to guide this process to its conclusion. She has directed the final writing process clearly and efficiently. But most of all, Dr. Fiori has offered the most critical component of Francis Bacon’s axiom. She has offered her time in dialogue, to help me shape my ideas and personal aspirations. For this, I am most grateful.

My hope with this dissertation is that all readers, both practitioners and academics, will find some nugget of inspiration for their own work. I also hope that this research will make a contribution to improvements, both continuous and radical, which promote sustainability in the built environment.

Blacksburg, December 12, 2012

Vera M. Novak

*Invent the Future*



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## - Chapter 1 -

# Introduction

### Chapter Summary

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This doctoral work was motivated by the recognized need to increase the delivery of both the depth and breadth of sustainability values in the built environment. This chapter serves as an introduction to the research methodology, and the application of the method to the research. The chapter also provides the organizational structure of the dissertation.

The selected research methodology is constructive research, which is distinguished by the dual focus on practical industry perspectives and theoretical knowledge. The research question draws from both areas, and the findings are expected to contribute to both areas. The overall research approach was multi-staged root cause analysis, aimed at identifying the core conditions and constraints that support or hinder increased delivery of sustainability in the built environment. As such, the process has been iterative. Each successive level of discovery was analyzed for potential root causes, which were then critically reviewed against current industry practice (either empirical research, or field case studies) and existing theoretical knowledge. This process helps to define the research problem. At the core of the research is the novel construction and testing of a practical solution for the identified problem. The root cause analyses and industry perspective are key factors in the validity of the findings, both in providing a practical solution, and contributions to theory.

The chapter presents a background and description of the original problem area. This is followed by an overview of the selected research methodology and the method as it is implemented for this research, including the contributions to practice as well as to theoretical knowledge.

Working definitions are provided, providing the clarification of the terminology concerning sustainability and process vs. project management. A dissertation structure is presented, with a visual representation of the research method correlated to the dissertation chapters.



## 1.1 Preliminary Problem Identification

The combination of three big trends - declining resources, radical transparency, and increasing expectations of sustainability- has redefined the corporate marketplace (Laszlo and Zhexembayeva 2011). The increased interaction of causes and effects require new organizations to be more responsive, flexible, and adaptable and match the rate of learning to the rate of change in the environment (Kanter-Ross et al. 1992; Senge 1990). In the construction industry, these challenges reach across traditional industry and trade boundaries and call for more collaborative, solutions-oriented construction design and delivery processes (Figure 1.1) (Augenbroe and Pearce 1998; Huovila and Koskela 1998). There is a need to increase the delivery of both the depth and breadth of sustainability values in the built environment.

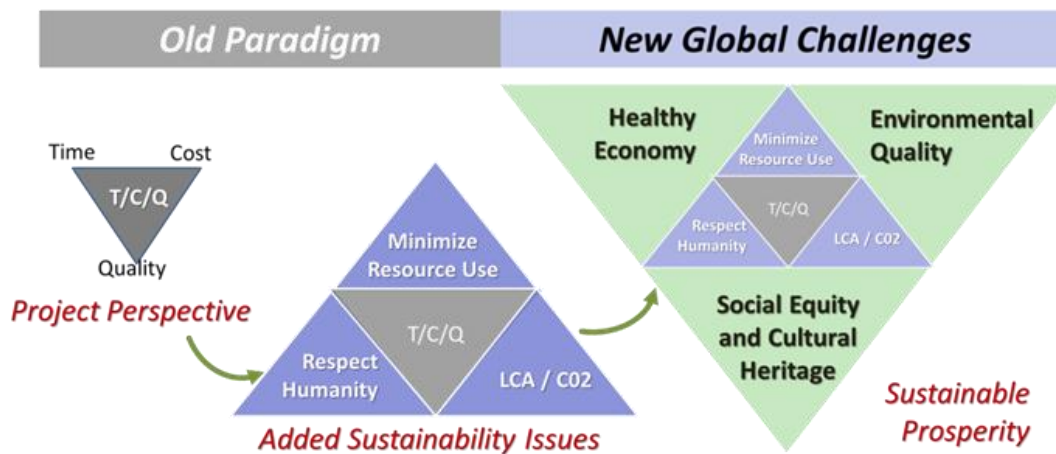


Figure 1.1 - Paradigm shift in value proposition of construction, building upon Huovila and Koskela (1998), Augenbroe and Pearce (1998), used under fair use, 2012.

Some projects have been able to absorb much of the added green building criteria through the “tightening of the belt,” increased collaboration and process integration (du Plessis 2012). However, the tension of time, cost and quality remains a limiting constraint for many projects, and the industry is still challenged with decreasing productivity (Bosworth and Triplett 2004). There is a call for a radical change or a mind shift to not just fix the construction process, but to transform it to deliver value beyond the tangible building product (Egan 1998; Miller 2009).

This has accelerated the evolution of more efficient construction process through integration and a focus on the elimination of waste.

The industry has responded by addressing the efficiency of construction, through increased integration of stakeholders and concurrency of process phases (AIA 2007; Sanvido and Norton 1994). Among these integrated project delivery (IPD) methods, lean design and construction is distinguished by the focus on the optimization of the whole, and the delivery of value (Lapinski et al. 2006; Magent et al. 2009). The most recent emergent practice from this community of lean practitioners and academics is the Target Value Design process, an integrated design management process, which aligns client value delivery with target costing (Ballard 2012; Salvatierra-Garrido et al. 2010; Zimina et al. 2012).

Attaining higher levels of environmental performance requires the design team to consider the building as an integrated system within the larger context of global sustainability issues, which in turn shapes a more integrative design approach, with the blurring of traditional knowledge boundaries (Cole 2012; Laszlo and Cooperrider 2007; Oyen and Nielsen 2009). This would be the case with regenerative design, which proposes that the current sustainability paradigms are rooted in an inappropriate mechanistic worldview (Cole 2012; du Plessis 2012). Thus, understanding the conditions and constraints needed by a design team to identify and deliver sustainability could be the very catalyst needed for the increased collaboration to manage the complexity of today's building environment.

## 1.2 Research Methodology

---

The research methodology is constructive research, as part of the design sciences. It derives the research aim from a real-world problem, which is explicitly linked to prior theoretical knowledge. The first phase of the research is the gaining of an understanding of the original research problem. This has been an iterative process, wherein each successive level of discovery was analyzed for potential root causes, which were then critically reviewed against current industry practice (either empirical research, or field case studies) and existing theoretical

knowledge. The researcher believes that this additional time spent in working through a root cause analysis and the repeated industry perspective is a key factor in the validity of the findings, both in the practical solution artifact and the contribution to theory. The second phase of the research methodology is the novel construction and testing of an empirical intervention, which contributes both to the practical functioning of the solution, as well as to the theoretical body of knowledge. The applied nature of this approach can provide a direct benefit to the industry, while the experimental nature presents a higher risk for the researcher regarding the relative “success” of the experiment.

### Research Aim

The aim of the dissertation research is to identifying the core conditions and constraints that support or hinder increased delivery of sustainability in the built environment. This is based on a dual focus of practice and theory, to understand the conditions and constraints of successful delivery, to identify the points of leverage to yield the greatest change, and to identify, design and test a solution method.

### Research Question

The research is developed in two questions:

- How can Target Value Design, an integrated design management process, elicit better delivery of sustainability values?
- How can design teams gain an understanding of the systemic nature of sustainability, and how can this understanding impact the design process?

### Constructive Research Methodology

Constructive research is part of “design science,” which is motivated by real world problems and is distinguished by the “design” of a solution meant to solve the identified problem (Figure 1.2).

The core features of the constructive research approach require that it:

- focuses on real-world problems,

- produces an innovative solution meant to solve the initial real-world problem,
- includes an attempt for implementing the developed solution,
- implies a close involvement and co-operation between the researcher and practitioners in a team-like manner, in which experiential learning is expected to take place,
- is explicitly linked to prior theoretical knowledge, and
- pays particular attention to reflecting the empirical findings back to theory (Lukka 2003)

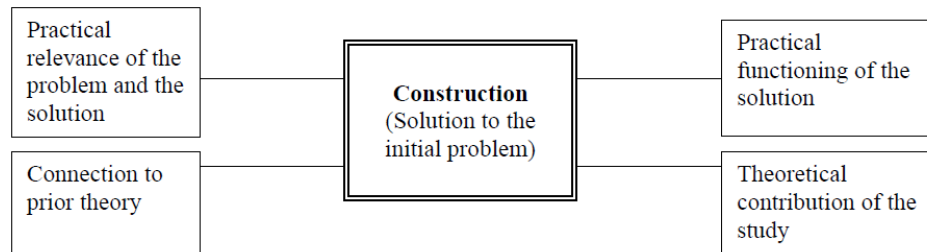


Figure 1.2 - Constructive research approach (Lukka 2003), used under fair use, 2012.

Van Aken (2004) describes the problem solving cycle as: defining the problem out of its “messy” context (Schön 1983 "naming and framing"), planning the intervention (diagnosis, design of alternative solutions, selection), applying the intervention and evaluation. The researcher’s empirical intervention is “designed” or created to address the specific problem, and is thus experimental in nature. The researcher’s empirical intervention is explicit and strong, the researchers become problem solvers (Lukka 2003; Womack and Jones 2005). The results of the research are artifacts, which contribute both to the real-world problem, and to theory.

Design science, or the science of the artificial (how things ought to be, in order to function) is used in the fields of engineering, architecture, medicine, management, and information technology (Argyris 1997; Holmstrom et al. 2009; March and Smith 1995). Holmstrom proposes this theory-building approach was employed in the development of the *Theory of Constraints* (Dettmer 1997; Goldratt 1990), and the emphasis on solution design as integral to the Toyota manufacturing improvements (Dillon 2011; May 2007; Rother 2003). This methodology is well suited to the construction industry, as it addresses the pragmatic aspect of the construction industry by addressing real life problems, while grounding the work in academic

knowledge and contributions. Indeed, an application of design science in the construction industry is the “The Last Planner,” a solution artifact in the form of a production improvement tool. This was developed in response to industry observation by Glenn Ballard, as part of a doctoral dissertation, and has continued to benefit from joint improvement efforts both from industry and academia (Ballard 2000; Jensen 2010; Rybkowski 2009).

## Research Method

The constructive research method is well suited to this project, as it provides a framework that links the solution artifact to practice and theory, both in the research origins and the research outcomes. It also provides a framework for the iterative process of problem identification and obtaining an understanding of that problem. (Figure 1.3)

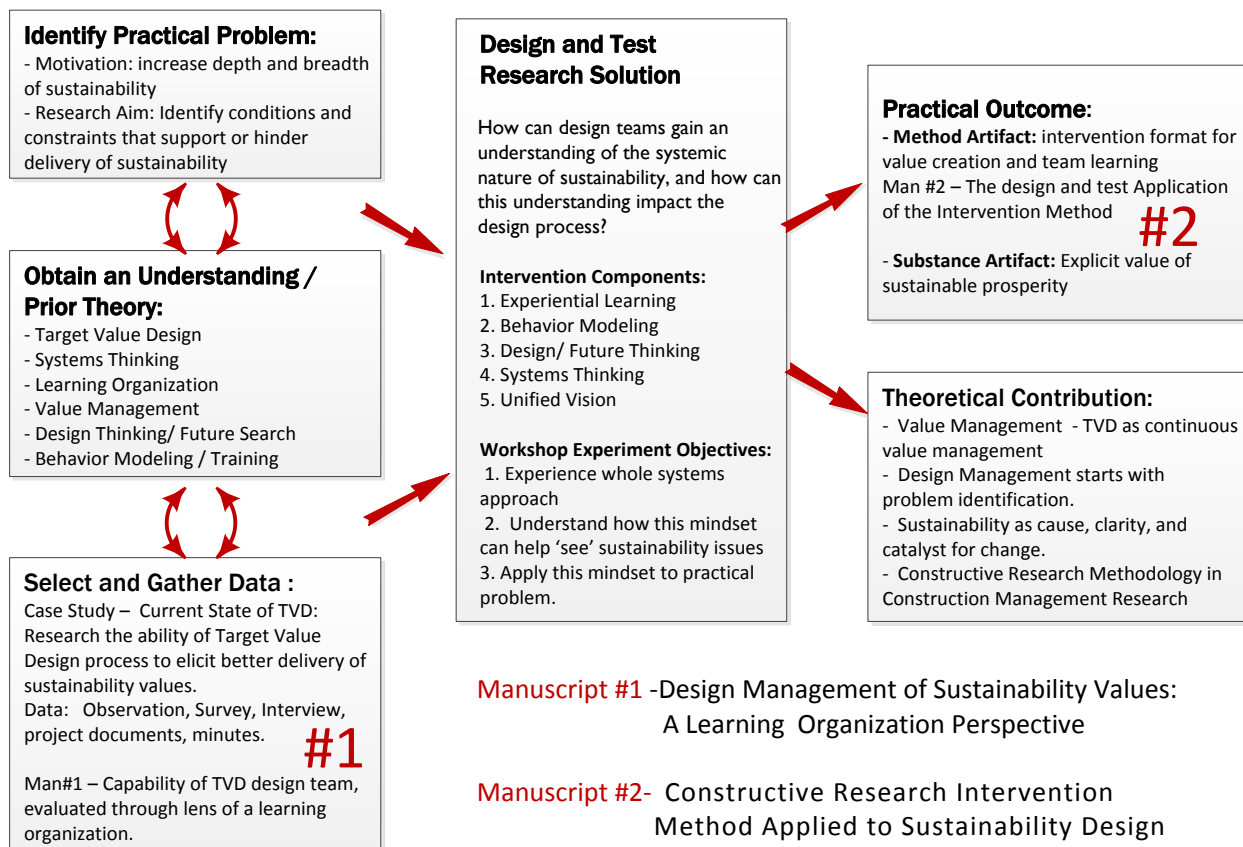


Figure 1.3 - Novak PhD research and manuscript map

The first element of the research method is to identify a practical problem area. The broadly defined problem that catalyzed this work was the need for improving the depth and breadth of sustainability in capital project delivery (du Plessis 2012) (Chapter 1). A literature review provided the background understanding of lean manufacturing and construction, as well as value management / value engineering (Chapter 2). Practical data input was derived from three exploratory case studies. The findings from these established the burden of persuasion to support further research into the paradigm of value as a link between sustainability and lean construction. Specifically, the findings pointed to the importance of the collaboration between core team members, and the commitment from the owner and the contractor to the creation of value (Chapter 3). Both the case study findings and literature review pointed to the design phase, as a greater opportunity for value creation than the construction phase. Thus, the scope was refined to a focus on the design phase, specifically the practice of Target Value Design, an innovative design management process developed by the lean construction industry, which extends the value delivery emphasis from lean construction into the design phase (Chapter 4).

The next element of constructive research is obtaining an understanding and grounding the problem in prior theory. This is an iterative process. As noted above, the background and defining of the problem already encompassed both literature review and empirical foundations. With the problem scope thus more closely identified, the literature review was directed to empirical studies and theoretical discussions of the emerging practice of Target Value Design, and design management. While previous studies had documented the organization, commercial terms, and operating processes of Target Value Design, there was a gap in research on the role of the actors, in their individual skills and collective abilities. This gap was reviewed specific to the ability to deliver value, rather than reduce waste or reduce non-value added process or materials.

The next element of the research is establishing the empirical foundations of the problem. This was achieved by means of a descriptive case study of an exemplary project team practicing Target Value Design (Chapter 5). The contractor of the selected case study is one of the industry

leaders in lean construction, and a lead innovator of the Target Value Design practice (Ballard 2012) and the health care client has more than 10 year commitment of linking sustainable design with evidence-based healthcare and lean principles. The data instruments of survey and interview were designed to probe for the conditions and constraints that influenced the delivery of sustainability, from the perspective of the process and the players. The data was collected and coded. Models drawn from value engineering/ value management, and learning organizations provide the basis for interpreting the observations and data (Chapter 6). This process further refined the problem area, identified some potential causes, and thus pointed to possible solutions.

At the core of the constructive research approach is the design of an innovative solution meant to solve the initial real-world problem (Chapter 7). The analysis of findings from the case study data provided the basis for the design of the research solution, an intervention method. This intervention method is tested through the implementation of a workshop experiments (Chapter 8). The conclusion of constructive research is the discussion of the contributions to practice and theory derived from the development and testing of the developed solution (Chapter 9).

### Research Outcome

The contributions to practical outcome are:

- Method artifact - intervention method artifact
- Substance artifact - explicit sustainable prosperity

The contributions to theoretical knowledge are in the fields of:

- Design Management – The focus on problem identification and problem solving, impact of the value focus on the process and the players in design management.
- Value Management - Target Value Design as a continuous value management process.
- Sustainability – As a the cause for change, the “wicked problem” that reveals the limitations of the current system, and the catalyst for a systems thinking mental model.

## 1.3 Working Definitions

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The following definitions will be used for this dissertation:

**Construction Process** - used in its broadest sense to include the *operational* practices of the project (built on Atkin et al. 2003). The choice of the work include both product and production phases (Figure 1.4).

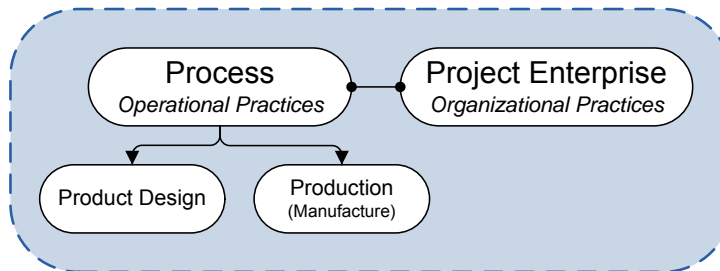


Figure 1.4 - Organizational terms and structures

**Product vs. Production** - Within this research, a distinction is made in the improvement of the product (i.e. the physical representation of the built environment) and the term **production**, which is used specifically in relation to the manufacturing of that product, (i.e. the constructing of the built environment product). This distinction helps organize the process improvements according to their scope.

**Project Enterprise** - the *organizational* mechanism, which could encompass both an individual company, a collective of companies, or a joint project undertaken by several companies. The latter might be the case in a construction project, which can be distinguished by the formation of a legal agreement, or even a temporal legal entity.

However, much of the business literature refers to enterprise as an individual company, and the existing infrastructure of the company in supporting its activities. Thus, to avoid confusion, this research will adopt the nomenclature of **project enterprise**, when speaking of the organizational



mechanism that is assembled for the specific purpose of the construction project design and delivery, and thus draws from all of the involved stakeholders. This will include non-tangible elements such as culture and philosophy, and recognize the identity of these within the project separate but influenced by the participating companies. This is in contrast to the **process**, which encompasses the operational practices in the transformation of materials.

**Lean in Construction** - For the purpose of this research, lean in construction is defined as a holistic construction process and project enterprise based on optimizing value through continuing improvement and a respect for humanity (built on Moussa 2000; Ohno 1988). Specific lean practices that have evolved from collaborative efforts of academia and industry are Target Value Design and the Last Planner. Organizational (enterprise) improvements are the Integrated Form of Agreement (IFOA) contract. The communities of practice have also adopted some of the practices from the Toyota System, such as supply-chain management (JIT), tact time, and value stream mapping. The scope and specific characteristics of lean construction are explored in this research, and may be considered a subset of value optimizing construction.

**Sustainable Prosperity / Regenerative Design vs. Green Design** – This research uses the following terms regarding sustainability, green building, energy efficiency, sustainable prosperity and regenerative design.

Sustainability is defined according to the Brundtland report (WCED 1987) as: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." A subset of this concept is green building, or green design, which is primarily directed at "doing less harm," or, more generally, "reducing the degenerative consequences of human activity on the health and integrity of ecological systems" (Cole 2012; du Plessis 2012). One of the methods that green building is implemented is through green building criteria, such as the USGBC LEED. A strong component of many green building programs is energy efficiency, in an effort to reduce the carbon footprint of the building industry. While not all energy efficiency measures embrace the broader

considerations of sustainability, energy efficiency measures more typically serve as an indicator of additional sustainability measures. Thus, examples presented in the text of energy efficiency are understood to be a subset of, but not equal to, the full definition of sustainability.

Since the 1987, there has been a greater awareness of global environmental challenges and the finite nature of resources. There is an increased understanding of the need to move “beyond green” [existing green building criteria] to a more regenerative approach to ecological issues (McDonough and Braungart 2002). This is as yet a nascent concept, and there is no common consensus for terminology representing this concept. Two of the terms have been selected for use in this work.

“Sustainable prosperity” is the term being used by Worldwatch for the Rio+20 UN Conference (Gardner and Mastny 2011), and is distinct from the term sustainable development, used in the 1992 Rio Earth Summit. “Sustainable prosperity” would come as a result of sustainable development that enables all human beings to live with their basic needs met, with their dignity acknowledged, and with abundant opportunity to pursue lives of satisfaction and happiness, all without risk of denying others in the present and the future the ability to do the same. This means not just preventing further degradation of Earth’s systems, but actively restoring those systems to full health (Worldwatch 2012). The key focus is on the consideration of “all human beings.”

Regenerative design is a term that has emerged from the design community (Cole 2012; du Plessis 2012).. “Within regenerative development, built projects, stakeholder processes and inhabitation are collectively focused on enhancing life in all its manifestations – human, other species, ecological systems – through an enduring responsibility of stewardship” (Cole 2012). It requires a fundamental re-conceptualization of the act of building design primarily in terms of imagining, formulating and enabling its role within a larger context (Mang and Reed 2011), and from the ecological and social perspective (Larrick 1997).

## 1.4 Dissertation Structure UbX Manuscript Option

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This dissertation work is presented in the formatting of the manuscript option, in accordance with the guidelines identified by the Virginia Tech Graduate School (Dean DePauw, 2012).

Guidelines are given as follows:

- The manuscript format for dissertation/thesis shall consist of at least one (for Master's degree) or at least two manuscripts (for Doctoral degree). The content of the manuscript(s) should be based upon research done at Virginia Tech. The manuscript(s) can be previously published, to be published, or in preparation for submission.
- The graduate student is to be the major contributor and writer of the manuscript(s), as usually represented by sole author. In the case of multiple authorships, the contribution of each author is to be detailed in the Introduction or separate Attribution section.
- The graduate student is to provide the Graduate School with a letter of copyright release for previously published & copyrighted material.
- Whether previously published or to be reviewed, the manuscript shall be formatted to fit within the margins acceptable by the Graduate School and satisfy all requirements for submission in ETD format.

The chapters of the dissertation are arranged according the constructive research sequence, to include the two manuscripts, as detailed in Figure 1.5.

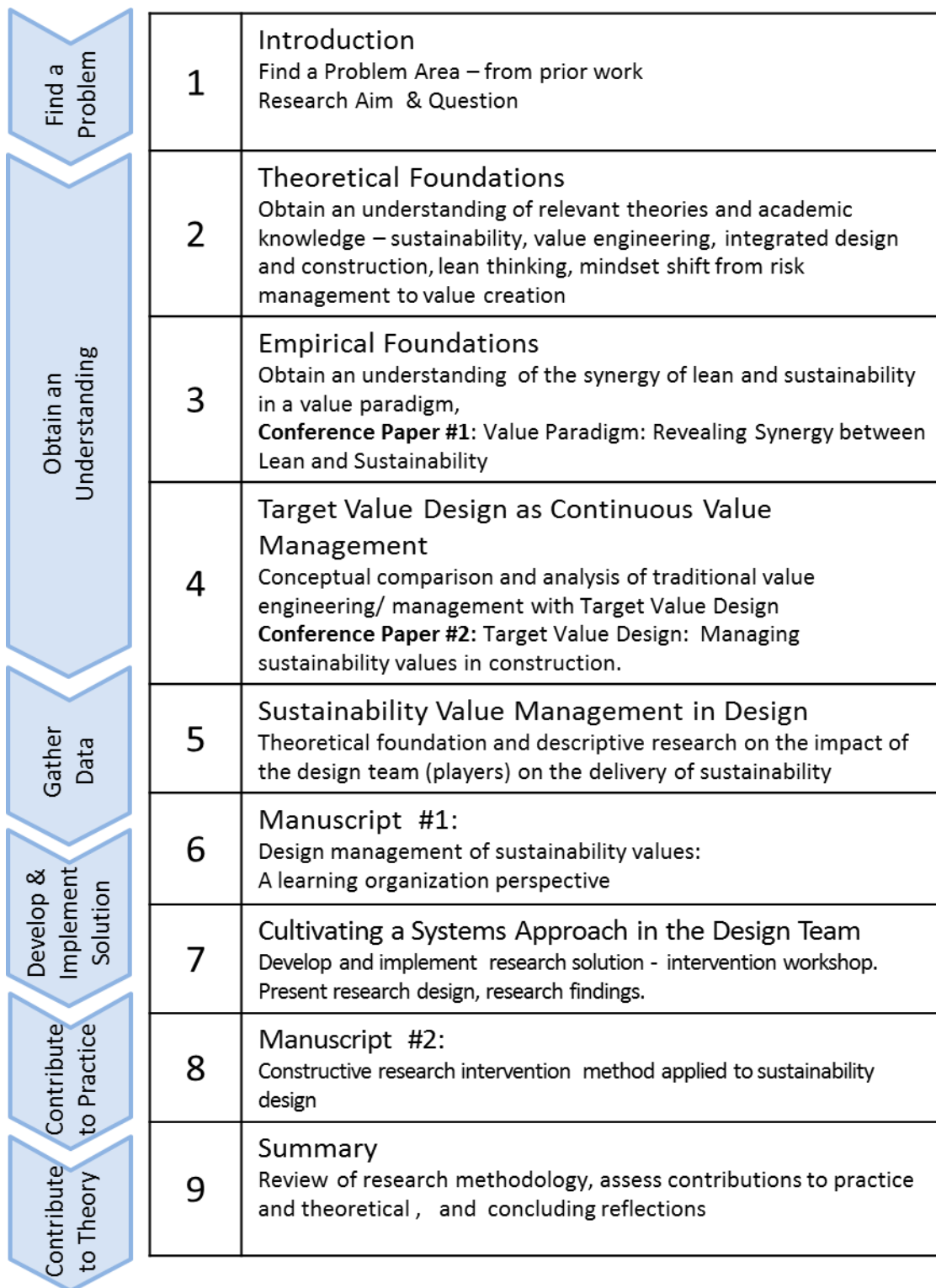


Figure 1.5 - Dissertation chapters aligned with constructive research sequence

Chapter 1 provides the introduction to the research area, the background of sustainability issues that motivated the research aim and the specific research aim. The constructive research methodology is presented, and outlined as it applies the specific doctoral work. This methodology applies to research that has both a practical and theoretical foundation. The original problem of this research came from the practical consequences of sustainability, and was initially grounded in researcher observations of previous work in both practice and theory. The research aim is to identify potential solutions for increasing depth and breadth of the delivery of sustainability values. The relevant theoretical foundations are presented in the literature review of Chapter 2.

Chapter 3 presents the empirical foundations, which consists of exploratory case studies, analyses, and findings. The findings provide the burden of persuasion to further investigation the value paradigm of lean construction, as it relates to sustainability. Other studies have identified the design phase as the greatest opportunity for value creation, thus the research scope is narrowed to the study of the Target Value Design (TVD) practice, which is an integrated design management process developed within the lean construction community. The material in this chapter was presented at the 20<sup>th</sup> Annual meeting of the International Group for Lean Construction, in July, 2012, in San Diego, CA. Chapter 4 compares the Target Value Design process with traditional value engineering practices, and the impact of Target Value Design as a continuous value management process on the allocation of skills to the design team members. This is formatted as it was accepted for the 2012 International Conference on Value Engineering and Management in Hong Kong.

Chapter 5 presents the case study that addresses the first research question: “How can Target Value Design, an integrated design management approach, elicit better delivery of sustainability values?” The first section of this chapter reviews the specific theoretical foundations for value management, and is followed by a section on the case study research methodology used for this

component of the construction research work. The findings are reviewed and presented in the chapter. This chapter includes the first manuscript, which is formatted as prepared for submittal for publication. While the chapter covers the *ability* of the *TVD process* to deliver sustainability values, the topic of the manuscript is the *capability* of the TVD design *team* to deliver sustainability, as evaluated through the lens of a learning organization.

The findings from the case study provide the basis for the core of the constructive research, which is an innovative solution to the research question: “How can design teams gain an understanding of the systemic nature of sustainability, and how can this understanding impact the design process?” Chapter 6 reviews the methodology and implementation of the intervention solution, along with a description of the findings. The chapter also includes the second manuscript of the dissertation, which describes the process of designing an intervention.

A concluding chapter reflects on the doctoral process, the iterative nature of the work, and the implications for the validity of the findings. Chapter 7 also includes a discussion of the future contributions to theory that can follow this research, and some final remarks about the merit of the constructive research methodology.

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## Chapter 2

### Theoretical Foundations



### Chapter Summary

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As presented in the previous chapter, the overall aim of the dissertation research is to identifying the core conditions and constraints that support or hinder increased delivery of sustainability in the built environment. This chapter provides grounding in literature and studies of the construction industry in support of the research aim, specifically sustainability, construction productivity and value engineering, integrated project delivery, lean construction, and value management.

It is helpful, in the review of this literature, to recognize the existing paradigms and definitions that are used within the construction industry. There is a traditionally held distinction between the design function, represented by the architect design *product*, and the construction function, which is represented by the contractor's responsibility for *production* (Koskela 1992).

A focus on *product* improvement is typically found in two mostly independent arenas, sustainability and value engineering. Sustainability, as it is currently expressed in green building criteria, is largely a representation of improvements to the product, such as high energy efficient mechanical equipment (Cole 2012; Kibert 2005; Stegall 2006). This lies within the domain of the architect, materials suppliers, or the client as expressed in the owner project requirements (Stegall 2006). There are some exceptions within the USGBC LEED program, such as waste diversion and air quality during construction (Tatum 2012). The contractors thus regard their

responsibility to sustainability as the fulfillment of the green building criteria, which have been identified in design (Mirsky and Songer). There is nothing surprising in this, as it represents the typical responsibilities in construction – the architect designs, and the contractor builds in accordance with the design documents (Jackson 2004). Construction operations are also subject to many types of sustainability requirements from regulatory agencies, such as site disturbance, noise ordinances, storm water pollution and controlling dust (Tatum 2012).

Value Engineering (VE) came to construction from the manufacturing industry as a process for considering alternative materials that can provide the same function for a lower cost (Miles 1961; Parker 1994). This VE process was relatively seamless, where design engineers work for the manufacturing company, but becomes more cumbersome in the disaggregated functional structure of the construction industry, and rendered even more complex by the practice of employing third party value management engineers (Fox et al. 2001; Kelly et al. 2004). The point of implementation may occur at the design brief, construction documents, or upon project completion. Thus, while always a review of the *product*, the contractor's *productivity* may be affected by the design changes (Korkmaz et al. 2010; Tatum 1987).

The construction industry has been primarily concerned with *productivity*, which is a ratio of total inputs vs. total outputs, as expressed in dollars (Bosworth and Triplett 2004; Oglesby et al. 1989). The success of this activity of production was considered separately from design, thus outside of the scope of the architect, and independent of the outcome measures of the product, such as the delivery of value, or sustainability (Arditi et al. 2002; Sheffer and Levitt 2012). The key functions identified for production improvements fall into the categories of labor and management, and focus on cost control, quality control (not quality generation), and scheduling (Grabell 2012).

This separation of design and construction is often identified as the source of phase-induced ignorance, which generates waste in both product and production (CBC 2011). Design and management of values, including sustainability, are conducted largely independent of input of constructability or even durability (Trusty and Horst 2003). Equally, productivity improvements

in construction, without the understanding of project target values or sustainability goals, run the risk of deviating from target outcomes, and trigger an increased demand for project documentation, and controls (Stevens 2012; Trusty and Horst 2003). This is a process model in which the right hand doesn't know what the left hand is doing. It sets the stage for conflicts, and results in a culture of risk-management that has a negative impact on the product outcome (Barber et al. 2000)

In response, the industry has experimented with new models to remove some of the barriers between the project design activities and the construction production, by enlarging the membership of the design team, providing a co-located workspace, and improving the flow of the design processes (CBC 2011). In addition to these organizational improvements, one model also adds a process focus on improving value delivery (Lichtig 2010). This model, called Target Value Design, is an emergent practice that has been developed within the lean construction community (Ballard 2012). The focus of lean construction on optimizing the whole, not the pieces, supports the crossing over of traditional stakeholder boundaries, and seems well suited to the delivery of sustainability values, which are complex and interconnected (Mossman et al. 2011)

This literature review provides the background knowledge necessary to guide the exploratory industry studies and interpret the findings for the identification of a salient practical problem, which is developed in the next chapter.

## 2.1 Sustainability - From Waste Management to Value Generation

### Global environmental challenges are outpacing AEC industry

The original concept of sustainability can be traced to the Brundtland Report (WCED 1987), which called for meeting the needs of the present without compromising the ability of future generations to meet their own needs. This challenged the existing perspective at a project level on the commercial requirements of time, cost and quality. A new perspective was needed to address not only current needs, both those of future communities. The concern of sustainability

was focused on extending the availability of resources, but it was also based on the assumption that all other conditions would remain favorable to human life. However, 30 years have passed, and the accelerated rate of climate change is rapidly closing the window of opportunity on the “do no further harm” approach (du Plessis 2012; Lovins and Institute 2011; Tatari and Kucukvar 2012). It demands a more rapid response to counterbalancing the rising carbon counts, while also providing solutions to stabilizing the economy and societies. Net-zero energy benchmarks, which were seen as far reaching just a few years ago, are now being replaced with positive-energy goals, and an awareness of the total life cycle costs of all products (Trusty and Horst 2003). Conservation is being replaced with regenerative strategies; single use with multi-use and adaptive re-use; social and political stabilization; and renewable energy resources. While the contribution of the construction industry to this future vision of community, humanity and planetary health may be feasible, according to the New Buildings Institute “the barriers to the widespread design and construction of low-energy buildings are not technical in nature, nor do they appear to be financial; more likely they are related to the motivation of owners and the skill set of the design and construction teams (CBC 2011).”

### How well has the AEC responded to this new paradigm?

Industry awareness of sustainability issues can perhaps be traced to the OPEC Oil Crisis, which triggered a rash of energy efficiency measures. It provided a point of reality to the growing social awareness of sustainable issues that was burgeoning in the 60’s. Scientific data, such as that presented in Rachel Carson’s *The Silent Spring* (1964) triggered the launch of several government agencies, such as the Environmental Protection Agency (EPA).

The manufacturing industry responded to sustainability as a social obligations that was regarded as a great trade-off to financial performance (Hart 2005) in the “take, make, waste” organizational paradigm (Anderson 1998). But the 1980’s brought a greater awareness of environmental degradation and an international call for change (WCED 1987). Germany responded with an “end-life” producer responsibility in Germany, which was later introduced as the “cradle to cradle” concept in the US (McDonough and Braungart 2002; Steger 1998). Hart charts the path from obligation to opportunity in sustainability, and forecasts the next step as

“beyond greening” (Figure 2.1). He states that “*under the right circumstances* (emphasis Hart),” firms could improve their own competitive position by creating societal value (Hart 2005).

## The Long and Winding Road

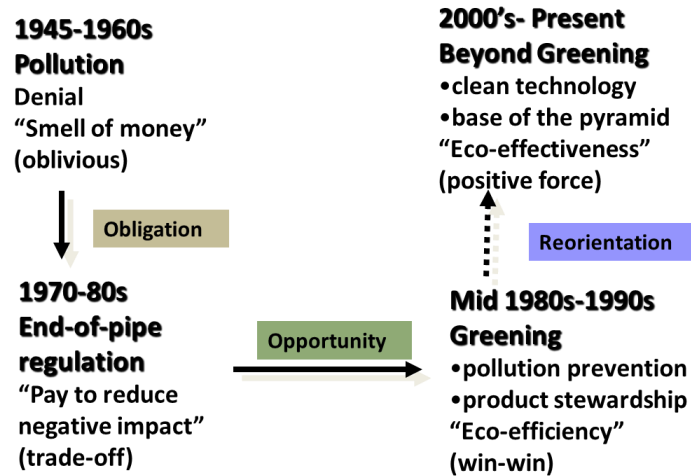


Figure 2.1 –Capitalism at the crossroads (Hart 2005), used under fair use, 2012.

In the construction industry, the focus on energy efficiency in the 1970’s largely dissipated with the return of low gas prices. However, the broader interest in a holistic building practice was retained and nurtured by government efforts, such as the Whole Building Design Guideline (SBIC 1984). While this was supported in principle by the U.S. Federal government, it was very much resisted by associations representing the construction industry. Eventually, public action groups took the initiative to develop green building programs (Austin Energy 2009), and the design community launched the US Green Building Council. Conceptual focus on holistic sustainability issues gave way to prescriptive green building checklists (du Plessis 2012).

Green building certification programs have spurred both market interest and a growing number of projects, but this approach typically results in cost increases from nontraditional materials, increased levels of building performance expectations and added labor costs for project documentation (Klotz et al. 2007; Mogge 2004). And while specifics such as reducing resource and energy consumption, measuring emissions, and conserving natural areas can be mandated or

specified, the reconciliation of these with the basic project criteria of meeting time, cost and quality (T/C/Q) can only be achieved if the incremental costs begin to break through the cost barrier and reduce costs through synergies and even elimination of redundant systems (Figure 2.2) (Hawken et al. 1999; U.S. DOE 2009). Hawken (1999) also points out that incremental thinking can overlook the potential for leapfrog innovations that can result from a whole systems thinking. Also, these green building certifications do not always guarantee high energy efficiency or good performance over the operational life of the building (Branco et al. 2004; Lapinski et al. 2006; Torcellini 2006; Turner and Frankel 2008).

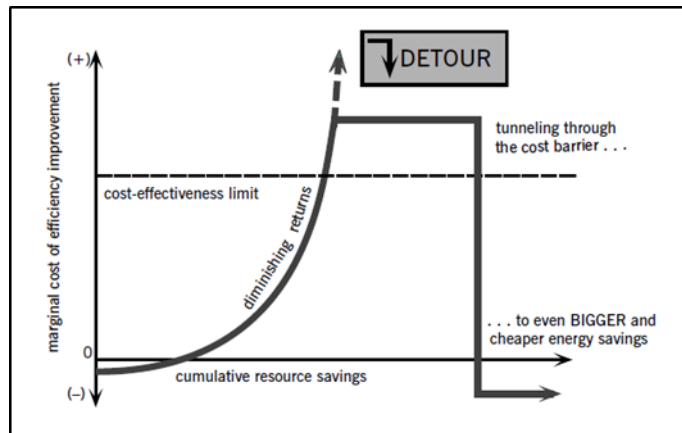


Figure 2.2 - Tunneling through the cost barrier (Hawken et al. 1999), used under fair use, 2012.

The construction industry is patterned and constrained by the context in which they operate, and is responsive to public demand. Green building in the construction industry is driven by consumer demand, which has in turn triggered an increase in local and federal government regulations (Architecture 2030 2010; Williams 2010). Building owners, responding to the market appeal, and supported by regulations coupled with tax incentive, have also recognized the benefits of green building to their bottom line through a reduction in operating costs, increase in building values; and increase in return on investment (ROI). According to a recent McGraw-Hill Construction report, *Green Outlook 2011: Green Trends Driving Growth*, (2011) green building represented 25% of new construction activity in 2010, and is expected to reach \$135 billion, or 48% by 2015.

While these numbers may seem impressive, there is no distinction between levels of “green.” For example, this same report cites an average reduction in operating costs of 13.6% on new buildings and 8.5% on retrofits. These are very modest ambitions, when compared to the challenge levels set by Architecture 2030. These levels are set to address the responsibility of the building sector for nearly half of the CO<sub>2</sub> emissions in the US. The proposes a fossil fuel, GHG-emitting, energy consumption performance standard of 60% below the regional (or country) average for new construction of that building type, with an equal amount of existing buildings to be renovated to these same levels (Architecture 2030 2010; Lovins and Institute 2011). This fossil fuel reduction challenge amount is increased until 2030, when all buildings are to be carbon neutral. Clearly the current level of green building is insufficient to address this challenge.

In addition to the energy savings, the construction industry is challenged to address the broader sustainability goals, moving beyond the project level perspective to contribute to the vision of community, humanity and planetary health. To reach this level will require a significant ‘mind-shift,’ coupled with the economic backing gained from financial and time savings in productivity gains and revealed waste. In economic theory, this inclusion of sustainability has been described as moving beyond a “survival economy” to “nature’s economy” (Hart 1997), or “sustainable prosperity.” According to Worldwatch, this is a level of sustainable development that enables *all* human beings to live with their basic needs met, with their dignity acknowledged, and with abundant opportunity to pursue lives of satisfaction and happiness, all without risk of denying others in the present and the future the ability to do the same. This represents a shift beyond just preventing further degradation of Earth’s systems, and requires actively restoring those systems to full health (Worldwatch 2012). Recent design literature has referred to this concept as regenerative design, with a greater emphasis on the complex and continually evolving interrelationship between human and natural systems (Cole 2012; du Plessis 2012).



## 2.2 Construction Productivity and Value Engineering

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In contemplating the construction industry's ability to achieve these higher goals of sustainability, the first consideration is the ability of the construction industry to improve within the current system, and to identify the current constraints. The trade-off between time, cost and quality is often cited as a limiting factor (Kerzner 2009). However, there are several indicators that the construction industry has both the capacity and capability to realize significant improvements within the existing construction production system. These are quantified through data on low productivity and embedded waste, as well as empirical evidence from innovative projects.

### Low Productivity in Construction

Low productivity in construction was first measured in 1983 by the Business Roundtable, a group of 200 of the largest corporations in the United States, who decided that something should be done about construction performance in all aspects, citing "ever-increasing costs, high accident rates, late completions, and poor quality" (Fitzgerald 2010; Oglesby et al. 1989). The resulting study, the Construction Industry Cost Effectiveness Project, described a "startling finding" that construction productivity in the 1980's had either increased at a lower rate than other industries, or actually declined (CICE 1983). The cost of construction had increased by 50% over the inflation rate in the same period. More recent records have confirmed that construction productivity has shown a slow decline during the measured timeframe of 1964 to 2003, while manufacturing productivity doubled in this time (WCED 1987).

Economic indicators such as these typically measure productivity based on the economic model of total factor productivity (TFP), the ratio between total outputs expressed in dollars vs. total inputs (labor, materials, equipment, energy, and capital), expressed in dollars. Other measures of productivity output are expressed in measurements of a physical unit (i.e. square foot or tons of steels). These productivity models are clearly adopted from the manufacturing industry and are rather reductionist of the rich nature of outputs of a built environment (including form, function and contribution to sustainability). However, they do provide a baseline measurement of

improvement potential in construction. In addition, labor productivity models have been useful in identifying labor and management efficiency gaps.

A study on potential areas of productivity improvement in the US construction industry (Grabell 2012), which compared the results of surveys in 1979 (Choromokos and McKee 1981), 1983 by Nasra (1983), and again in 1993 by Mochtar (1994), identified key functions that were consistently identified over time by the study respondents (Figure 2.3). These functions were: putting in place the mechanisms that will allow the proper training of the labor force, design practices to improve the quality and constructability of drawings and specifications, instituting formal quality control processes such as total quality management, and improving the effectiveness of cost control and scheduling, specifically the regular monitoring of achievement by comparing against planned activities in a continuous process throughout the life of the project (Arditi et al. 2002). These functions are mostly representative of the categories of labor and management, and point to the relative importance of these categories for productivity improvement.

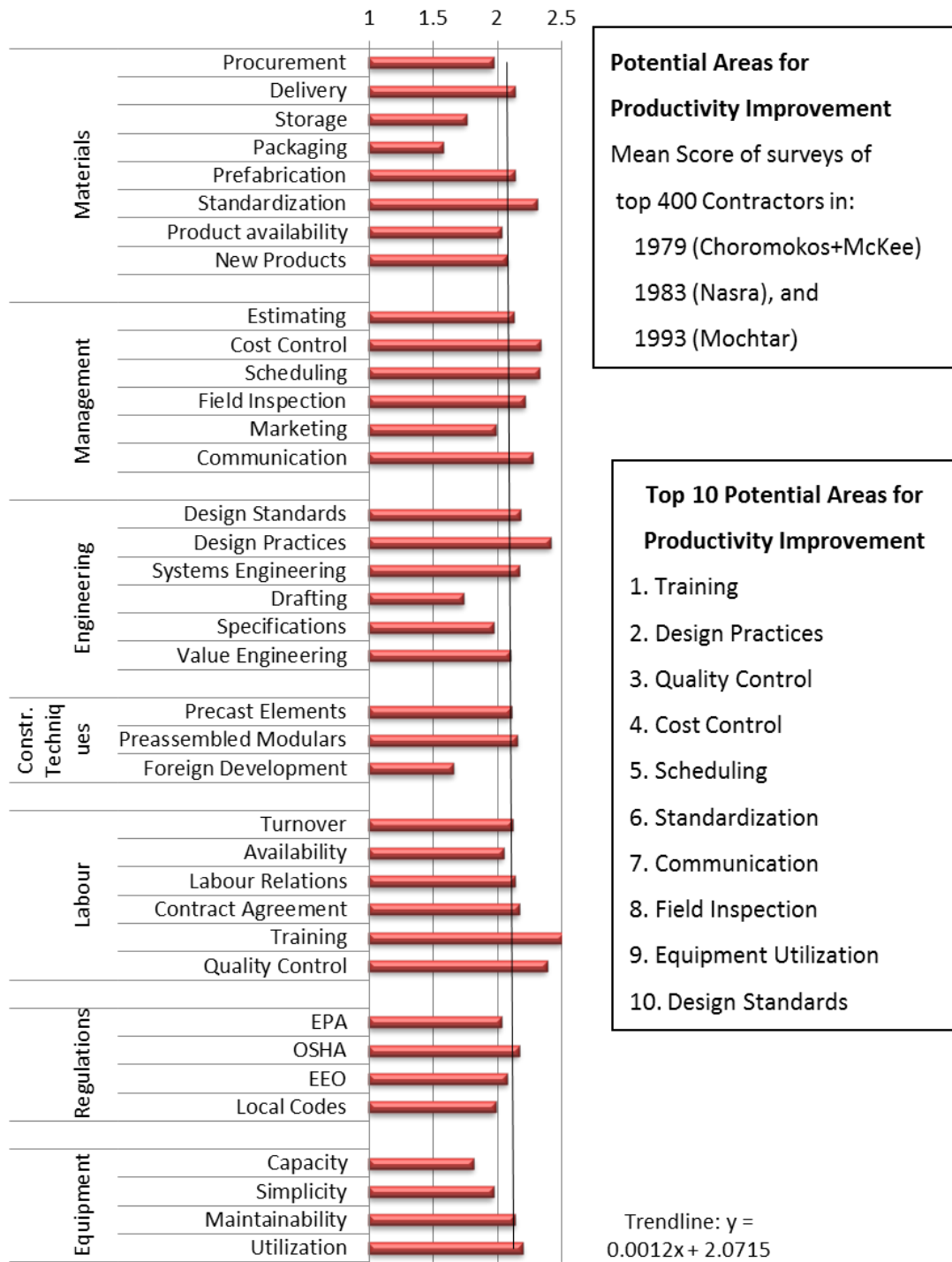


Figure 2.3 – Data derived from Arditi and Mochtar (2000). "Trends in productivity improvement in the US Construction Industry" Table 2, pg. 19, used under fair use, 2012.

Notably, the categories that were cited as having lower potential in productivity improvement, or categories in which construction was already relatively efficient, were materials, construction techniques, regulations and equipment (Grabell 2012). The category of “engineering” in this study encompasses design practices, as well as systems engineering and value engineering. This perspective reflects the practices of manufacturing, but mostly represents the discipline of design in construction. The key area for improvement was design practices, which indicates that, “with the increasing complexity of construction projects, contractors are experiencing greater productivity problems because of design errors and deviations” (Arditi et al. 2002). Suggested improvements are for a formal design review program, with the aim to improve the quality and constructability of drawings and specifications (Kirby et al. 1988).

The studies were labeled as productivity studies, which was in accordance with the connection of management science to production (Koskela 2011). But the data also suggests implications in the areas of management, engineering and labor. The construction industry think tank, the Mindshift Group, recognized the traditional “silo” approach of capital project delivery as being a cause of inefficient production, and called for a more integrated system to reduce waste (Miller 2009). Specific areas of waste to be harvested were identified as boilerplate planning and sub-trade coordination (design process problems), hierarchical dilution and phase-induced ignorance (communication) and problems that come with fielding a new team with every project (labor). These inefficiencies in business practices were quantified in the loss of billions of dollars a year in a 2004 U.S. Dept. of Commerce report (U.S. Dept. of Commerce 2004). More recently, the Construction Industry Institute (CII) estimates there is up to 57% non-value added effort or waste in the current business models in the US (NIBS 2007).

This situation of low productivity is not unique to the United States. The United Kingdom’s Office of Government Commerce (UKOGC) estimates that savings of up to 30% in the cost of construction can be achieved where integrated teams promote continuous improvement over a series of construction projects. UKOGC further estimates that single projects employing integrated supply teams can achieve savings of 2-10% in the cost of construction (OGC 2007). In 1998, Sir John Egan issued the “Rethinking Construction” Report, which challenged the U.K.

construction industry to address the waste and poor quality arising from current work practices (Egan 1998). Ineffective utilization of labor and wastage of materials was estimated to cause unnecessary costs of around 42 percent (Cain 2004).

One of the primary reasons given for this level of waste is the “proprietary and closed systems, unclear workflows and non-standardized data within and between industry information silos” (NIBS 2007). This National Institute of Building Sciences report further explains that the dollars are widely distributed and that most practitioners have an accepted way of doing business such that the embedded waste and pathways to improvement are not readily discernible. These closed systems constrain industry improvements to incremental improvements of inefficient processes, rather than substantive changes that would involve the entire capital facilities industry (NIBS 2007).

### Value Engineering

The productivity studies identified areas of improvements within the engineering category, such as systems engineering and establishing value engineering as a regular practice in all phases of a projects. As noted in the introduction, these are all related to the development of the product, whereas the other categories can be mostly understood as improvements to production. This distinction is important in identifying potential solutions.

The concepts of value analysis for product improvement can be traced to the work of Lawrence Miles, a purchase engineer for General Electric Company during the manufacturing industry boom of the 1940s (Miles 1961). Faced with material shortages, Miles needed a method to consider alternatives and establish the criteria for acceptable changes. While Miles did introduce the concept of value as a function of cost, he also identified the following parameters for determining the necessity of costs: utility (function), life (durability), quality, appearance and customer features. However, this is a difficult concept to implement in practice, as the actual measurement of these variables is challenging and can be subjective. Thus, only the variable of “function” was retained in the definition in Value Engineering, presented by Society of

American Value Engineers (SAVE)<sup>1</sup>: Value = Function/ Cost.

This general definition became an accepted and common use of terminology, championed by the US Department of Defense's Bureau of Ships in 1954. The implementation of value analysis by engineering personnel within the DOD resulted in the placement of this function firmly within the engineering profession, a name change to "value engineering" (VE), and the emergence of a systematic and structured approach of value "events" at delimited points of intervention (Kelly and Male 1993; Parker 1977). Operating within the narrow constraint of function (utility) as the defining variable of value, and the stated goal of achieving these functions to "meet the customers' needs at the lowest cost," value engineering can also be stated as the minimal required function for the lowest overall cost. This simplified "function/ utility" model of project valuation is reflective of the post-WWII manufacturing market, which was characterized by rapid product innovation, with consumers more oriented toward quantity rather than quality. Resources were abundant and at a low cost, and management was more concerned with increasing sales than with reducing costs (Imai 1986). However, this economic model no longer holds true in a mature product market, where consumers no longer respond to product proliferations or even brands (Moon 2010).

Industry implementation of VE in construction adapted to the demands in the market sector and broke the boundaries of the classical VE definition (Parker 1977). One of the early pioneers of value engineering in construction, Alphonse Dell'Isola, reintroduced Mile's concept of quality (Dell'Isola 1997). Zimmerman and Hart included life-cycle costing and energy consumption, both of which could be discounted to present value (Zimmerman and Hart 1982).

There are actually many types of value that have been introduced in the value engineering community (Zimmerman and Hart 1982) . These are:

- Use Value - received from the delivered function. Based on traditional VE, and typically represents the properties and quality that perform a function.
- Esteem Value- includes the emotional regard for the item in the purchase price

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<sup>1</sup> SAVE International, [www.value-eng.org](http://www.value-eng.org)

- Exchange Value – amount willing to accept in trade, expressed either in monetary terms or a defined product
- Cost Value - amount of money willing to incur to produce the value (i.e. actual construction costs.)

The importance of identifying the type of value is to help make the values explicit, in order to be communicated within the value chain of the product. For example, the owner might express esteem values when building a heritage building, or a company headquarters with high expected visitation. There will also likely be cost values and use values, which are to be communicated to the product design and production phase.

The evolution of value engineering was instrumental in producing a methodology to assess alternatives based on a predefined set of values. It also helped to recognize the importance of the creative process, the need to think big, and to believe in the power of the collective power of people to find solutions (Zimmerman and Hart 1982). Both of these are important precursors to the Target Value Costing in Construction. Target Value Design (TVD) was initially developed within the lean construction community as an adaptation of target costing to construction projects (Macomber et al. 2007). TVD has since become a fully integrated design management process, “used to structure and manage the project definition and design phases of construction projects with the goal of delivering value to customers within their conditions of satisfaction, which typically include cost and time, but may include other conditions as well” (Ballard 2012; Jørgensen and Emmitt 2009; Zimina et al. 2012)

### Implementation of VE in Construction Products

Value Engineering was introduced to the construction industry through the capital improvement project procurement of government agencies (FFC 2001), and codified into the Value Engineering law, known as Public Law 104-106. The definition modified the meaning of value engineering to encompass functions not only of the product (i.e. project, system, building, facility), but also of the service as well as the supply chain. The scope of the value equation was also greatly modified to include life cycle costs. This introduced the concept of value within a timeframe, both current and future, and provided the gateway through which VE would later be

applied to include sustainability (FFC 2001).

As this modified VE practice has spread to privately funded capital improvement projects, it was further adjusted to include a variety of interpretations and implementation strategies. A study by Kelly & Male identified four approaches to VE in North America (Kelly and Male 1993). First, there is a value design charrette, led by a value engineer with the purpose of bringing together the client and design team to evaluate the client brief. Alternately, the design sketch may be reviewed in the form of a 40-hour study, which is again chaired by the value engineer and carried out by an independent team of design professionals. Upon completion of the construction documents, a clause may allow contractor changes in order to reduce costs. And finally, a VE audit may be contracted by a large holding company to ensure the project is delivering “value for the money” (Kelly and Male 1993).

All of these implementation approaches have in common the aspect of being an additional action to the standard construction design and delivery process, thus incurring an additional cost and time factor. While the savings identified in the VE process are expected to outweigh the costs, this element of uncertainty and delay has been a motivating factor in looking for alternative implementations strategies to achieve the intent of the VE process (Kelly et al. 2004).

Value engineering in Japan has taken a slightly different approach, where it is not an event, but rather a continuous process carried out within the philosophy of continuous improvement across all phases of the construction process. An in-house value engineer is employed. Differences in culture also apply. Whereas in the U.S. (and the U.K.), the goal is a demonstrable financial return for the short term exercise, the Japanese seek satisfaction from a holistic assessment of the problem with a range of possibilities that can be considered long term and are determined by consensus among the team (Drucker 1971). The Japanese system is therefore intuitive and future oriented compared to the U.S. system of immediate returns (McGeorge and Palmer 1997).

### Sustainability: Environmental Value Engineering (EVE)

Value Engineering was developed based on an economic model, where the value (function,



esteem, exchange, or cost) were related to some level of monetary exchange, either cost or purchase. As stated previously, the Value Engineering law, Public Law 104-106, provided for cost to also include life-cycle costing. This made it possible to reconcile with the other mandates for federal agencies to provide energy efficient buildings.

According to the Sustainable Federal Facilities Guide, with life-cycle costing, “tradeoffs and decisions can be made to balance environmental performance with total costs (i.e. initial, recurring, and nonrecurring) reliability, safety, and functionality. When all alternatives are compared equally (i.e. “apples to apples”), sustainable development technology and integration can then be fully evaluated in the acquisition process” (FFC 2001). A sustainable solution for a project can thus be expressed as the best value for both current and future generations.

This overlay of environmental considerations has been built into a modification of the VE system, called the Environmental Value Engineering (EVE). This analysis methodology, pioneered by Dr. Wilfred H. Roudebush in 1989, combines the late Dr. Howard T. Odum's energy analysis with traditional value engineering (Kibert et al. 1991). EVE can be used to compare multiple built environment alternatives over a life cycle consisting of 10 phases: natural resource formation, natural resource exploration and extraction, material production, design, component production, construction (assembly), use, demolition, natural resource recycling (feedback), and disposal.

The increasing use of integrated design processes creates new opportunities for VE as an informal, continuous process executed within the existing project staffing (Dell'Isola 2002). It also adds an element of time, both regarding the point of time in the construction process in which it is implemented, as well as the extension of time to include life cycle costs in the calculations. This factor of time, and the recognition of the multiple stakeholders involved in the assessment of value have supported the inclusion of value analysis into an integrated design and construction process.

## Constructability as Value Management

One of the key areas identified by the aforementioned studies of productivity improvement (Arditi et al. 2002), was design practices, to improve the quality and constructability of drawings and specifications. In research sponsored by the Construction Industry Institute, Tatum (1987) introduced the current spelling of constructability with an “a,” and offered a definition of “the optimum integration of construction knowledge and experience in planning, engineering, procurement, and field operations to achieve overall project objectives” (Jortberg 1985). Studies identified the greatest benefit when contractors took a proactive role in the development of the project plans, rather than relegating construction input to a process of reactive reviews, or limited to providing cost and schedule estimates of various alternatives (Tatum 1987). Three key areas were identified for constructability input: 1) developing the project plan, 2) site layout and 3) construction methods. The first two areas can be understood as increasing the value management of production, while the third area also has potential for input into the value management of the product.

These early studies provided the basis for the Construction Industry Institute (CII) to develop a constructability program designed around the presumption that constructability input needed to be an ongoing process through the entire project (CII 1993). The difficulty lies in the implementation. As recently as 2005, Pulaski and Horman (2005) report that “the means by which this knowledge is introduced in construction projects is still largely rudimentary.” While there have been efforts to use tools such as best practices, computer models or checklists, the most common practice is still the peer review of construction documents. Studies have shown that 83% of constructability knowledge is in the form of tacit knowledge, or knowledge that exists only in the heads of the experts (technical skills, intuition, insights) (Hanlon and Sanvido 1995). Furthermore, this tacit knowledge is evoked by cues from explicit knowledge (information that has been articulated in a written form) (Weick 1995). Thus, the design review can be seen as the “cue” that elicits the tacit knowledge. However, this post-hoc review process results in significant amounts of “rework and inefficient design effort, frustration, and conflict between designers and constructors” (Arditi et al. 2002).

Pulaski proposes a model that would facilitate more of the proactive approach proposed by CII, and would organize constructability knowledge based on appropriate timing and levels of detail. The point of interface would still need to be face-to-face meetings. Pulaski acknowledges that a “key component to properly addressing constructability is the human interface aspect of organizing constructability input for design.” He indicated the need for further research “to determine how best to extract constructability knowledge from general contractors, specialty contractors, and suppliers at each point of the design process. The simple introduction of a contractor at different points in design is not enough to take full advantage of their expertise. Neither is performing design reviews sufficient. Further research must address how to overcome differences between designers and contractors, and engage project participants in the design process to optimize constructability input” (Pulaski and Horman 2005).

## 2.3 Integrating Project Delivery

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The 1983 construction industry cost research not only pointed to potential areas of productivity improvements, but also provided an analysis of the possible causes. It reported that “one major reason that construction is comparatively inefficient is its inordinate fragmentation,” and the report called for improvements in four areas: 1) planning and scheduling 2) cost estimating, budgeting and control accounting; 3) quality assurance; and 4) materials management (lack of skilled labor) (CICE 1983). Almost 30 years later, the Construction Buildings Consortium was still calling for “integrated processes to be applied to all aspects of project development, from design and construction through occupancy” (CBC 2011). These are difficult changes in culture, which are echoed and have precedence in other industries, for example, concurrent engineering in manufacturing. This is driven by the concept that all elements of a product’s life-cycle, from functionality, manufacturability, assembly, testability, maintenance issues, environmental impact and finally disposal and recycling, should be taken into careful consideration in the early design. The increased need for early information drives the process change from a linear, “waterfall” style, to an iterative, integrated concurrent process (Figure 2.4).

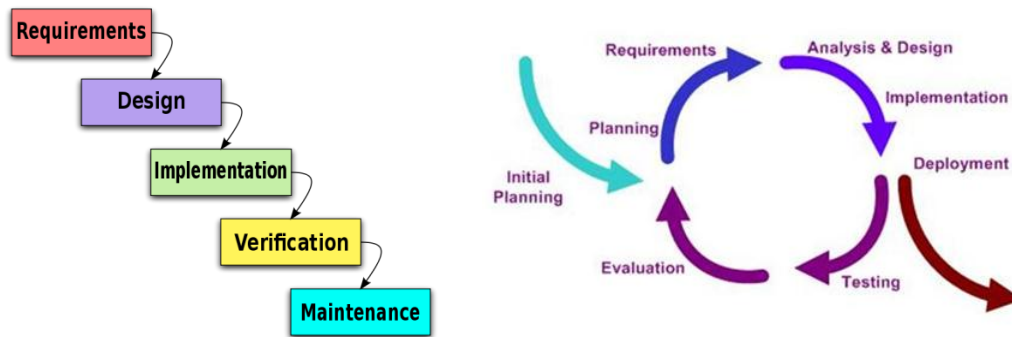


Figure 2.4 - “Waterfall” linear implementation vs. iterative concurrent engineering

Within the construction industry, there has also been experimentation with integrating the processes of product design and production. Many of these have been on the level of physical co-location of involved parties; the overlapping and/or integration of constructability information with design; the creation of shared risk/ shared reward contractual documents; and the introduction of Building Information Modeling (BIM) to facilitate data sharing (Mauck et al. 2009; Owen et al. 2010). While there are many variations, there are two primary process methods that have emerged in the market: design-build, which principally represented the extension of a contractor’s business model to bring design in-house, and integrated project delivery (IPD), which was an initiative from the design community to involve more stakeholders in design (Jackson 2011; Weigle and Garbor 2010).

### *Design-Build and Integrated Project Delivery*

The need for speed-to-market was the initial impetus for a change in process. Constructors recognized the need to increase the input of constructability information into the design phase and proposed an overlapping of the design and construction phases, first through “construction management at risk,” and then into a single source contract of “design-build” (DB) in the early 1990’s (Morriss 2011). However, the concurrency of a linear process may not be sufficient to create an integrated process. The co-location of the trades is an organizational effort, which may retain the same process procedures, only with a shorter and more iterative cycling of documentation. Nonetheless, the physical co-location facilitates greater interaction between the stakeholders, and is more likely to lead to increased trust, open communication and true

collaboration. Also, DB firms are typically contractor-led firms who have hire designers to work in-house. One concern by the design community is that the design becomes subordinated to the constructability, which does not fulfill the spirit of the integrated process. Bringing the designer in-house could actually increase the tendency toward a closed loop process, which is essentially no different than the old system of negotiated work alliances (Chan et al. 2002; Quatman 2000).

Data of delivery method market share for non-residential construction indicates that design-build has been slowly gaining market share. However, as it does not account for all of the decrease in market share from the traditional design-bid-build, suggesting the presence of other alternative project delivery methods (Figure 2.5).

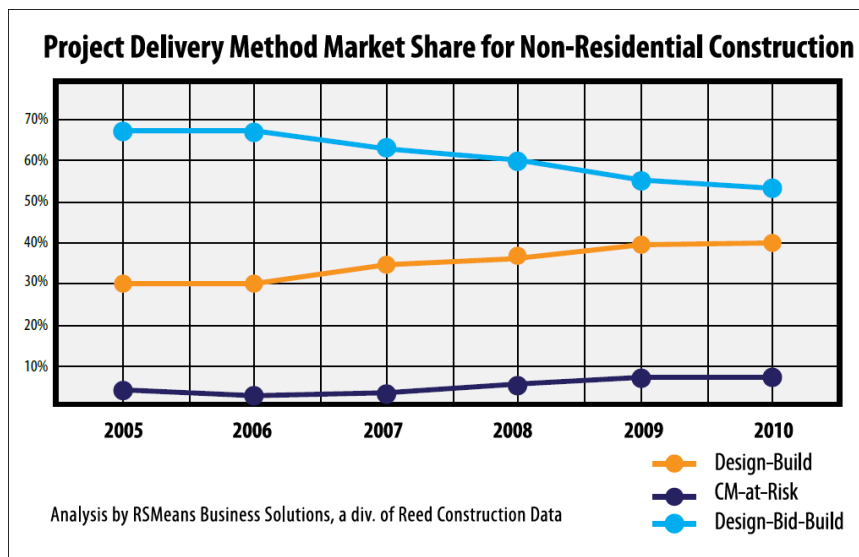


Figure 2.5 - Change in project delivery methods over time, Reed Construction Data (2011), used under fair use, 2012.

The other notable innovation in project delivery that has been gaining prominence is the Integrated Project Delivery (IPD). While this is not a project delivery method, per se, as it was developed within the design community as an integrated design process, the associated contractual agreement governs the project through to completion. Developed initially in California to address the “owner’s on-going demand for more effective processes that result in better, faster, less costly and less adversarial construction projects,” the American Institute of

Architects published an IPD guide in 1997, (AIA 2007). The stated intent is to “integrate people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction.” IPD principles can be applied to a variety of contractual arrangements and IPD teams can include members well beyond the basic triad of owner, architect, and contractor. In all cases, integrated projects are distinguished by highly effective collaboration among the owner, the prime designer, and the prime constructor, starting early in design and continuing through to project handover.

There have been variations on these construction delivery approaches, but the defining characteristics were summarized in a Primer on Project Delivery, jointly produced by the American Institute of Architects and the Associated General Contractors of America, as outlined in Table 2.1 (Danaher et al. 2007).

	<b>Design Build</b>	<b>Integrated Project Delivery</b>
Defining characteristics	<ul style="list-style-type: none"> <li>• Two prime players - owner, design-build entity</li> <li>• One contract -owner to design-build entity</li> </ul>	<ul style="list-style-type: none"> <li>• A contractual arrangement among multiple parties including, at a minimum, the owner, the architect and the contractor</li> </ul>
Typical characteristics	<p>Final design-builder selection may be based on any of the following: Direct Negotiation, Qualifications Based Selection, Best Value: Fees or Total Project Cost, or Low Bid.</p> <ul style="list-style-type: none"> <li>• Project-by-project basis for establishing and documenting roles</li> <li>• Continuous execution of design and construction</li> <li>• Overlapping phases—design and build</li> <li>• Some construction-related decisions after the start of the project</li> <li>• Overall project planning and scheduling by the DB entity prior to mobilization (made possible by the single point of responsibility)</li> </ul>	<ul style="list-style-type: none"> <li>• Shared risk and reward</li> <li>• Continuous execution of design and construction</li> <li>• A minimum of three prime players—owner, architect, contractor</li> <li>• Some construction-related decisions after the start of the project</li> <li>• Overall project planning and scheduling collaboratively by the entire team</li> <li>• Selection of the architect and contractor team is typically accomplished through Direct Negotiation, Qualifications Based Selection or Best Value: Fees.</li> </ul>

Table 2.1 – Primer on project delivery (AIA and AGC 2011) , used under fair use, 2012.

While IPD is a recognized form of project delivery in the private sector, the public sector is still tied to older delivery forms. Thus projects may use the spirit of IPD, while contractually delivered under DB.

How effective are these process changes? A 1998 study comparing tradition design-bid-build with the new project delivery management forms of DB and CM@Risk confirmed that a DB project delivery can achieve significantly improved cost and schedule advantages (Konchar and Sanvido 1998). The measurement of quality was limited to asking facility owners to rank the difficulty of the turnover process and the actual vs. the expected performance of principal facility systems. A score of 10 indicated the highest level of achieved quality. The results of the study are presented in Table 2.2 - Comparison of quality performance. Though this information is presented as evidence of delivery improvement from DB over DBB and CM@Risk, it is also worth noting that the data indicate that there is only a moderate level of satisfaction in most of the quality metrics by all of the delivery methods. While the study did show that design-build addressed the cost and schedule issue, the level of quality was still far below complete customer satisfaction.

Quality metric (1)	Construction management at risk (2)	Design/build (3)	Design/bid/build (4)	Maximum standard error (5)
Start up	7.43	7.5	5.96	0.19
Call backs	8.07	7.94	7.04	0.19
Operation and maintenance	6.69	7.67	6.88	0.19
Envelope, roof, structure, and foundation	5.36	5.71	4.95	0.19
Interior space and layout	6.28	6.15	5.19	0.19
Environment	5.34	5.24	4.86	0.19
Process equipment and layout	5.63	5.61	5.07	0.19

Table 2.2 - Comparison of quality performance (Konchar and Sanvido 1998), used under fair use, 2012.

As noted in the review of value engineering studies, quality is difficult to measure. However, on one recent project, the project outcomes were reported as percentages of typical request for information (RFI), and typical owner change orders. On this project by Sutter Healthcare, the numbers were just 10% of typical RFIs, and just under 7% of typical owner change orders, representing less than 1% of project costs. This indicated a high level of clarity and communication of the expectations on the project, meeting the owner's conditions of satisfaction. The delivery method on this project is described as lean project delivery with a relational contract expanded from the typical tri-party agreement (owner, designer, and contractor) to a full 11 partners, representing the full scope of major project stakeholders (Post 2011).

#### *Other Production Efficiency Tools*

Additional tools have been developed that can support an integrated design and delivery process, and improved constructability of the project. Building Information Modeling (BIM) is often promoted as a key component of integrated design and delivery. The design community has recognized the benefits of a scaled, multi-dimensional geometric model in communications with owners and contractors. Supported by clash detection tools, this model can also improve constructability and reduce rework. Linear scheduling tools have emerged to improve production management and data collaboration. However, the question of stewardship (accountability, responsibility and liability) have hampered its implementation as a central point of graphical communication (Smith and Tardif 2009). Also, there are issues with information management. Each phase and each trade has a slightly different need for data. The synchronizing of changes can be challenging. Finally, combining all of this information in one file can become unwieldy and information overload. The BIM software community is working toward a system that maintains a central source of data points rather than trying to maintain a central model. This will require a common data format, but could potentially resolve interoperability issues between software.

#### *Gap Analysis of Process Improvements*

A review of these design process improvements can be regarded from several perspectives.



First of all, do they help meet the minimum commercial terms of time, cost and quality? The previous research would suggest that both DB and IPD can significantly improve cost, while IPD could also improve quality.

Second, how do they address the top areas for productivity improvements identified by the Arditi study and the Construction Industry Roundtable recommendations (Arditi et al. 2002; CICE 1983)? IPD improves the design practices, cost control management, and communication, where DB is more organizational in nature, and does not uniquely address anything other than possibly communication. This still leaves a gap in the several areas (Table 2.3)

**Gaps in Construction Process Improvements  
not filled by Design-Build, or Integrated Project Delivery**

- Productivity Improvements (from Arditi and Mochtar 2000)
  - Labor training, equipment utilization
  - Implementation and field inspection of quality control
  - Scheduling and standardization.
- Recommendations from CICE Roundtable (1983)
  - Cost estimating, budgeting and control accounting
  - Quality assurance
  - Materials management (skilled labor)

Table 2.3 - Gap analysis in construction delivery processes

These gaps suggest the need for yet another level of construction process improvements, which leads the research to an investigation of lean in construction.

## 2.4 Lean in Construction

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Lean in construction draws from the lessons of the Toyota System, lean manufacturing, systems thinking, and industrial engineering (Koskela 1992; Oglesby et al. 1989). There have been many interpretations of the Toyota System, but the two basic precepts of the management model are regularly identified as continuous improvement and respect for humanity (Womack and Jones 1994). In one of the later books in the lean literature, Liker describes the characteristics that

many admire in Toyota as “a passion for excellence, driven by core values, highly self-critical leaders who are humble and leave their egos at home, a desire to build something that will last forever, and complete faith that investing in people is the only way to succeed” (Liker and Franz 2011). Toyota puts people first, so they can use their powers of problem solving and passion for the “elegant solution” to identify the right question for the right reason. Continuing improvement can put meaningfulness into the work through the opportunities for improving the process or the product. By extension, it also shows a level of respect for the skill and problem solving ability of the workers, who are empowered to offer input and suggestions. Robinson and Schroeder, in a comparison of successful lean initiatives with less successful ones (as defined by the rate of ongoing productivity improvement) identified the critical component that is often missing is the ability to get large numbers of improvement ideas from front-line employees (Robinson and Schroeder 2009). Continuing improvement can create a culture that is more welcoming of change, and which is well versed in assessing the pragmatic implications and the contributions of innovation to a core vision of the company. Truly innovative organizations create a climate conducive to innovation in all their parts, not only in segregated units (Damanpour 1991). Innovations can add value as social benefits, improved technical feasibility, or other intangible benefits (Slaughter 1998).

Green offers the “possibility that lean construction may act as a catalyst for change in the workplace (Green 2011). The underlying philosophy of lean is to “optimize the whole, not the pieces,” which encourages the articulation of clear values to provide an overall vision, developed as a collective exercise. This is coupled with a tradition from Toyota, wherein the trade workers are governed by a set of very precise and complete “standards of work,” which they helped to create. This approach leaves a middle area open for “creative adaptation,” and credits middle managers with a much greater capacity for innovation. It also assumes that they have “sufficient domain control to break with the institutionally embedded practices that characterize the construction sector” (Green 2011). Additionally, the lean approach includes collaborative relationships with partners and the cost-sharing among construction stakeholders, which are known to result in cost savings, reduced conflict, and lower levels of risk for all parties involved (Augenbroe and Pearce 1998).

## Lean Construction Research

The development of lean construction was grounded in theory and practice (Ballard and Howell 2003). Performance gains in manufacturing as a result of the adoption of lean manufacturing practices prompted research into the applicability of lean production philosophy to the construction industry (Koskela 1992). The concepts of industrial engineering had been introduced into construction by Parker and Oglesby, through their textbooks on production methods improvements and productivity management (Oglesby et al. 1989; Parker and Oglesby 1972). Koskela challenged the assumption of trade-offs between time/cost/ quality by identifying the presence of non-value added “flows” in the design process, the material process, and the work process (Koskela 1992). Early applications of lean in construction followed the pattern of adoption of lean in manufacturing, with a focus on efficiency improvements in the production phase (Kravik 1988; Monden 1998; Ohno 1988).

In addition to the growing awareness in academia, field research provided insight to practical problems, and potential solutions. This pioneering research work was conducted by Ballard and Howell, who observed that “only about 50% of the tasks on weekly work plans are completed by the end of the plan week” (Ballard and Howell 1994). Upon further analysis of the project plan failure anomaly, they proposed that constructors could mitigate most of the problems through “active management of variability, starting with the structuring of the project (temporary production system) and continuing through its operation and improvement” (Ballard and Howell 1994). Ballard later developed this concept into the Last Planner System, for improving “percent plan complete (PPC).” (Ballard 2000).

Lean construction research gained a formal voice in 1993, with the founding of the International Group for Lean Construction (IGLC). Their stated goal is to: “better meet customer demands and dramatically improve the AEC process as well as product. To achieve this, we are developing new principles and methods for product development and production management specifically tailored to the AEC industry, but akin to those defining lean production that proved to be so successful in manufacturing.”

The scope of the definition has since experience both horizontal and vertical integrations, both into design and facilities management, and supply chain adaptation of lean principles. One of the specific practices that have been developed are the Target Value Design, for application of lean in design management, an emerging practice that calls for a more active owner involvement in the design process. Research presented at the 19 annual conferences of the IGLC since the initial conference in Finland is depicted in Table 2.4, as organized by the topic areas designated within each conference. The data indicates that topics that are consistently represented are theory development and production management. Topics that have developed more recently are the specific product developments such as prefabrication, and process management topics such as contract and cost management, and an increasing emphasis on people, culture and change.

**IGLC Conferences**

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
<b>Topic Areas</b>	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
<b>Theory / MetalIndustry Studies</b>																				
Theory		X			X	X	X		X	X	X	X	X	X	X	X	X	X	X	X
Lean Adoption																				X
Implementation (Case Studies)				X	X	X			X		X	X	X	X		X				
Industry Studies			X					X								X				
<b>Product Design and Development</b>																				
Prefabrication Assembly, Open Building										X	X	X	X	X		X	X	X	X	X
Green Building, Sustainability Outcomes								X												X
<b>Production Management</b>																				
Lean Construction Tools		X		X		X														
Supply Chain Management			X		X		X		X	X		X	X	X	X	X	X	X	X	X
Safety Quality & Environment		X	X						X	X	X	X	X	X	X	X	X	X	X	
Production System Design	X	X	X		X		X	X						X	X	X	X	X	X	
Production Planning & Control			X	X		X			X	X	X	X	X	X	X	X	X	X	X	X
Enabling Lean with IT	X			X				X	X	X	X	X	X	X	X	X	X	X	X	X
Stabilizing Work Flow		X			X			X	X			X								
Buffer Mgmt & Work Structuring											X	X								
Performance Measurement	X	X	X	X				X	X	X	X									
Site Application Tools Techniques							X													
<b>Process Management</b>																				
Strategy & Implementation			X	X		X			X		X									X
Contract + Cost Management		X		X							X					X	X	X	X	X
Design Management			X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
People, Culture & Change			X					X				X	X	X	X	X	X	X	X	X

Table 2.4 - IGLC conference topics as listed on [www.iglc.net](http://www.iglc.net), interpreted and organized into table by author

This general trending is confirmed by a study of the IGLC literature from 1996 through 2009, which reveals that 1/3 of the research is focused on the production process and tools, followed by research on theory, people and partners, and design management, each representing about 7% of the total (Jacobs 2010).

While there are some topics of research of lean in construction that have parallels in the research for lean in manufacturing, such as supply chain management, there are significant differences in the overall nature of the body of research in these two industries. The catalysts for research in lean manufacturing was the perceived threat to the manufacturing industry, both from the competition of the fuel-efficient Japanese automobiles, and the flood of high quality and low cost products as a result of the increased efficiency in the Asian manufacturing industry. This triggered two well-funded research centers. The International Motor Vehicle Program (IMVP) began as a 5 year research program in the aftermath of the 1973 oil crisis and was based at MIT, with contributors from Harvard and international sources. The most notable outcome of this research program was the publication of *The Machine That Changed the World* (Womack et al. 1990), and the introduction of the term “lean manufacturing” (Kravcik 1988). A second program was the Air Force Office of Scientific Research (AFOSR) program established by secretary of defense to establish a program for US-Japan industry and technology management training. This program was funded at \$10 million per year between 1991-95, and resulted in the literature by Jeffrey Liker (Liker et al. 1995; Liker et al. 1999).

The construction industry, by contrast is not faced with no such external threat, since the products are rooted in place and must be “manufactured” by contractors on location within the USA. The problems of productivity and quality are internal problems, and are the focus of industry group studies over the years (CBC 2011; CICE 1983; Miller 2009). The study of lean construction is dispersed across university programs (Alves et al. 2007). Also, unlike the manufacturing industry, which had an identifiable corporate leader who has a clear leadership of mastery of lean, i.e. Toyota, the construction industry has no such identified leader. Notwithstanding, there has been interest in lean construction among leading construction companies and large US industry associations (AGC, AIA, COAA) (Alves et al. 2007).

Just as there is no consensus on the definition of lean production in manufacturing (Pettersen 2009), the research literature regarding a definition of lean in construction is equally open-ended (Alves et al. 2007). No “coherent philosophy for lean construction has been developed” (Jørgensen and Emmitt 2008), and “formulating a definition that captures all the definitions of lean is a formidable challenge” (Pettersen 2009). Koskela suggests that the principles presented by Womack and Jones (Womack and Jones 1996) do not constitute a complete theory nor an exhaustive, mature foundation for the transformation of any productive activity (Koskela 2004). Indeed, Ohno, the “father” of the Toyota Production System, had noted a danger in attempting to copy an existing model or method like the Toyota Production Systems framework without understanding its importance to, or role in, increased production output (Liker 2004). Ohno emphasizes the need to address the root cause of problems, and identify the intended outcome. Thus, the emphasis should be less on providing a definition or a prescriptive model to follow, and more on the identification of components of that model and adopting a new way of approaching a process or project enterprise.

The continuous improvement of lean in construction is well supported by a network of academics, consultants and industry innovators, who combine their efforts to bridge the gap between the theories related to lean construction and their field implementation (Alves et al. 2007). Both the IGLC annual conferences and the Lean Construction Congress have supported this interaction between academics and practitioners, by welcoming them in conversation and providing open access to the papers through an online format. However, there is criticism concerning the lack of detail regarding management practices, and a lack of description on data collection and validation (Jørgensen and Emmitt 2008).

### Lean in Construction

While drawing lessons from lean manufacturing, lean in construction stays closely aligned with the original concept from the Toyota Management Systems culture of valuing human resources as a primarily tool for optimizing the process, and thus the product (Ballard 2000; Howell 2010;

Tommelein 1997; Womack and Jones 1996). This is an important factor in reducing waste, as studies cited in Sir Egan's call for Rethinking Construction estimates that labor is used at only 40 – 60% efficiency (Egan 1998).

One of the best known lean construction practices is the Last Planner System (LPS™), which seeks to improve work flow reliability (Ballard 2000). It creates dialogue and causes a network of commitments, equalizes the process of decision making throughout the organization, and has a mechanism to even out flow of work. The implementation of the LPS™ has also been proposed as a good point to initiate a more encompassing organizational learning process, along with pull-planning sessions and action learning (Alves et al. 2007). The Last Planner System is often utilized as complementary production system to the design process of IPD. Additionally, practitioners in the lean construction community developed an Integrated Form of Agreement (IFOA) contractual format, which added a formal share risk/ shared reward system to the IPD contract (Lichtig 2005). This additional provision promotes transparency and trust in the management process, which drives the collaboration of the team towards the reduction of waste in labor and rework of materials (Lichtig 2005). The contract extends the contractual provisions to include the production phase and essentially carves a permanent seat at the design table for the contractor. In addition to the Last Planner System, the concept of lean can extend to some element of off-site fabrication and modularized assembly. Building Information Modeling (BIM) can be helpful in further supporting the integrated process that characterizes lean in construction (Miller 2009).

“Lean thinking” has been the topic of much academic debate, as it is an intangible construct. It has been described as an operational philosophy characterized by the constant pursuit of identifying and eliminating non–value-added (waste) activities and processes from the value stream (Stone 2010). However, this definition does not capture the focus on value, and is restricted to the operational aspects of construction management. Research indicates an interdependent relationship between the team culture (operational philosophy) within a construction project and the transformation and behavior of the participants (Orr 2005; Zuo and Zillante 2005). As lean thinking would seem to have both an operational role and an

organizational role, it could be understood to be a philosophy that pervades all aspects of the construction business. It is anchored in the pillars of lean, continuing improvement and a respect for humanity. This research will not join the fray of debate in making the definition of lean thinking explicit, but will recognize the potential influence and impact such an underlying philosophy might have on a project outcome.

### Lean in the Design Phase- Target Value Design

Target Value Design (TVD) is an emerging concept being developed by innovators in the lean construction industry to address the challenges of managing multiple stakeholders in an integrated process, making explicit the value proposition, and balancing continuous improvement with tradeoff decisions (Ballard 2012; Zimina et al. 2012). The TVD process is continuous from the business planning through the construction process (design and production) and into commissioning and facility start-up. While it has roots in manufacturing's VE and Target Costing, it is heavily shaped by lessons from lean product development (Ballard and Reiser 2004; Gagne and Discenza 1995). The practice touches upon the "product value definition, developing operations and facility designs, performing detailed engineering, and designing the production systems to deliver facilities on IPD projects faster, less expensively, with higher value and better safety performance" (Lichtig 2010). Target Value Design could be considered to be the explicit practice representing lean thinking in design.

In stark contrast to the traditional cost escalation experienced in design-bid-build, the target value design approach begins with an allowable cost determined by the owner's business plan, reconciles this with market cost (that may be equal to or generally higher), and then sets a target cost lower than allowable cost (Figure 2.6). This cost is then roughly allocated by project components, and the team designs to this detailed estimate. In the most recent development of the target value design concept, team members have included iterative real-time modeling and estimating while working as a team in a weekly meeting, or a co-located operation, referred to as a "Great Room." The collaborative effort allows the team to design for constructability, greatest function, quality and value, and ease of maintenance. This extra effort in the planning stage has been successful in reducing worksite information requests, change orders, and rework. For



example, the Sutter Health care hospital project in California was distinguished by the unprecedented inclusion of 11 stakeholders in a shared risk/ shared reward contract developed by the Lean Industry (Lichtig 2006), and using Target Value Design in the design process. The project had only 10% of the typical requests for information for an equivalent conventionally built hospital, according to the job construction manager (Post 2011). Additionally, there were only 6% of the more typical owner-initiated change orders, which amounted to less than 1% of the project costs. Furthermore, a third of the contingency fund remained at the end of the project (Post 2011).

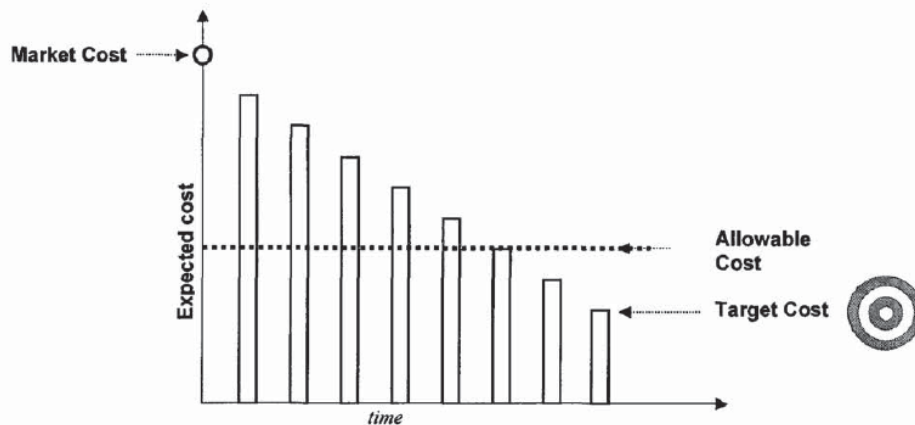


Figure 2.6 - Costing terms associated with Target Value Design (Rybkowski 2009), used under fair use, 2012.

Some of the key differentiating characteristics of Target Value Design from traditional design processes are (Macomber et al. 2007):

- Design to a detailed estimate, vs. estimate to a detailed design
- Design for what is constructible vs. evaluating constructability after design
- Work together first, then design independently vs. design then compare
- Work on solution sets far into the design process, before making a narrow choice
- Co-locate for work in pairs or groups vs. working alone.

This summary, lean construction can trace its origins to lessons learned from the Toyota System and lean manufacturing, as well as industry improvements in production management. Academic research supported this early emphasis on production improvement, and also established a body of knowledge in theory development. In more recent years, there has been a shift both in industry and academic research to the management of the process and the management of value through contractual structure and the people and culture of a project.

## 2.5 From Waste Management to Value Creation

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### Revisiting Productivity, Waste and Value

As discussed above, there have been several alternatives to construction processes that support integration and focus on the reduction of waste. However, waste can truly only be defined in reference to an explicit value. The Toyota production system presents the waste/value relationship in three tiers (Monden 1998):

- Reduction of pure waste, or non-value adding activities
- Minimization of operations, which are not directly value added but necessary to support value-adding activities.
- Net operations to increase value.

This categorization can also help organize the understanding of construction delivery processes in the construction industry. Related to time/cost /quality, the first two categories have as an outcome the reduction of time, reduction of cost, and the reduction of lost quality (i.e. rework, scope adjustments, low delivered energy efficiency). This reduction of lost quality is not the same as the increase value through net operations. Increased net value of a project is expressed by enlarging the scope (how much: program, geometry) or the expectations (how good: quality, system or facility performance), *without* increasing the parameters of time and cost.

This reduction of waste can also be understood as the increase of productivity, and efforts at waste reduction aligned with the improvement areas identified in a productivity studies, presented previously in Figure 2.3.

*Pure Waste Reduction*

The first level of productivity improvement is the reduction of pure waste. In construction, this is expressed through a variety of tools or processes (Table 2.5), and mostly addresses the reduction of waste of excess materials and labor. Typically the reduction of waste is still accomplished with the silo of the activity, or material, and driven by the focus to reduce time and cost.

<b>Tool/ Process</b>	<b>Waste Reduction</b>
BIM - Clash Detection	Reduce Rework
BIM - Take-Off	Reduce excess materials
Linear Scheduling	Reduce waste of labor
Just-In-Time Supply Chain	Reduce excess storage facilities and labor in material handling
Value Engineering	Reduce overproduction in terms of value ratio: function to cost

**Table 2.5 – Approach to waste reduction in the construction industry**

The reduction of waste has also been linked with the corresponding sustainability emphasis on the reduction of resource consumption. Waste can be harvested from excess materials due to reduced rework, optimized material use and estimating. Reduced material consumption is also understood to refer to the reduction of energy consumption due to improved energy performance, and the resulting reduction of carbon and pollution related to these efficiencies (Bae and Kim 2008).

*Minimize Non-value Added Activities*

The minimization of non-value activity is also primarily a waste reduction activity, but has the added benefit of initiating a crossing of the activity silo boundaries. For example, design-build can reduce both schedule and labor time, by simplifying the contractual documents and overlapping of the design and construction phases. Integrated Product Design (IPD) further supports the savings of time and overproduction through the earlier involvement of the

constructor and other stakeholders in the design process. Furthermore, the shared risk and reward introduced by the IPD provides motivation for the core contractual team to reduce excessive work, rework, and change orders that might deplete the contingency fund, as this is the source of the “shared reward.” This Integrated Form of Agreement (IFOA) contract provides for an even greater integration of the trades into the core team, and requires a clear allocation of funding for the shared reward. Both of these integrated processes offer the opportunities for the constructors to actively contribute to the design process, in order to identify not only excess or inappropriate materials, but also to reveal redundancies between trades or possible synergies in coordinating labor and materials.

### *Increase of value*

The reduction of lost quality cited in the first two levels of waste reduction is not the same as the third level, which is the increase of value through net operations. This increased value would include enlarging the scope of the project (how much: program, geometry) or the expectations (how good: quality, system or facility performance), without increasing the parameters of time and cost. With the Target Value Design process, this added value is often realized as a result of synergistic systems or materials, or is identified as options to be implemented from the release of contingency funds as they are made available (Ballard 2012).

This final category of net value added is a key distinction between lean construction processes and other integrated delivery methods. Integrated Project Delivery (IPD) and Design Build (DB) are characterized by the logistics of the involved parties, the sequence of the phases, and/or even by the assignment of risk and reward. However, only in lean construction is the purpose of these activities addressed. The literature of lean in construction clearly outlines the key focus on the identification and delivery of value to the customer (Howell and Ballard 1997). Thus, lean introduces a paradigm shift wherein value becomes the driver, around which cost and time are organized. This can also be expressed as pull planning, where the value is identified and production flow is organized to deliver the full value, with nothing lost to waste.

The dynamics of lean construction introduces a radical shift in the assumptions and mindset

concerning the delivery of value. In the hierarchy of values, it can be understood that the commercial terms of time/ cost/ quality represent the set point of market value, which can also be represented by the Guaranteed Maximum Price (GMP). In a traditional delivery, the GMP is often derived independent of contractor input, and does not always align with the original project estimate. Yet, a constructor operating under a CM@Risk contract is held responsible to not exceed this GMP. Also, the project architect and engineer contracts carry their own penalties, which reinforce the silos and a protective stance. There is no incentive to add value to the product. This negative environment is representative of an entity operating below the set point of minimal value (Figure 2.7).

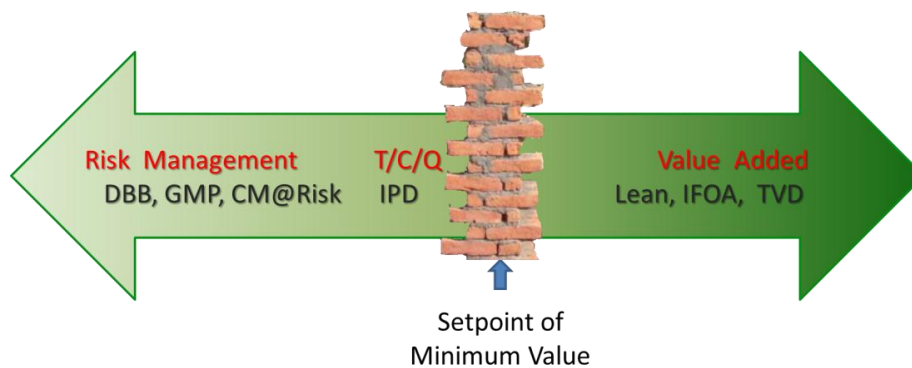


Figure 2.7 - Moving past the “brick wall” setpoint of minimum value

In contrast, with Target Value Design (TVD) and IFOA, financial incentives are shared by the entire team (as designated in the IFOA contract) based on “successfully achieving superior performance and exceeding expectations and benchmarks” (ConsensusDOCS 300 §11.2). The process in TVD of setting the target cost below the market cost provides an economic buffer for the project market viability, and the iterative design and estimating creates a sense of confidence in the predictability of the project outcome and the production costs. All of these factors result in a psychological comfort zone that supports innovation, and rewards the creation of added value. The TVD process further facilitates a process of designing to solutions, or to “ideal state” (Kusnierz 2012), which pushes the team to consider values beyond the minimum costs. This would seem to fit the requirement for an industry mind shift “built on trust, flexibility, and tightly integrated work teams focused on delivering value – not just a building” (Miller, 2009).

## Shifting the Set point of Value

Value is an abstract concept that takes on meaning in relationship to a person, or the perception of the value relative to an object (Thomson et al. 2003). Value in construction can be understood as a continuum, or a value chain (Kelly et al. 2004). It is anchored at one end with the quality expectations of traditional project specifications. In addition to the project perspective of value, a constructed building can have value to the neighborhood, or it may represent a value to the architect or constructor, who can point to the building as a reference of quality work. The value of the building can also contribute to an ecosystem, by replenishing resources (Abidin and Pasquire 2007). The definition of value can also change through time, as a concept, as an edifice, and then as raw materials in the deconstruction. There is also value in work, satisfaction for workers engaged in problem solving and craft. Emmitt et al (Emmitt et al. 2005) describe value within lean construction as “an output of the collective efforts of the parties contributing to the design and construction process, central to all productivity, and providing a comprehensive framework in which to work. Value must be established before doing anything else. An emphasis is placed on net value creating operations” (Emmitt et al. 2005).

In engineering, value has been expressed through value engineering calculations, in reference to cost. The boundary of the variables included in this cost equation continue to be pushed to include green building through the Environmental Value Engineering process (Kibert et al. 1992), and efforts to assess the intangible elements of value in the cost structure (Neap and Celik 1999). While this would capture more of the variables included in the original Miles definition, the question of relevancy arises, given the successes of recent process improvements. Value engineering was developed to assess the relative merits of exchanging one material for another, in order to drive down the cost and meet the commercial terms. But if the concern over cost has been addressed through the increased efficiency of process, then is the existing form of value engineering still relevant? If the project can be delivered within expected market costs (based on industry comparable and market exchange value), then the difference between the target value cost and the market cost could represent an opportunity to increase value. The exercise of value analysis shifts from being a discrete event that is set up to protect the owner’s interest, to an integrated and continuous discussion in which the owner takes part. There is an intangible

element of value which can be expressed in narrative owner benefits, and project marketability.

### *Nested Values – Value Beyond Buildings*

Kelly et al. (2004) propose that the relationship of owner value to value “beyond buildings” can be understood as an extension of the relationship of the project to the business of the corporate enterprise (Figure 2.8). By that same reasoning, inasmuch as the project is nested within the corporate business activities, so too are these corporations nested within the triple bottom line of sustainability.

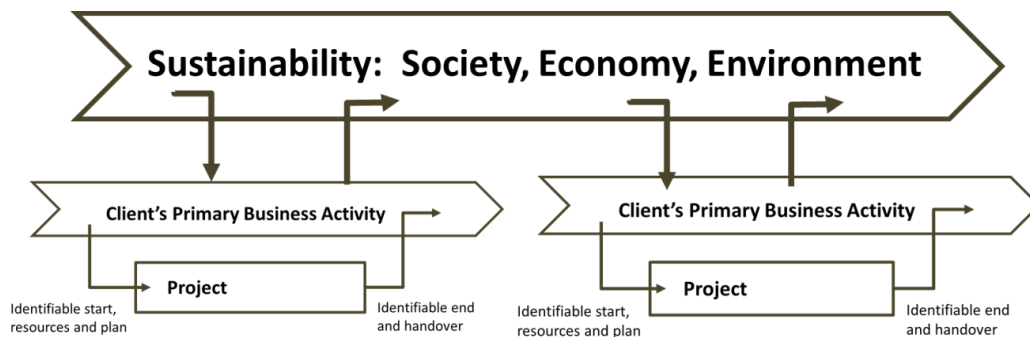


Figure 2.8 - Nested relationships, built on Kelly et al. (2004), used under fair use, 2012.

This can be understood from the perspective of Life Cycle Costing (LCC), which introduces the concept of a project beyond the traditional parameters of the handover of the physical asset, and helps to quantify the impact of the building on the client’s business. Similarly, a Life Cycle Analysis (LCA) makes explicit the relationship between the building and the greater context of sustainability (Trusty and Horst 2003).

In a similar fashion, the values of each of these entities are defined in relationship to the nested entity. The overarching values of sustainability would thus “pull” the value stream from the project enterprise through the corporate enterprise. It provides the organizational structure to develop the project value chain. This in turn can guide the target values for all the stakeholders involved in a project. This value hierarchy created from embedding single project processes within a higher multi-project portfolio offers a strategic view of the individual project (Moussa 2000). This same hierarchy for corporations helps guide the corporate vision and values.

### *Value of Sustainable Prosperity*

Value has a long tradition of use as a measure in economics, with a parallel usage in construction. For much of history, it was based in the theory of exchange value, where utility for the user was the defining perspective, and deemed to be quantifiable if one had enough facts (Hicks and Allen 1934). Yet as early as 1906, there had been inquiries into the dynamics of the subject, when Pareto published the small, but very influential volume, of the *Manuel of Political Economy (Manuale di economia politica)*. Pareto abandoned the concept of utility, believing it was not measurable, and proposed instead the concept of preferences. This rested on the premise that facts of observable conduct could theoretically be made into a scale of preferences, but they do not enable us to proceed from the scale of preference to a particular utility function. This observation can be seen in the more inclusive definition of value as used by Miles, but was entirely forgotten in the later adoption of value engineering. However, the concept of value as a preference draws attention to the need to define the point of view of the preference. Is this the user, the corporation, those whom might be impacted? Does this also include the environment?

This ever broadening stakeholder view is precisely what is driving the shift in the perception of value, especially in the corporate arena. Stakeholders know that corporate behavior has significant effects on society. Paine argues that the idea of a corporation as an amoral, artificial person is outdated and is largely rejected by citizens who have been adversely affected by the illegal and, indeed immoral behavior of many modern corporations. Companies are to be held accountable for both the benefits and harms brought on by their actions. There is an expectation of corporations as true personae, with values that emphasize ethics, culture, environmental standards, product safety and community investment (Figge and Hahn 2004; Paine 2002).

This concept of value as a preference transcends the concept of utilitarian measure both in the broadening of the scope, but also of the object being evaluated. No longer just the product, but also the corporation is subject to scrutiny. Pursuant to the concept of nested values, these value expectations extend to a more global perspective, which clearly have implications on all levels,



project, corporation, and global. Thus, looking at construction through the lens of value is both salient, and in alignment with a growing global consciousness.

### Sustainable Prosperity

Sustainability is a topic touching on the deeper issue of the survival of mankind as we know it. In the middle of the 20th century, Ellul proposed that “the bet or wager of the century is not some unqualified conquest of nature but the replacement of the natural milieu with the technical milieu. The modern gamble is whether this new milieu in contrast with the natural milieu will be better or even possible.” At the end of that century, Russo and other ponder the same question, yet with greater urgency (Ellul 1954; Russo 2004). Du Plessis argues how “the inability to fully escape the mechanistic worldview and its limitations in dealing with complex and living systems are bringing the current paradigms to an evolutionary dead end” (du Plessis 2012). The environmental and economic issues facing our planet are well documented, and outside the scope of this dissertation. This work accepts for fact the urgent need to transform the current systems to a sustainable global economy that the planet is capable of supporting indefinitely, and recognizes that achieving this level of sustainability poses an enormous challenge.

The word sustainability is most commonly defined according to the Brundtland report’s sustainability concept (WCED 1987), which called for meeting the needs of the present without compromising the ability of future generations to meet their own needs. This was a bold concept in 1987, and was based on the total population at the time, and the knowledge of world resources. In the meantime, Middle East oil reserves hit their peak in the early 90s, world reserves of readily accessible oil are expected to be depleted within a generation, and the population of the world has gone from 5 to 7 billion. The future will experience an even greater tension between increasing population and diminishing natural resources (Lovins and Institute 2011).

To address the needs of the future will require a dramatic redirection of the global economy - shifting distribution of wealth, identifying economic strategies that are not growth-centric, prioritizing the creation of green jobs, and transforming entire sectors, such as the construction

industry. While this is a daunting task, avoidance or procrastination to act will only increase ecologically devastation, social unrest, and deprivation of resources for humanity.

The term “sustainable prosperity” was chosen by Worldwatch in their preparatory documents to drive discussions at the Rio+20 UN Conference (Gardner and Mastny 2011). This term builds upon the Brundland term, and is also distinction from the term sustainable development, used during the 1992 Rio Earth Summit. According to Worldwatch, “sustainable prosperity” would come as a result of sustainable development that enables *all* human beings to live with their basic needs met, with their dignity acknowledged, and with abundant opportunity to pursue lives of satisfaction and happiness, all without risk of denying others in the present and the future the ability to do the same. This means not just preventing further degradation of Earth’s systems, but actively restoring those systems to full health (Worldwatch 2012).

The distinction is a significant change in the perspective towards environmental issues. Sustainability measures are presented as “doing less harm,” (McDonough and Braungart 2002; Reed 2007), reducing the “degenerative consequences of human activity on the health and integrity of ecological systems” (Cole 2012) ecological footprint, or minimizing waste. Sustainable prosperity pushes past the mental model of limitations to a mental model of creating innovative solutions to actively restoring systems, and creating prosperity. This can be depicted in a growth model, such as Elgin’s Stanford report on complex social systems, which has many parallels to the complex equation of the triple bottom line of sustainability: humanity, economy, and the environment (Figure 2.8) The current situation could be viewed as being in a stage IV crisis, in which there are a few possible paths. One is to “muddle through” the crisis. Another is to dissolve into social chaos, either of which might trigger an authoritarian response. The best case scenario is a “discontinuous systemic change – a quantum leap to a transformed, restructured, and more efficient system” (Elgin 1977). Stegall (2006) presents a similar view, noting that the current crisis of sustainability cannot be fully solved by the current views of “design for the environment, “because they “focus only on a product’s physical attributes.” Stegall proposes a role for the designer to contribute to a “sustainability society” by “envisioning products, processes, and services that encourage widespread sustainable behavior.”

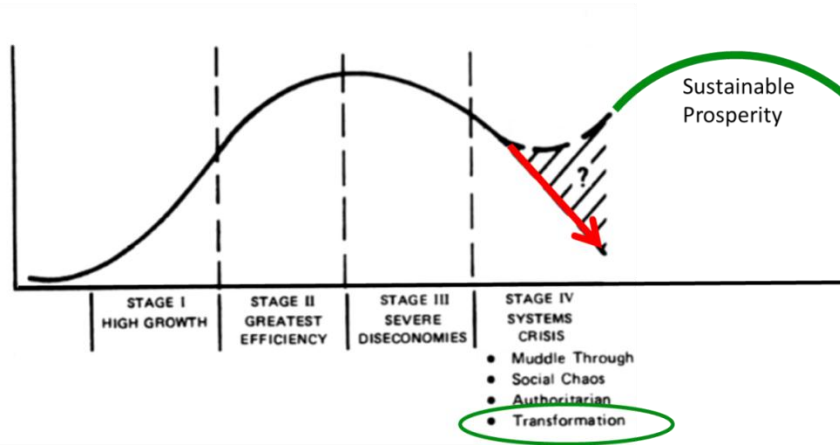


Figure 2.9 - Complex system growth model, built on Elgin (1977), used under fair use, 2012.

In a survey of nearly 240 members of the CERES group (network of investors and business leaders committed to a thriving sustainable global economy), 92% of the respondents identified climate change as the most important sustainability issue that corporations need to address. Nobel Prize Scientist Richard Smalley believes that to solve the energy challenge, we will have to find a way to double our production of energy. “To give all 10 billion people on the planet the level of energy prosperity we in the developed world are used to, a couple of kilowatt-hours per person, we would need to generate 60 terawatts around the planet - the equivalent of 900 million barrels of oil per day” (Smalley 2004).

Energy production is a goal, but only a piece of the puzzle needed to identify a value. Another clue comes from Jeremy Rifkin in the *Empathetic Society*. He suggests that the combination of an interconnected information technology (I.T.) distribution together with distributed renewable energy would make possible a sustainable, post-carbon economy that is both globally connected and locally managed (Rifkin 2009). This focus on energy does not ignore the problems associated with population growth. There is a correlation with sufficient energy, *if* distributed, *and* equitably controlled for the greatest distribution of wealthy. As nations began to gain in GDP for all demographic groups, then the fertility rate generally drops. However, this does not preclude the need to identify value associated with population, or for any of the other factors of

sustainability. Meadows (1982) proposes that the most effective way of dealing with complex environmental problems is to find an alignment of the goals in the system, so that all actors (the eco-system as one of these) are working harmoniously and naturally toward the same outcome. This is the foundation of systems thinking, with the recommended approach of finding the right leverage point (Meadows 1999; Senge 2008).

Thus, sustainable prosperity values might transcend the existing sustainability metric of energy reduction, and instead call for net energy generation, which is both distributed and managed for local passive survivability and tied to the grid. This includes the need for “resilience,” or the ability to maintain the functionality of a system when it is perturbed, or maintain the elements needed to renew or reorganize if a large perturbation radically alters structure and function (Walker and Salt 2006). What can be expected of the future is the unexpected. The ability of a system to embrace uncertainty and remain fully functional creates an environment of prosperity.

### *Futurists*

Identifying values for sustainable prosperity focuses on ideas of the future, as perceived through the eyes of the present. In a paraphrasing of Churchill’s famous statement, Canadian futurist and philosopher Marshall McLuhan offered the thought that: “We shape our tools and thereafter our tools shape us.” This recognition of a need for expertise in the “shaping of tools” is the basis of the three concerns of the field of futures: futures research, futures studies and futures movements (Beare and Slaughter 1993). Futures research is concerned with economic and technical forecasting, and has largely been the mode of expression of sustainability. Futures studies is the term used to describe the work of academics, educators, critics and commentators, who wish to communicate futures ideas to a wider audience. Futures movements are those new social movements that have a particular futures orientation and vision of a preferred world, whether in relation to peace, justice or the environment (Hicks 1996).

This research will fall mostly under the realm of Futures Studies, to study images people have now about the future. Futures researcher Dator emphasizes that “the future” cannot be predicted, but “alternative futures” or “preferred futures” can and should be envisioned, invented, implemented,

continuously evaluated, revised, and re-envisioned (Dator 2007). To be useful, futures studies needs to be initiated first, and then be linked to strategic planning, and thence to administration. As the future is every changing, so should the process of futures envisioning be continuously ongoing and changing. The purpose of any futures exercise is to create a guiding vision, not a "final solution" or a limiting blueprint.

Futures studies draws from the core of work that emerged in the 1990's. Writers such as Inayatullah and Slaughter have mapped out the knowledge base of futures studies; others, such as Wagar and Henderson explore futures-related issues in rich and insightful ways (Beare and Slaughter 1993; Henderson 1995; Inayatullah 1995; Slaughter 1995; Wagar 1963). Futurist workshops have a long history, though somewhat sparse. Jungk's workshops were developed in response to the socio-political unrest of the 1960s in Europe (Jungk 1952; Jungk and Mullert 1987). Ziegler picked up the work in the 1970's in the USA, with a much wider repertoire of processes for envisioning preferred futures (Ziegler 1991). More recently, Laszlo and Cooperrider have implemented futures workshops for sustainable value creation, based on the growing business opportunity to "do well by doing good" (Laszlo and Cooperrider 2007).

Polak, in his seminal work *The Image of the Future*, describes man's drive to know the future in order to avoid catastrophe and procure blessing. Both magic and religion probably arose at least in part out of this desire for certainty and the power to alter the course of events. From this arose the sciences of the heavens, astrology and its more sober offspring, astronomy. This pursuit of a purposeful intervention of the future brought a consideration of the concepts of value, means and ends, and ideals and ideology. The very act of creating a blueprint of the future is to become aware of ideal values as the first step in the conscious creation of images of the future. Polak defines a value as that, which guides toward a "valued" future. The image of the future reflects and reinforces these values. Once man dares to think about the future and feels free to experiment in thought with an imagined other and better, then a purposeful striving for change becomes meaningful. Human dignity is supported through self-determination (Polak and Boulding 1973).

### *Mindshift*

For many years, humans have been reeling over the sudden realization of the consequences of their behavior on environmental degradation. Rachel Carson's *Silent Spring* came as shock to most people, as did news flashes of the Love Canal, or the Exxon Valdez oil spill. With an increasing awareness of resource scarceness, pollution, toxins, and other environmental ills comes a sense of guilt. One can become "neurotically hypersensitive to consumption habits," with a "disappointment and disapproval that would foster resentment, a total collapse of one's own conscience, or a coping strategy that includes belittlement of the news or the messenger" (Welch 2010). This engenders a strong sense of negativity, helplessness, despondency and even anguish about the anticipated problems facing their society and the world at large.

Polak argued that such images act as a mirror of the times. By this he meant not just that people's concerns necessarily reflect the times they live in, but that the pessimism or optimism of such images has much to say about the health and well-being of that society. He suggests that there is a close correlation between the rise and fall of images of the future and the rise and fall of society and culture itself. As long as a society's images of the future are positive and flourishing they act like a magnet drawing society on towards its envisioned future (Polak and Boulding 1973). Once such images begin to decay and lose their vitality, however, then culture cannot long survive. Writing during the 1950s, Polak accurately foretold the late twentieth century as being unique in only possessing negative images of the future (Polak and Boulding 1973). This corresponds with the Stage IV systems crisis scenario depicted in Figure 2.7. Only in the last few years has there been a shift to reports of success stories, and a sincere attempt to resolve environmental issues.

The shift in the empirical reporting can be a reflection of the events, but the change in tone could be traced to the renaissance of a shift in thinking. Western thinking in general has been dominated by substance metaphysics, which Aristotle described as "exclusively concerned with primary substance... the science to study that which is, both in its essence and in the properties which, just as a thing that is, it has" (Aristotle, 340BC). This has driven the scientific approach of breaking objects into component pieces for the purpose of study, which has been the prevalent

thought dominating Western culture (Koskela and Kagioglou 2006). An alternative is the philosophy of process, or the general theory of reality. The process philosopher is one who holds that what exists in nature is not just originated and sustained by processes but is in fact consistently and inexorably *characterized* by them. On such a view, process is both pervasive in nature and fundamental for its understanding, but it is still fundamentally *a sequentially structured sequence of successive stages or phases*. The next step in this philosophy is systems thinking, identified by Peter Senge, which sees the interrelationships between things and processes (Senge 1990). This is the philosophy of a collective entity, and does not take a reductionist approach to the seeking of symptoms and outcomes.

The Toyota Production System, and the evolution of the Toyota Management System, can be interpreted as process metaphysics operating with systems thinking (Fujimoto 1999). While the West has been quick to adopt the components of Toyota Production System, it can be argued the inadequate results may be due to the missing connection between though process and systems. It has been submitted that these are uniquely Japanese characteristics, which cannot be transferred to the U.S. Yet this does not consider that the history of process physics corresponds with the first philosophers of the Western civilization, namely Heraclites and Parmenides (Koskela and Kagioglou 2006). Nor does it consider the origins of systems thinking in the Western World, or, more pertinently, the introduction of integrated design process (IDP) in construction.

An equally persuasive argument is made in favor of global environmental issues triggering the change in behaviors and consequently a change in philosophy. Rifkin posits that human evolution is measured not only by the expansion of power over nature, but also by the intensification and extension of empathy to more diverse others across broader temporal and spatial domains. The growing scientific evidence that humans are a fundamentally empathic species has profound and far-reaching consequences for society, and may well determine our fate as a species. “What is required now is nothing less than a leap to global empathic consciousness and in less than a generation if we are to resurrect the global economy and revitalize the biosphere” (Rifkin 2009).

### *Economic Opportunity*

The business logic for sustainability has been largely operational or technical and has mirrored the relatively negative directives: pollution prevention, risk reduction, reengineering, or cost cutting. Yet environmental opportunities can become a source of revenue growth, based on strategy or technology development. Hart, a leading authority on the implications of environment for business strategy, proposed a framework for sustainable value in four stages (Figure 2.9). The first stage starts with pollution prevention (or waste reduction); stage two continues to product stewardship (e.g. Design for Environment) to minimize not only pollution from manufacturing, but also all environment impacts from the full life cycle of product. Stage three steps across the line into a future context to develop sustainability vision, and stage four identifies clean technologies, which are selected based on the framework of the previous stages.

Hart proposes that a vision of sustainability is like a road map to the future, showing the way products and services must evolve and what new competencies will be needed to get there (Hart and Milstein 2003).

*Beyond greening lies an enormous challenge – and an enormous opportunity. The opportunity to create sustainable value-shareholder wealth that simultaneously drives us toward a more sustainable world is huge. The profit motive, if properly focused, can accelerate (not inhibit) the transformation towards global sustainability (Hart 1997).*



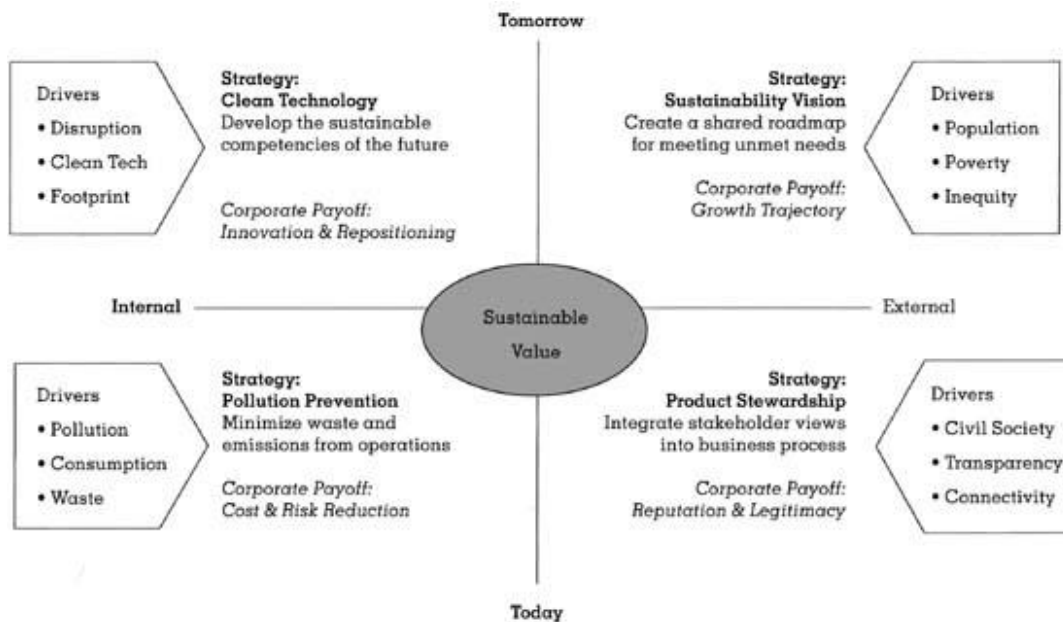


Figure 2.10 - Creating sustainability value (Hart 2003), used under fair use, 2012.

This sentiment is echoed by the CERES group, a national coalition of investors, environmental organizations and other public interest groups who are working with corporations to expand the adoption of sustainable business practices. In a 2007 survey, when the CERES members were asked to identify the top areas where sustainability could have the biggest impact on business, three areas stood out from the others: Improved risk management, improved operational efficiency/cost savings, and building long-term shareholder value. All three of these areas also help the business resilience and contribute toward a more secure future, which supports the business proposition for sustainability (Flemming 2007).

### *Transformation Path*

This same CERES study offered some insight into moving toward these future goals. Almost 80% strongly agreed, and another 20% somewhat agreed that *collaboration*, such as partnerships between NGOs, companies and investors, is important for progress on sustainability issues. And when asked to identify the single most effective method for investors to spur sustainable business practices, 46% of the respondents chose *direct engagement* with corporate CEOs and board members, and another 15% cited asking companies to improve disclosure on sustainability

issues. Only 14% chose government regulations or incentives. This would seem to be a significant change from the most recent decade, when the federal and municipal governments drove legislation for increased energy efficiency or sustainability standards, often at the urging of public action groups. Some of this discrepancy may be explained by the composition of the CERES group, which is predominantly made up of corporations who have already initiated sustainability efforts and are not reliant on a government entity for market share (CERES 2010).

The path from the status quo toward the ideal states identified in the futures workshops will have both technical and strategic challenges. There is a need to create a vision, establish a framework, and work collaboratively with transformational individuals who have the mind-set of solution finding with problem solving. With these parameters in place, a value map can be designed to identify transition scenarios that strive for a fundamental, irreversible reframing of the current paradigm. While the transition scenarios will be renegotiated and reshaped as the process unfolds, they provide a long-term perspective as an orientation for short-term action (Sondeijker et al. 2006).

### Change of “Mindset”

Changing from a risk management, or waste reduction focus to a value added focus requires more than the implementation of tools. Miller calls for this new mind shift to be built on trust (Miller, 2009). Jackson proposes that the mental shift can occur as a result of the organizational change to integrated project delivery (Jackson 2009). She characterizes this mindset as a problem solving attitude, outlined Table 2.6, and suggests that a transformed industry will require “transformed individuals” (Jackson 2009).

Problem Solver	Alternative Behavior
<ul style="list-style-type: none"> <li>• Accepting – Critiques</li> <li>• Responsive &amp; Reflective</li> <li>• Values NOT knowing</li> <li>• BOTH/ AND thinking</li> <li>• Flexible and adaptive</li> <li>• Multiple perspectives</li> <li>• Accepting of Self &amp; Others</li> <li>• Values Difference</li> <li>• Questions Assumptions</li> <li>• Primary Mood – Curious</li> <li>• Comfortable with Uncertainty</li> <li>• Learn by Doing</li> </ul>	<ul style="list-style-type: none"> <li>• Judgmental – Criticizes</li> <li>• Reactive and automatic</li> <li>• Know-It already</li> <li>• EITHER / OR thinking</li> <li>• Inflexible and Rigid</li> <li>• Own point of view only</li> <li>• Intolerant of self/ others</li> <li>• Fears differences</li> <li>• Defends assumptions</li> <li>• Primary Mood – Protective/ Defensive</li> </ul>
<p><b>Table 2.6 - Making the mental shift to IPD (Jackson and Wagner 2009), used under fair use, 2012.</b></p>	

Jim Collins also refers to the importance of choosing the right people in his best seller business book, *From Good to Great*, with his description of getting the “right people on the bus.” These are people who have an integrated mindset, which he characterizes as:

- Able to Transfer Their Egos
- Responsive to Nature
- Reflective Practitioners
- Possess Genius of “AND”
- Mission Oriented
- Servant Leaders
- Question Thinkers
- Learners First

Many of these same traits were also noted by Ohno, Hino, Shingo and other early Toyota System developers (Dillon 2011; Hino 2006), as critical to the success of the continuous innovation process.

Gaining an understanding about the necessary shift in mindset provides some foundational knowledge to the issue of the human interface, as mentioned by Pulaski for the optimal transfer

of constructability information (Pulaski and Horman 2005). It adds to the understanding of the conditions needed for a collaborative process, to include an institutional structure (contracts, shifted funding), an organization change (co-location, iterative design/ estimating), and also a shift in mental modes, both individually and as a team. This forum for collaboration and increased constructability knowledge can also provide the mechanism to facilitate all product related input from other key stakeholders, such as the owner, engineering, trades, user groups, and public partners. The new mode of operations raises many questions regarding the integration of design management with construction management, the shift of stakeholder roles from reactive to pro-active, the related responsibilities of value management and the sequencing of knowledge management. A few of these concepts will be touched on in the case study analysis presented in Chapter 5.

### Empirical Data

Comparative evaluation of projects is difficult because the individual practices of lean cannot be isolated, with multiple interdependencies difficult to understand (Ballard 2012). Indeed, the underlying focus of lean in the optimizing the whole, not the pieces, is equally applied to the process as the product. An integrated project delivery (IPD) culture of collaboration is typically implemented to some degree, regardless of the contractual basis of the project (ConsensusDOCS 300 §11.2, IFOA). Many projects are reported to recognize that the contractual format often lags behind the innovations in integrated process delivery, due to the limitation imposed on the contracts by the public funding mechanism. Teams report that they may work around the contract, and create their own collaborative culture. Likewise, the hard hand-off between design and construction is virtually erased, with the full time participation of the contractors at the design table, and the increased involvement of the designers throughout construction and commissioning.

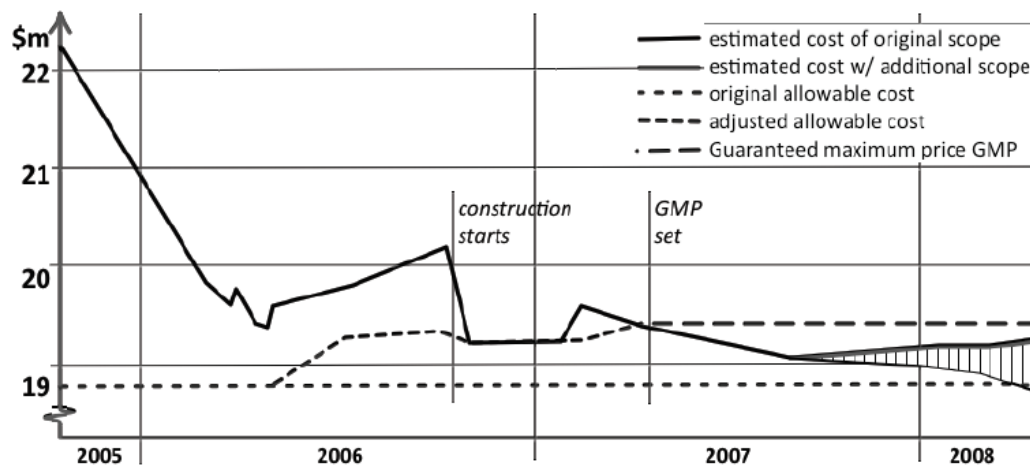
The empirical studies that have been completed indicate a positive correlation between the integration of the lean principles and the product outcome (Mossman et al. 2011; Tommelein et al. 2011). Myers review of 16 companies who applied lean construction principles listed findings of less rework, and reduced waste in materials (Myers 2005). Recent case studies reporting on

projects using some combination of IPD and target value design were found to be completed with as much as 19 percent below market costs. Equally interesting is that the typical pattern of cost escalation was reversed and expected costs actually fell as design and construction progressed process (Mossman et al. 2011). An early project that was instrumental in the emergence of target value design as a practice was the St. Olaf’s Fieldhouse project, in which the cost was 35% lower than market cost, based on a comparable project and industry data (Table 2.7) (Ballard and Reiser 2004).

	<b>St. Olaf Fieldhouse</b>	<b>Carleton College Recreation Ctr</b>
Completion Date	August 2002	April 2000
Project Duration	14 months	24 months
Gross Square Feet	114,000	85,414
Total Cost (incl. A/E & CM fees )	\$11,716,836	\$13,533,179
Cost per square foot	\$102.79	\$158.44

Table 2.7 - St. Olaf Fieldhouse cost comparison (Ballard and Reiser 2004), used under fair use, 2012.

Lean construction is being increasingly adopted in certain market sectors, such as hospital facilities projects, on the basis that “risks associated with time, cost, quality, and safety issues can be reduced by implementing lean thinking, IPD, and BIM” (Mauck et al. 2009). One of the well documented cases is the Sutter Health Fairfield project, which was able to complete the project on time by shifting some of the time into a more thorough design/ planning phase. The project was completed at 19% below market cost, and change orders were virtually eliminated (Kemmer et al. 2011) (Rybkowski 2009). Figure 2.11 depicts a graph charting the estimated costs, both of the original scope and the additional scope desired by the owner, compared to the budget established by the business case, which is known as the allowable cost. A notable distinction of this TVD process is the strong decrease in projected costs and the maintaining, or further decrease in these costs through the construction phase, as depicted by the solid line in the Figure. The cost decrease after the start of construction results in a release of contingency funding, which can be used to increase scope.



**Figure 12: project estimates over time for the Sutter Fairfield MOB Project**  
 [Project completed in 25 months, despite 3 month construction start delay. Target cost (\$18.9m) was set 14% below market (\$22.0m). Actual cost (\$17.9m) for original scope was 5% below target and 19% below market. Additional scope (\$.45m) represented by vertical hatching.]

Figure 2.11 - Sutter Fairfield project cost and timeline, (Rybkowski 2009), used under fair use, 2012.

The successful implementation of the IPD and TVD approach cannot be taken for granted. Another Sutter Health expansion project experienced a highly unusual mid-job switch in general contractors, which resulted from the project cost increases and construction delays, despite an avowed implementation of IPD and TVD. Future research is needed to establish the conditions and constraints of a successful implementation of a lean process.

## 2.6 Conclusions UbX Research Gaps

The construction industry has been challenged with the urgent need to “discover a beginning-to-end, trust-based integrated paradigm that proves it is indeed possible to not just fix the [construction] process, but to transform it, and to create less expensive, higher quality, and sustainable green buildings that meet the needs of builders and users” (Miller 2009). This challenge is magnified by the escalating challenges of sustainability, to not just reduce the footprint and minimize waste, but to contribute to a vision of sustainable prosperity on the level of community, humanity and planetary health. Achieving this goal will require a harnessing of

improvements in the value management of both product and process, the integration of the design and construction management processes, and above all, a shift in mindset from risk management to value creation.

The literature identifies future areas of research as follows:

- The relationship of lean and sustainability from a value paradigm, vs. waste reduction
- The contribution to value generation of the Target Value Design practice
- Improving constructability input for increased value in the design process through an integrated design process

These identified areas of research were instrumental in shaping the scope of the research projects carried out as part of the doctoral work, and are presented in the following chapters.

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## Empirical Foundations

### Chapter 3



### Chapter Summary

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The constructive research methodology, which was selected for this research, is distinguished by the dual focus on practical industry perspectives and theoretical knowledge. The previous chapter established the theoretical foundations and this chapter provides the empirical foundations through the findings from exploratory case studies. The study examines the proposition that there can be a synergistic link between lean construction and sustainability, as expressed through the construct of value.

Three case studies were selected as exemplary projects, of contractor companies with a long history of lean applications, and projects with a minimum LEED Silver. While previous studies have explored the correlation of lean practices and green building from the perspective of waste reduction, this exploratory study offers a unique focus on the contribution of lean thinking toward the creation of sustainability value. The findings provide the burden of persuasion for further research of project value expressed as sustainability values, and the implementation of lean as a means of delivering sustainability values.

The material in this chapter was presented at the 20<sup>th</sup> Annual meeting of the International Group for Lean Construction, in July, 2012, in San Diego, CA.

# Value Paradigm: Revealing Synergy between Lean and Sustainability

## Abstract

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The current construction environment is characterized by risk aversion, and the delivery of value is constrained by the tension between time, cost and quality. Similarly, the approach to sustainability in the built environment remains largely focused on waste reduction and minimization of the carbon footprint. Yet the challenges of global environmental issues call for a paradigm shift from this reductionist, ‘scarcity’ approach to one of sustainable prosperity through resource renewal and value generation.

The industry has recognized the need for a more integrated approach, not just to fix the process, but to transform it to deliver value beyond the tangible building product. Lean construction stands out as the approach that can facilitate a net enhancement of sustainability value through fully integrated design and delivery processes.

The author explores the synergy between lean construction and sustainability, as expressed through the construct of value. Data from exemplary lean projects are gathered through survey and interviews of both prime contractor and owners, offering a two point perspective for enhanced data quality and reliability. The findings suggest a strong correlation between the cohesiveness of lean thinking and the level of collaboration on the delivery of sustainability values.

## Introduction

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The systemic nature of sustainability is complex and interconnected, and resists being broken down into isolated disciplines (Rekola et al. 2012). Incorporating sustainability goals into design and construction calls for a crossing over of traditional stakeholder boundaries, especially when aspiring to the more challenging regenerative sustainability goals (du Plessis 2012). For

example, a moderate goal of 30% energy savings on a building could involve a mechanical contractor and insulation trades, but setting a goal of net generation of energy would call for the involvement of an energy modeler, all contractors who come in contact with the thermal envelope, lighting designers, renewable energy technicians and also occupants. Understanding the conditions and constraints needed by a design team to identify and deliver sustainability could be the very catalyst needed for the increased collaboration to manage the complexity of today's building environment (Edwards et al. 2010).

Among the various construction processes, lean construction has been identified as the one that can support a focus on the sustainable values while streamlining the delivery process (Lapinski et al. 2006; Riley et al. 2005). This approach of "increasing value while reducing waste" harvests the considerable waste from non-value added effort or material in traditional construction, thus capturing time and capital that can be used to add value, or sustainability "quality." This study will take a closer look at the historical precedence for the application of lean in the delivery of sustainability, and further explore the distinction between reducing waste, and increasing value.

## Background

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### *Origins of Lean – Toyota System and Sustainability*

One of the principal precedents of lean thinking is the Toyota Production Systems. Much has been written about the transfer of the "lean" culture from Toyota, or Japanese culture, to the modal ways of thinking in the West (Liker and Hoseus 2008). There are levels of understanding, which come from time and perspective. Such may be the case with sustainability. When lean was first introduced to the United States, in the 1990's, sustainability had not yet gained the recognition in manufacturing as it has today. Thus, the "framing" of the industry recipients were not tuned to hear or look for messages of sustainability.

The sustainability connection can be found in the two pillars of the Toyota System: "continuous improvement:" and "respect for humanity." Humanity can be understood at many levels. Zen Buddhism, one of the primary religions of Japan, draws deep connections between the well-being of people and the well-being of the environment (Edmonds 2011; James 2004). In order to

verify if this understanding was also present at Toyota, the author contacted Andrew Dillon, the translator of many of the early works by Ohno and Shingo, the originators of Toyota System. Dillon confirmed this interconnected understanding of humanity, and explained that it is based on the underlying Japanese cultural concept that all people share a common fate, which is reliant on the sharing of resources. As such, a respect for the earth is a core component of the Japanese tradition (Andrew Dillon, personal communication, June 6, 2011). Together, the pillars of continuing improvement and respect for humanity represent the willingness to envision the future of humanity in balance within a planetary ecosystem.

Indeed, the first energy efficient cars in America were the Japanese import, though the American public was not very receptive at the time. In 2007, Toyota's President, Mr. Watanabe, shared his vision of a "dream car that cleans the air, prevents accidents, promotes health, evokes excitement and can drive around the world on a single tank of gas" (Stewart and Raman 2007). It is interesting that just a few years later Amory Lovins of the Rocky Mountain Institute demonstrated the feasibility of this concept, which he called the hypercar. These are vehicles that are fully recyclable, 20 times more efficient, 100 times cleaner, and cheaper than existing cars. Lovins (2011) has also identified similar possibilities for construction. Thus, historically, there has been an alignment of the values of sustainability within lean.

When sustainability is established as one of the pillars of lean, the practices are aligned to support these concepts. However, lean practices, implemented in isolation and without the underlying principles, may have an adverse effect. For example, Bae and Kim (2008) cite the problem with increased pollution costs from additional truck runs in just-in-time delivery. Purchasing based purely on efficiency studies may result in problems with ethical sourcing. And there can even be conflicts with narrowly defined green building imperatives, which are not reconciled with broader considerations of sustainability (Green 2011). A more holistic approach to sustainability and the alignment of business goals with the respect for humanity provides the perspective needed to adjust any narrow prescriptive benchmarks.

### *Reducing Waste vs. Increasing Value*

Lean construction is often presented as a philosophy of “increasing value while reducing waste” (Howell 1997), yet, lean implementation often starts with waste reduction, practiced in the isolation of existing activity silos. This is reductionist at best, and may also result in upsetting the already precarious project flow (Cusumano 1994). Value is also typically presented in a compartmentalized view, in measurable attributes of “materials, parts, product’ as related to cost (Womack and Jones 1996). In lean construction, value is understood in the broader sense of fulfilling the requirements of the customer, which may also include intangible components, such as customer satisfaction (Koskela 1999). Value is a relative and subjective term, dependent and ever-changing with the context (Salvatierra-Garrido et al. 2010). Customer values represents different interests from owner, users and society, all of which are embedded within a continuous value chain (Bertelsen and Emmitt 2005; Kelly et al. 2004). As society is intrinsically part of a global system, value generation must be considered in relation to the external environment and social problems (Salvatierra-Garrido et al. 2010). Understanding and making this collective value tangible in the briefing and design phases can be pivotal in delivering value and defining waste. The lean community has pioneered a Target Value Design model to facilitate the involvement and consideration of needs from all user groups, including sustainability concerns. Studies in value management are shaping the understanding of designing for the future (Kelly and Male 1993; Ziegler 1991).

## Research Design

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### Working Proposition

While previous empirical studies have explored the correlation of lean practices with green building from the perspective of waste reduction (Pulaski and Horman 2005; Sanvido and Norton 1994), this exploratory study offers a unique focus on the potential contribution of lean construction towards the creation of enhanced value in the context of sustainability. This opportunity for value beyond the specifications has emerged as projects with highly developed lean practices have reliably broken through the traditional project tensions. A recent study of 12 construction projects using lean in the design and construction phases reported final project costs

on the average of 15% less than market costs (Tommelein et al. 2011). This research examines the proposition that there can be a synergistic link between lean construction and sustainability, as expressed through the construct of value.

This proposition is developed through the logical linking of three sequential areas of inquiry, as identified in Figure 1. The first explores the correlation between increased cohesiveness of lean with the delivery of project value. The second area of inquiry covers the relationship of the specific project-centric values with the company sustainability values, and the impact on the project processes.

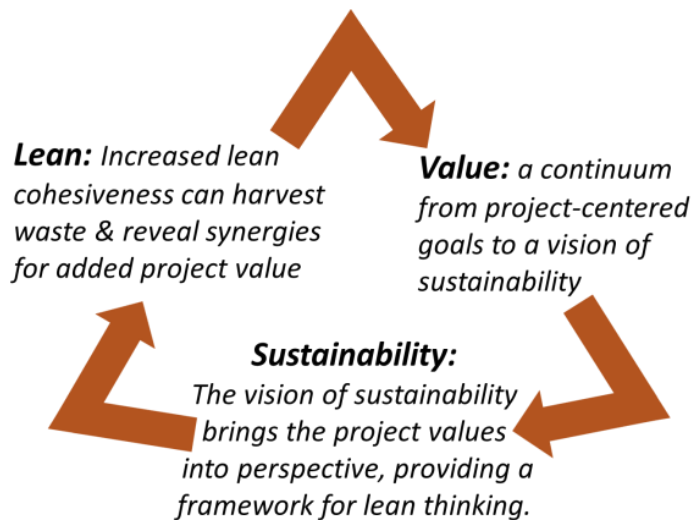


Figure 1- Logical linking of proposition

A final line of inquiry brings the logic of the proposition to a full circle, by examining the opportunity for this broader vision of sustainability to serve as a point of reference to distinguish value from waste, at a project level. Establishing value as an appropriate construct of change in the context of the construction process provides a focal point for the implementation of construction process improvements.



## Definitions

For the purpose of the research, the following definitions were established at the beginning of the interviews.

*Value* - A distinction is made between values and value. Values, expressed in the plural, are core beliefs, morals and ideals of individuals, the conviction that some things “ought to be.”

Collectives of people, such as organizations and society, also have values. When values are commonly shared, they form a culture that underpins the activities of business organizations. Values are thus understood in a more holistic manner, beyond the utility function of the value engineering approach. They form a value chain connecting the product, the business, and the surrounding environmental issues (Emmitt et al. 2005).

*Sustainability* - Sustainability values are currently framed as green building requirements at the level of the project’s value, such as the USGBC LEED criteria. The working definition of “sustainability” for this research was the definition put forth by the Brundtland report: (WCED 1987) "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

*Lean Thinking* - The definition of lean thinking that was presented for the interviews was: “Increase value, decrease waste.”

## Methodology

Case study methodology was selected for the purpose of exploratory research into existing project and to capture data on the innovations from the field (Yin 1994). The selection of cases was based on the criterion of USGBC LEED certification and high level integration of lean thinking. The level of integration has not been developed as a metric, but the lean thinking was defined as “increase value, decrease waste.” The selection was opportunistic, with “high integration of lean thinking” stated as a guiding criteria to elicit recommendations from the lean academic community and industry communities of practice. The integration of lean practices

was established through survey data. Three cases were chosen that have unique geography, owners and contractors, but are united by the common market sector of secondary education. All three contracts were design-build delivery, as designated by the projects' regulatory environment. However, all three modified the delivery method to include the owner in the core team and establish a shared risk and reward mechanism.

Data are gathered through survey and interviews of both prime contractor and owners, offering a two point perspective for enhanced data quality and reliability. The construct validity of the overall research question was the key driver in the design of this case study. Is there a relationship between the integration of lean and sustainability? Is "value" an appropriate measure? The internal validity of this case study was addressed through the structuring of the interviews with open ended questions and giving participants the opportunity to offer additional commentary. This exploratory case study approach is generalizable to theory development.

### *Study Design*

This research examines the proposition that there can be a synergistic link between lean construction and sustainability, as expressed through the construct of value. The findings would provide the burden of persuasion for the logical development of the following phases of the research.

The research survey and interview questions were organized into the following objectives:

- Establish a Baseline of project information, and address the questions:
  - WHAT lean practices and philosophy are being implemented?
  - HOW and HOW MUCH are lean thinking and lean practices integrated into the design and construction process?
- Gain knowledge about the perceptions of cohesiveness of lean on the project. Cohesiveness is defined as the consistency of the application of lean and lean thinking across people, processes and practices. This is based on the observations of the participants, answering the questions:
  - HOW and WHY can lean cohesiveness facilitate increased project value?

- Gain knowledge about the perceptions of project quality, company vision statements, and the correlation between them, answering the question:
  - HOW is the value of the project related to the broader values of sustainability?
- Gain knowledge about the perceptions of the direct application of sustainability values to construction design and production.
  - HOW can a sustainability vision provide a framework for determining value on a project? (for the purpose of distinguishing value from waste)

### *Interpreting of Data*

Data gathered from the interview were transcribed, and the two data points (contractor and owner) compared and compiled into a summary of findings. These findings were then matched to the proposition that lean construction & sustainability have areas of synergy. The rival theory, that there is no synergy, was also explored (Yin 1994). The data collection and analysis are interrelated during the open ended interview questions (Corbin and Strauss 1990; Glaser and Strauss 1967). A strict adherence to interview protocol guarded against bias by the interviewer. Patterns from the data, from the transcript information and the survey were identified, and reviewed for significance to the research aim.

In the construction field, the phenomena are continually changing (i.e. the characteristics of construction process and enterprise), and thus the analytical method should also have change built into the process. In this study, the paradigm that was being observed was “value,” and its correlation with the construction process and the outcome of sustainability. However, the way this paradigm is integrated into either process or outcome was left open for discovery. The data instruments were designed to gather both quantifiable data (conditions that can be factually reported), as well as qualitative data (participant perception).

## Findings

From the collected data, in-depth case descriptions were developed through an analytic strategy of theme identification and inter-case data points. The phenomena of lean and sustainability were assessed independently, and then compared for areas of similarities, compatibility and synergy.

### Integration of Lean in Practices and Phases of Construction

The first area of inquiry explored the integration of lean thinking within the construction design and delivery processes. “Lean Thinking” was defined to the participants as “increased value, decreased waste.” The data was collected from a survey question which presented a list of 5 phases of construction, and asked participants for a yes/no response to the statement: “On this specific project, Lean thinking was used in the following phases.” The responses are presented in Table 1. The data is assessed for the level of agreement between owner and GC, within the project.

Lean Thinking in construction phases:	Project #1		Project #2		Project #3	
	Owner	GC	Owner	GC	Owner	GC
Programming		yes	yes		yes	
Design	yes	yes	yes	yes	yes	yes
Procurement			yes	yes	yes	
Construction	yes	yes	yes	yes	yes	yes
Ops & Maintenance			yes		yes	

#### **Cohesion of understanding between owner and GC, within projects**

both parties identified implementation as a % of total phases	2 of 5	40%	3 of 5	60%	2 of 5	40%
At least one party identified implementation as % of total phases	3 of 5	60%	5 of 5	100%	5 of 5	100%
% owner/GC agreement compared to total identified phases	2 of 3	67%	3/5	60%	2/5	40%

**Table 1 - Lean thinking in construction phases**

According to the data, the owner’s on Project #2 and #3 perceive that lean is implemented in all phases of construction, while their contractors identified fewer phases. The following question in the survey provides additional information to this discrepancy between owners and contractors. All participants agreed that lean thinking was used in two phases: design and construction. The

following survey question asks for participant perception of inclusion of specific lean tools and practices within these phases (Table 2).

		Use of Lean Tools and Practices:		Project #1		Project #2		Project #3	
				Owner	GC	Owner	GC	Owner	GC
		Design	IPD (Integrated Project Delivery)	yes		yes	yes		
IFOA/ IPD Contractual Agreement				yes		yes			
Value Stream Mapping				yes	yes	yes			
Set Based Design				yes	yes				
Target Value Costing			yes	yes	yes	yes			
Construction	Just In Time Supply			yes	yes	yes			
	Partnering	yes		yes	yes	yes			
	Last Planner System		yes	yes	yes	yes	yes	yes	
	Prefabrication		yes	yes	yes				
	Modularization			yes	yes				
Lean Tools	6 Sigma								
	Kaizen Events			yes					
	Choosing by Advantages			yes					

**Cohesion of understanding between owner and GC, within projects**

both parties identified implementation as a % of total phases	0 of 13	0%	9 of 13	69%	1 of 13	8%
At least one party identified implementation as % of total phases	5 of 13	38%	12 of 13	92%	6 of 13	46%
% owner/GC agreement compared to total identified phases	0 / 5	0%	8/ 12	67%	1/6	17%

NOTES Project #1: Other: Collaborative Design Process (CDP), Colocation, BIM for collision checking  
 Project #2: Participant notes: Kaizen is less formal, more integrated, a way of thinking rather than a series of events.

**Table 2 - Use of lean tools and practices**

Project #1 was very much contractor driven, with complementary, but independent lean practices cited by the owner. On Project #3, the survey and follow-on interview questions indicate that the contractor’s understanding of lean was limited to the implementation of The Last Planner. However, the owner perceived that the project was implementing Target Value Costing, a practice that calls for active input of the contractor for iterative estimating of components. This process, along with the IFOA/ IPD contractual agreement, is distinct from the standard process of work in the degree of inclusion and the type of work of the contractor. There could be several explanations for the discrepancy between owner perceptions and contractor perceptions, but the point of interest for this research is the gap in the understanding of lean as a philosophy, rather an emphasis of lean as practices or tools.

By contrast, Project #2 respondents indicated a 92% implementation of the listed tools and practices cited in the survey, and had much higher levels of agreement (60% lean thinking in construction phases, 67% practices). Lean was described by one interviewee as Integrated Project Delivery enhanced by Target Value Design, and supported by the Last Planner.

The survey provided an opportunity for additional commentary. Building Information Modeling (BIM) was suggested by one participant as a tool for clash detection, but neither the survey nor following interviews identified BIM as mandatory for lean construction.

### Structure of Integration

The research also examined the structure of the integration of lean, both as established in the contract and in the design and construction management process. In all three projects, design-build was the contractual delivery method, as it was proscribed by the funding agency. However, these contracts were then adjusted to accommodate a shared risk and reward structure through the contingency funding. Some of the participants also commented that IPD-type risk sharing contracts (such as the Integrated Form of Agreement –IFOA) can support a culture of collaboration, but are not a guarantee of a fully integrated lean process.

The data from the interviews also provided an insight into the difference between a fully integrated design and delivery process vs. a concurrent design and delivery brought about by organizational restructuring. In Project #2, the design process clearly engaged the efforts of owner, GC, professionals and trades in problem solving, target costing, set based design and value stream mapping. This was not just a reporting process, rather a continuous and “real-time” design and estimating process, which had been developed out of frustration with “traditional stop/start design processes.” The phases are recognized, but not formalized. Value stream mapping was used throughout construction to adjust for unexpected complications and costs. By contrast, in the other two projects, the phases of construction seem to have remained relatively unchanged, despite the co-location of the core design team.

## Champions

Another perspective was the level of involvement of the players, in both lean and sustainability initiatives. During the interview, an open-ended question was asked about the “champion” of lean and green building efforts. The answers pointed to either the contractor or the owner, but not the designer (Table 3).

Champion:	Project #1		Project #2		Project #3	
	Owner	GC	Owner	GC	Owner	GC
Champion for Lean?	Contr.	Contr.	Owner + contr.	Contr. + Owner	Owner	Contr.
Champion for Green?	Contr.	Contr.	Owner + contr.	Owner + contr.	Owner	Owner
	Contractor Driven		Jointly Driven		Owner Driven	

**Table 3 - Champions of lean and green building**

The projects exhibited similar patterns to those identified in the earlier questions. The responses in Project #2 were unanimous in their identification of jointly driven initiatives of both lean and green building initiatives. Surprisingly, this project was the only one that cited resistance on the part of the architect and engineer, as well as initial push-back from the managing partners of the trades. The owner, in response to the question about notable exceptions to the lean thinking, noted that: “The architect and engineer had a tough time overcoming their resistance to the interactive practice, accepting that others could have good ideas. It was a big paradigm shift to share ideation.” However, all project interviewees were adamant about the need for complete commitment from the owner group and the contractor. This finding differs from the more common industry emphasis on the collaboration between designer and contractor, for example through IPD or design-build.

## Continuum of Value Paradigm from Project to Sustainability

The second area of inquiry explores the construct of value. If lean thinking is defined as “increasing value while decreasing waste,” then what is value? Is value defined and created by the absence of waste, does value define waste, or can value exceed that which is created by waste reduction? For example, on project #3, in which both participants identified the potential of lean

integration, the goal was to reveal more waste, with no specific mention of value. This might indicate a concept of value creation through the absence of waste. Only Project #2 participants identified the potential for revealing value, and offered specific examples. This section of the research explores the relationship of value from the perspective of a project-based concept of quality, to value as understood through sustainability at a global level.

The collected data identified a strong correlation between the existence of a corporate vision statement that included sustainability and the championing of green on the project case study. (Table 4).

	Project #1		Project #2		Project #3	
	Owner	GC	Owner	GC	Owner	GC
Company Vision Statement?	No	Yes	Yes	Yes	Yes	No
....include sustainability?	No	Yes	Yes	Yes	Yes	No

Table 4 – Company vision statements and sustainability

On Project #1 the contractor company had a sustainability vision to “empower clients to make informed decisions regarding sustainability.” The client, on the other hand, had no known vision statement regarding sustainability. The reverse is true on Project #3, where the client had a defined commitment of “environmental stewardship driving the educational mission,” while the contractor cited compliance with LEED goals. Project #2 both owner and contractor had stated commitments to sustainability at the corporate level.

The survey also established percentages of overall participant business that used some level of green building. On Projects #1 and #3, the contractors cited only partial levels (40% and 85% respectively), while Project #2 cited 100%. Follow-up questions during the interviews identified that while LEED certification had increased awareness of green building, it also created barriers to sustainability goals outside of this benchmark. One contractor also noted that they did a lot of civil work, which was not governed by any green certification, and therefore the contractor did not recognize any civil work as included in sustainability.



Many of the participant comments also revealed that green building was understood solely within the context of green building criteria, and not within the triple bottom line of sustainability, which would also include social and economic goals. There were notable exceptions, such as the contractor of Project #1, who provided several insightful examples of how sustainability goals such as day lighting can align with client goals such as educational performance improvements.

### Vision of Sustainability brings the project value into perspective

The final area of inquiry brings the logic of the proposition to a full circle, by examining the opportunity for *project* “value” to be understood relative to a broader perspective of global *sustainability* value. Participants were asked for their perspectives on the proposition that: “the vision of sustainability brings the project values into perspective, providing a framework for lean thinking.”

The responses were very consistent with previously identified patterns among the cases. Project #2 participants were in absolute agreement, stating “that’s how you get from gold to platinum,” and “this is critical to identifying innovations.” They had sustainability goals beyond LEED, and could cite several examples. Both participants also expressed that the greater goals of sustainability help to break through the barriers in the design phase, to capture synergies of resources to support the additional value. The contractor on Project #1 was also supportive, citing several examples of product improvements driven by sustainability goals that exceeded project specifications, but which decreased waste and thus were self-financed.

Lean was also cited as breaking through the barrier of excessive detailing of prescriptive specifications. As the design process includes more discussion and alignment of project values and goals, it allows the opportunity for field interpretation for the benefit of the project. Workers adhere to best practice installations, but aren’t constrained in the details. Materials submittals are a confirmation of previous project decisions and a submittal of technical information for operations & maintenance.

Consistent with previous data patterns, the owner on Project #1 and the contractor on project #3 did not immediately recognize the conceptual relationship between sustainability goals and lean construction. However, both projects cited the benefit of including a non-construction member on the core team, to challenge each aspect of design relative to the perspective of the user group, a community group, or broader issues of sustainability. This is, in essence, the concept expressed in a practical application and a demonstration of how sustainability can drive behavior.

## Conclusions

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The significance of this research rests in the opportunity for the construct of value to serve as a catalyst that shifts construction management from limitations of a “do no further harm” approach to a perspective of positive sustainable prosperity. The case study findings correlate elements of lean thinking and lean construction with the integration of sustainability in the design and delivery.

The three cases exhibited patterns that were consistent and showed a strong correlation between lean and sustainability. Project #1 and #3 were driven by one stakeholder, contractor or owner. The other party was compliant but not as engaged. The lean activities were compatible, but not synergistic. Only Project #2 had a shared committed leadership. Their level of engagement was very similar through all the phases, practices, scope, structure and leadership. The participants from this project actively leverage the synergy that the integrated process of lean offers to the delivery of sustainability. They also understand a link between value from the project perspective and global sustainability perspective. This data indicates support of the research hypothesis, both by the absence of integration resulting in the absence of sustainability beyond LEED, and in the example of Project #2, which supports the synergistic link.

This research also identified several “myth-busters” regarding both lean and sustainability:

- BIM and shared contractual agreements (IFOA) are understood to be contributory but not mandatory for lean construction.

- Integration of lean is most effectively driven by a collaboration of the general contractor (GC) and the owner. The collaboration of the designer, engineer and trade in the IPD process are important, but lack of support can be worked around.
- Lean construction does not always include a focus on value delivery. Some of the lean practise may be solely focused on the reduction of waste.
- Operational integration may result only in phase concurrency, not phase integration.
- There is a correlation between corporate vision statement, green champion, and integration of green within all project levels.

This exploratory research was designed to provide the burden of persuasion for further research on the following topics:

- Project value expressed as sustainability values.
- Empirical data capturing the characteristics of lean integration.
- Implementation of lean as a means of delivering sustainability prosperity values.

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## Chapter 4

### Target Value Design as Continuous Value Management



#### Chapter Summary

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The format of this chapter is the presentation as accepted for the 2012 International Conference on Value Engineering and Management in Hong Kong, on December 6-7, 2012.

The topic of the paper is the evaluation of the Target Value Design process as a continuous value management approach, and the impact on the delivery of sustainability values in design. Target Value Design is an emergent practice of integrated design management, and the process and individual tools have been developed organically within the construction design culture. Target Value Design process has a focus on value delivery that has a constant and thus continuous presence in this integrated process, in comparison with the more discrete events of traditional value engineering. Descriptive research of a case study examines the impact of this practice on the project culture and the practices, including the value identification, the product value improvement, and the design process improvement. Integrating value management as a continuous practice into the design process also redistributes the responsibility of value management to all of the design team members. The paper reviews the new skills that have emerged as the team members accept their new role as value managers.

The final section of the paper addresses the potential role of Target Value Design in supporting the delivery of sustainability. Key discoveries are listed in the conclusion, and followed by a discussion of the opportunities for future research from this new paradigm of distributed accountability of value management.

# Target Value Design: Managing Sustainability Values in Construction

Novak Vera <sup>1</sup>

**Abstract:** Global environmental awareness has raised the benchmark for the construction industry, calling for higher value and more sustainable green buildings. This added expectation and increased project complexity has catalyzed a shift toward integrated project delivery (IPD), for improved efficiency and *reduced waste*. Coupled with the increased confidence of the lean construction processes to deliver projects within schedule and budget, the opportunity has emerged to *add project value*. How can this value be defined and managed? This paper examines a continuous value analysis approach taken by the pioneering Target Value Design (TVD) practice, contrasting it with more traditional value management events. Descriptive research of an exemplary case study examines the impact of value management on the design culture and practices, as well as stakeholder responsibilities. The redistribution of value management skills traditionally held by a third party is recognized as a challenge and opportunity for further research and training development. The research suggests that TVD can facilitate the delivery of sustainability value, as long as they are explicit and articulated in a unified vision.

**Key words:** Lean, sustainability, value, design, construction.

## 1. INTRODUCTION

The construction industry is faced with compelling pressure to change, on several levels. Global environmental awareness has raised the benchmark for capital improvement projects, calling for less expensive, higher quality, and more sustainable green buildings (Kibert 2007). Decreasing productivity relative to other industries has raised public concerns about efficiency (Bosworth and Triplett 2004; Egan 1998), and owner dissatisfaction with high construction costs and compromised quality has only been amplified by the recent economic downturn (Miller 2009). The resulting combination of increased complexity, lower tolerance for waste, and higher value expectations have served as a catalyst for innovations in the design and construction delivery process.

Integrated Project Delivery (IPD) was introduced by the design community to address the increased complexity of projects, through early involvement and integration of more versatile expertise and business practice (AIA 2007). This philosophical approach of shared risk/ shared reward was then codified in a multi-party contractual agreement, building upon prior work of project alliancing and partnering (Lahdenperä 2012; Lichtig 2006). Such collaborative agreements represent a pivotal shift in the commercial terms of project management, as they incentivize process improvements with monetary and non-monetary motivation (Zimina et al. 2012).

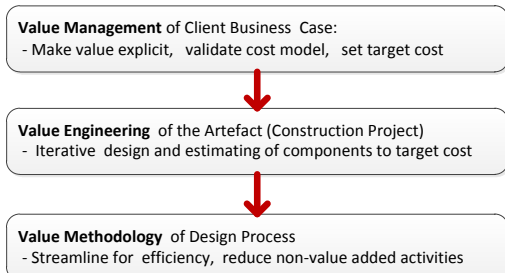
The introduction of lean thinking into the IPD process has served to further operationalize the focus on collaboration, value management and productivity improvements (Moussa 2000). With increased confidence in the ability to resolve the traditional tension of time, cost and quality, the opportunity emerges to consider added project value, in particular added sustainability values.

## 2. TARGET VALUE DESIGN

Value management in construction is a discipline that uses concepts and practices that emerged in manufacturing, but has been adapted to the distinct demands of the construction industry in the uniqueness product, and temporary composition of players. Unlike manufacturing, construction does not typically operate in a high volume repetitious production mode. Thus, a post design constructability audit is faced with the obstacle of embedded time, money and emotional involvement, as well as an increased risk of triggering a ripple effect of impacts in the complexity of the product. The construction product is better served by a value methodology that starts by leveraging opportunities in design for high-impact changes with lowest process costs, and continues managing value throughout the construction process.

Target Value Design (TVD) is one such strategic process, which has emerged from Integrated Project Delivery. It includes value management for the client business case, value engineering of the construction project, and value methodology throughout the design process (Figure 1). The integrated nature of Target Value Design has similarities with the Value Engineering approach used in Japan, which can be traced in both instances to the Toyota philosophy of continuous improvement. It also fits the descriptions of value management as a “team-based, process driven methodology” (Male et al. 2007), and is similar to a future scenario of value management by Kelly, Male and Graham (2004).

**Figure 1 –Continuous value management in TVD**



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There are several distinguishing characteristics of Target Value Design when contrasted to Value Engineering (as practiced in North America), as shown in Table 1, and detailed below.

**Table 1 – Comparison of VE and TVD**

	<b>Value Engineering</b>	<b>Target Value Design</b>
Timeline	Discrete event(s) at fixed point(s) in time	Continuous throughout design and construction
Practitioner	Value engineer/ manager external to design team	Core Team (incl. owner, design, contractor), + input from trades
Targeted Outcome	Least Cost (Value rationalized to meet set budget)	Most Value (Cost optimized to deliver explicit value)

In the Target Value Design, value management is continuous throughout design and construction. Owner value is the key driver for project design, to which the cost is optimized. The process is one of continuous improvement, through iterative component design and estimating (Ballard and Reiser 2004). This contrasts with historical applications of value engineering, in which the value is rationalized at a set point in the design process to meet the budgeted cost.

Integrating individual value engineering events into a continuous value analysis process also re-distributes the accountability of value management. Traditionally, value design and delivery was the responsibility of the architect, supported by the third party value engineering practitioner. While the practice of TVD does not preclude the inclusion of a discrete value management event, it is likely to include the design team at a greater level of involvement.

This internalization of value management impacts the expectations and skills needed by team members. For example, the iterative component design and estimating changes the involvement of the project estimator. It calls for earlier and more regular estimating of designed components, refining levels of granularity as the design progresses. Additionally, as a value manager, the estimator can draw on previous experience and data collection to “cause rather than to predict,” as a contributing resource to the design team (Ballard 2012). This concept first appeared in 1987, during industry discussions advocating improved constructability during conceptual planning (Tatum 1987), but was lacking a design process that would support this more pro-active role of the contractor, and indeed, all stakeholders.

Another notable difference in TVD compared to traditional project management is the involvement of the owner, both before and during design. The explicit project values are first aligned to the owner value system, recognizing hierarchical owner values (Male 2002), and the client is asked to evaluate project requirements beyond the conventional nature of a project brief. In recent TVD cases within the healthcare industry, clients have adopted increasingly sophisticated practice of lean management, future state mapping, modeling and space validation, as well to-scale modeling of space (de Souza 2009; Sobek and Lang 2010). In some cases, the outcome of this exercise has been an improved functioning of existing space that reduced requirement for additional space. Making owners values explicit helps to focus the creativity and innovation of the design process (Selart and Johansen 2011).

The target outcome of the TVD process is distinct in the relationship of value to cost. Cost is optimized to deliver explicit value, compared to the traditional VE definition of value rationalized to meet a set budget. The TVD approach draws from a market-based target cost concept (Cooper and Slagmulder 1997; Tanaka 1993), but raises the bar with the challenge to *meet* owner expectation of value, which often may exceed market comparables, but *not exceed* the target cost, which is often set below-market. This value-to-cost spread is understood to represent the cost of waste inherent in the construction industry, and provides the creative tension to convert cost into a design criterion rather than a design outcome (Ballard and Reiser 2004). Empirical results confirm this assumption of available waste. In a recent study of 12 construction projects using Target Value Design in the USA have reported final project costs on the average of 15% less than market costs (Tommelein et al. 2011).

While there is an increasing body of knowledge documenting the logistics of this emergent practice (Ballard 2012; Zimina et al. 2012), this study examines Target Value Design from the perspective of the players and the process in the management of value. The following section of the paper describes a “state-of-the-art” characterization of the Target Value Design process relative to the culture, the tools, and the personal mastery of value management skills. The final section takes a closer look at the challenges and opportunity of delivering the complexity of sustainability values.

### 3. CASE STUDY

The project case study was selected on the merit of the constructor, an early adopter and innovator in lean construction, and the client, who has extensive experience with lean management of health care services. Both have a demonstrated commitment to sustainability. The unit of analysis is the third phase of a long-term, multi-phase project, in which the core team has been working together for several years. This long timeline is unusual in the construction industry, but was instrumental in allowing the team to advance the development of the practice of Target Value Design. The investigation was based on a triangulation of data gathered from survey and interviews with the eight core team members (representing owner, designer, contractor, and mechanical engineer), observation of weekly meetings, and project documentation of value added change orders.

#### 3.1 TVD Culture – Value-Driven Design

Target Value Design emerged as an applied practice within the collaborative design culture of the Integrated Lean Project Delivery (ILPD), developed by the contractor. When asked to identify key characteristics of ILPD, study participants cited communication and the ability to identify, share and manage vision as well as risk. Even the nature of information exchange is influenced by the requirements of the iterative design process of TVD, as team members had to adjust to increased financial transparency and the sharing of incomplete information. This is unusual in an industry that is accustomed to solo completion of tasks, which are then “reported out” to other team members. Offering partially developed ideas for group discussion represents a degree of vulnerability and requires a higher level of trust in the team learning.



Study participants were asked to define Target Value Design from their own perspective. Some of the comments reflected on the change in culture brought about by this process:

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“changes the project language from a discussion of what things *cost* to one of what things are *worth*.”

“it demands that *multiple solutions* are considered for each of the major project elements, and that these potential solutions be evaluated on a *best value* basis.”

“*accepted and shared vision* of what the product will be to deliver the owner expectation of value.”

“designing a project to a *performance goal* within a targeted price.”

“*working as teams* to overcome issues when the targets are exceeded or want to be exceeded.”

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Another notable element of change in the project design culture is the continued and active involvement of the client, and of the user groups. Not only does this increased input inform the design and improve the functionality of the space, but it can greatly reduce the rework and adjustments that are often experienced after project hand-over. Client participation with the trades in component team meetings facilitates an open discussion of design solutions to meet client values and performance goals, reducing the reliance on prescriptive documentation. This improved understanding of design intent reduces requests for information (RFI) that traditionally cause delays in construction. Finally, clients have a clear expectation of the final product, which reduces client change-orders in construction and can improve client satisfaction.

### 3.2 Tools/ Practices

Viewing the case study’s Target Value Design process through the lens of traditional value practice (Figure 1) helps to categorize the tools and practices by virtue of their intended outcomes. These are roughly identified as value identification and validation, product value improvement, and process improvement.

#### 3.2.1 Value Identification and Validation

Value identification tools are traditionally used in a client brief to help make values explicit. These have typically been delimited by a functional or utility viewpoint. However, for this project in the health care sector, the client had identified a business metrics of a patient’s “likelihood to recommend” to another patient. Thus the explicit value was to “improve patient care.” This patient perspective reintroduces variables to the value equation that practitioners will recognize from Miles’ early work on value management (Miles 1961). Nursing staff are invited to identify design features, appearance and quality issues that facilitate patient care and satisfaction, and impact their work. Business managers consider the service life of materials and designs, while recognizing the need to accommodate new technology. Explicit values are defined, such as an adaptable yet durable design layout and materials.

#### 3.2.2 Product Value Improvement

The team adapted several tools from lean practices and Toyota to help guide value-based decisions for improving product value. These are decision making tools that help identify the relevant value, align the impacts and interface by means of the value stream,

and assess the merit of several options from the perspective of the relevant values. For example, the practice of Value Stream Mapping was adapted from lean manufacturing, and is used in a more conceptual form to identify a future state and reverse engineer the current state, revealing waste and solutions (Howell and Ballard 1998). The A3 reporting is a well-documented method of capturing and sharing data on a topic, with an emphasis on problem recognition and resolution. (Shook 2008; Sobek and Smalley 2008). The Choosing-by-Advantages tool is a little-known outside of lean construction circles, but is particularly well suited to selecting between alternatives based in relative advantages of multiple criteria (Suhr 1999).

The client of this case study has very highly evolved internal lean management practices, which they brought to bear on the design process. This included a computer simulation of patient use of facilities, which captured the pattern of movement from treatment rooms to recovery rooms. In one example, this model identified an opportunity to combine recovery rooms from different departments into a central location, reducing space requirements and improving the work flow for nursing staff. Another example of designing to patient care, rather than fitting patient care into existing spaces process might involve building of a mock-up patient room, or surgical theater, and fitting the walls around it.

Site visits of similar facilities are common early in the design process. However, in this case, the entire core team was involved in this process. In the parlance of lean project management, this is known as going to *gemba*. The facility walk-through is instrumental for tacit knowledge exchange, especially identifying constructability opportunities and key concerns for mechanical contractors.

#### 3.2.3 Process Improvement

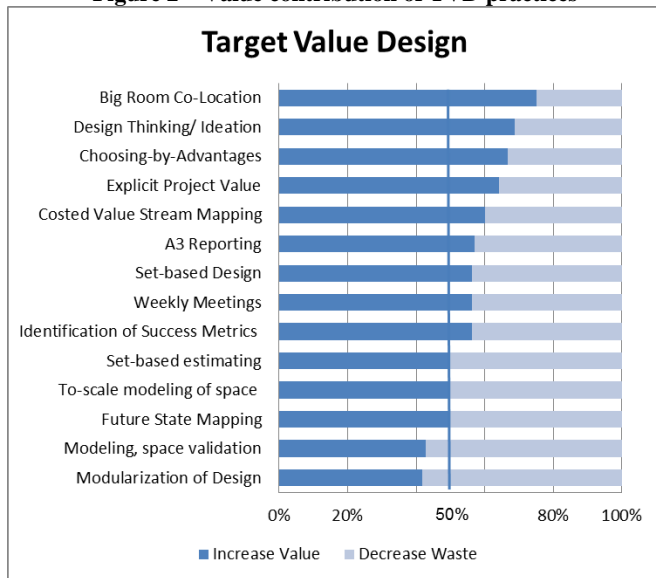
Value management is typically centered on project improvements, but this team had a unique opportunity to consider *process* improvements. This is a result of the longer time frame of the project and the consistency of the team members over that time, as well as the dedication to continuous improvement by all the team members. Over the course of the previous project phases, the team had modified or added new practices to improve value delivery. For example, several of the participants cited the benefits of implementing the Choosing-by-Advantages method, in helping the team to articulate the attributes and relevant advantages of the options under consideration. They also identified the merit of this method in generating a value-based discussion, which crossed over traditional skills-based roles.

Participants in this study were asked to rank these practices relative to their contribution to waste management versus value creation. The listing of practices used for the survey was derived from literature, preliminary interviews, and observation (Ballard 2012; Zimina et al. 2012). The results of the identified TVD tools showed a slightly heavier emphasis on value creation over waste reduction (Figure 2). Participants were also given the option to designate “both” value creation and waste reduction, which were tallied as a split count.

The Big Room, or co-location of the team, was cited as most likely to contribute to value, but it should be noted that while the team had a dedicated weekly meeting space, they were not co-located for their work. Thus the scoring could reflect a projection

of potential benefits. Scoring of all the remaining practices represented some level of actual experience. The limitation in terms of inclusions of practices and generalization is acknowledged.

**Figure 2 – Value contribution of TVD practices**



Four of the top practices selected as value contributors are design thinking, Choosing-by-Advantages, explicit project value and costed value stream mapping. These are all practices that help create and align value with project goals. Interviews with the project participants revealed that the design thinking and explicit project value definition had not been developed as fully as the others. They cited the need for a heightened awareness, and the formal inclusion of these practices in future projects.

Another significant process improvement of TVD was the virtual elimination of project phase boundaries. The participants' general consensus was that the TVD process was continuous from project inception to facility completion. There was no traditional handover to construction management, as the contractor was already involved in the TVD. The weekly team meeting shifted to more of a project briefing format, and a real-time forum for requests for information (RFI), this eliminated much of the traditional paperwork involved with RFIs and provided immediate and actionable feedback. This continuity of players provides the ideal platform to consider the innovation and mastery of individual value management skills.

The team set a *process* improvement goal of “minimal redesign and repricing,” which are derived from the lean criteria of “value added” activities (transform the product or service, done right the first time, and for which the customer is willing to pay). These goals serve as a catalyst for transparency, collaboration and efficiency. They fine-tuned the iterative design approach, starting with rough estimates and concepts and gradually increasing the level of detail. In order to not duplicate actions or create rework, the trades were encouraged to share partial information (concepts), offer financial transparency for estimating purposes, and build upon each other's input.

### 3.3 Value Practitioner Skills

In addition to the team skills, each trade was now faced with the challenge to develop specific skills to support a continuous management of values. They also identified a need for smaller more frequent events, or triggers, to check value alignment.

The contractor, in the case study, understood the opportunity to use estimating as a strategic analysis tool to make value-based trade-off decisions. He developed a cost estimating metric that compared the proposed project alternatives based on program quality cost. This formula used the variables of: a) program elements (what you get), b) a building cost factor, equalized for time and location, and c) a performance factor that related the equalized cost to an averaged baseline cost. The resulting Model PQC Factor is used to identify the relative quality of the proposed design alternatives. As this spreadsheet became increasingly populated with data for both products and design alternatives, it provided an efficient process tool for identifying best value.

The designers were equally innovative in the redesign of their knowledge management process, based on lean project delivery. A few of their key process improvements were “getting the right people at the right time” and implementing a “just-in-time” concept of design information. For example, they developed a process of fixing the location of big items, such as structures, stairwells and elevators, based on site and code considerations, prior to getting user input. This eliminated unnecessary redesign rework, and focused the applicability of the user input.

The need for value management skills is particularly applicable to trades who have not traditionally been present in the design phase. For example, mechanical contractors could be asked to help design the highest value systems for the customers, rather than to price out a fixed design. This calls for different level of knowledge and skills, both in perspective of their own trade contribution, and in the interface with other trades. The mechanical contractor on this case confirmed that TVD provided the structure for design input, but stressed that the uptake of that information was very much dependent on the alignment with the explicit customer values.

## 4. THE SUSTAINABILITY CHALLENGE

While the case study team demonstrates a very highly developed proficiency in delivering the stated values of patient care, there was an ambiguity regarding the delivery of sustainability. Interviews revealed a discrepancy between the implicit understanding of the owner's dedication to sustainability, and the explicit articulation of actionable criteria of green building. This can be understood within the context of the ongoing discussion in the value management community of capturing values beyond those of function, or utility.

In past years, sustainability has been introduced into value management by means of cost equivalencies. Zimmerman and Hart (1982) included life-cycle costing and energy consumption, both of which could be discounted to present value. According to the Sustainable Federal Facilities Guide, with life-cycle costing, “tradeoffs and decisions can be made to balance environmental performance with total costs (i.e. initial, recurring, and nonrecurring) reliability, safety, and functionality. When all alternatives are compared equally (i.e. “apples to apples”), sustainable development technology and integration can then be fully evaluated in the acquisition process.” (FFC 2001). In this

way, sustainability for a project could be expressed as the best value for both current and future generations. However, this reductionist thinking continues to limit the problem solving approaches to linear, transformational views.

Sustainability can be seen as both catalyst and the goal of a more systemic understanding of value. Sustainability issues are inherently resistant to being broken down into isolated green building criteria. For example, reducing the consumption of hot water is a function of water, but also of heat, natural resources, carbon footprint, and even ecology. Thus, sustainability transcends the typical design focus on functional requirements, which have been parsed to individual stakeholder activity silos and addressed in a sequential process (Kibert 2007).

Academic research has proposed a supply relationship of project values and company values (Kelly et al. 2004). As “value should be considered in a global context considering economic, social, political and environmental constraints” (Salvatierra-Garrido et al. 2010), the company and project values can be viewed as nested values within this greater whole. An understanding of this nested relationship of values can provide guidance for making owner’s values explicit, and rendering them actionable for the contractor team.

The data from this case study points to the role of explicit sustainability values in driving project design. Specifically, participants were asked how opportunities to address sustainability issues beyond the green building were handled. In contrast to the cohesiveness on most other survey and interview questions, the participants had widely disparate responses. They either were not aware of any additional opportunities, or they pointed to the energy saving mechanical equipment. Outside of the explicit goal of energy savings, the participants were not able to identify any other sustainability goals. Some participants referred to an Owner Project Requirement, but none had a readily available copy. Nonetheless, all participants were in agreement about the owner’s commitment to sustainability. The lack of a unified vision of sustainability values created gaps in the value creation dialogue.

On the other hand, the sustainability initiatives that *were* clearly articulated, for example the LEED criteria, were fully supported through the Target Value Design process. The participants were in agreement that the practices of TVD facilitated the delivery of the explicit goals of sustainability, and provided the structure to address sustainability at a systemic level.

When asked how sustainability goals affected their work, participants responded in a positive manner. The goals were either considered to be so engrained in the process and documentation that it caused no extra work, or that the goals kept the team “on their toes” to seek out high quality materials and installations. Even the documentation for LEED certification was recognized as a process of commissioning to ensure quality standards were met.

## 5. CONCLUSION

We have presented a descriptive study of Target Value Design as currently evolved by an exemplary case study team. These TVD practices have been developed organically within the construction design culture, and have successfully integrated elements of the value methodology into the product design process. There is a growing body of academic research and support for product development methodologies of Target Value Design (Ballard 2012;

Tommelein et al. 2011). This contribution of this research is the analysis of the TVD from the perspective of value management and the human agency.

The key discoveries are summarized below, followed by a discussion of the resulting opportunities:

- TVD has integrated independent value management *events* into a continuous value methodology *process*.
- TVD encompasses value identification and validation, product improvement, and process improvements.
- TVD changes the relationship of the client to the design process and to the core team.
- The accountability for value management in TVD is distributed to all design team stakeholders, which represents new skill opportunities and responsibilities.
- TVD practices can be differentiated by contribution to value vs. reduction of waste.
- TVD can facilitate the delivery of sustainability, as long as they are explicit and articulated in a unified vision.

Target Value Design is a process that has been developed in response to the challenges of the construction industry design process, and is unique in the approach of integrating previously independent value management events into a continuous value methodology process. A retrospective analysis of this market-derived practice from the perspective of traditional value engineering can help identify potential transfer skills and knowledge from other industries, such as kaizen costing, various forms of value analysis (Zero-look, 1<sup>st</sup> look, 2nd-look), teardown methods, and others mentioned by Cooper & Slagmulder (1997).

The analysis provided in this research also recognized the different aspects of value that are encompassed within the continuous Target Value Design process. First, there is the explicit articulation of value, and the validation of the business case with the market value, based on this explicit value. The second is the optimization of the product value, through the reduction of waste and the alignment of value to the product trade-offs. The final aspect was the management of value in the TVD process. Understanding this value structure encourages the formal recognition of these aspects within the logistics of the process. The lack of the formal inclusion of all of these aspects was notable with regard to the delivery of sustainability on the case study project.

A further level of understanding was developed with regard to the value contribution of the Target Value Design practices. Some contribute more to value improvement, others more to waste management. This is an important distinction to manage expectations of the TVD practice, and to guide the implementation of this practice in new project teams. Two of the top practices that contribute to value are the articulation of explicit values and a formal process of ideation/ design thinking to develop solutions for delivering these project values.

A new paradigm is presented for accountability of value management and related skills. Due to the integrated nature of TVD, the responsibility for value management is distributed among individual core team members. As noted, the case study team had an exceptionally long time frame within which to develop these skills, as well as a highly developed commitment to continuous improvement. More typical in construction is a short time frame and a new combination of players for each project. Thus the opportunity to learn value management skills in the field is limited. This represents an opportunity for organizations such as SAVE to

develop the knowledge and training for value management skills for the many trades involved in construction. The mastery of skills could thus be embedded with the individuals, and included as qualifications in a procurement process.

The research also confirms the critical role of the client, and the need for a well-defined process to define sustainability values (Novak 2012; Thyssen et al. 2010). There is an opportunity for additional descriptive studies of owner skills and responsibilities (Ballard and Reiser 2004). This research has practical implications for the proliferation of TVD, and the managing of owner expectations.

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## Chapter 5

# Sustainability Value Management in Design



### Chapter Summary

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The previous chapters have provided an understanding of the overall research aim, which is to identify the core conditions and constraints that support or hinder the delivery of sustainability in the built environment. The research approach is developed as two research questions, the first of which is reviewed in this chapter: “How can Target Value Design, an integrated design management process, elicit better delivery of sustainability values?” While previous studies have documented the organization and commercial terms of Target Value Design (TVD), this research focuses on the impact of TVD on value delivery, specifically of sustainability values.

The research strategy is to identify and study an exemplary design team practicing TVD, in order to leverage the innovations of the lean construction community in value management through design. Survey and interview questions are designed to identify:

- The **Ability** of the TVD **process** (to deliver sustainability values)
- The **Capability** of the TVD **team** (to delivery sustainability values)

The complex challenges of the delivery of sustainability serve as a filter to reveal the limitation of the current TVD process, and identify the next opportunities for improvement. The findings of the TVD process are presented in this chapter, whereas the data analysis of the capability of the TVD team is presented in the following chapter, as the first manuscript. The data from this case study identifies the gaps in the delivery of sustainability as the practical problem area that is addressed in the research design solution, presented in Chapters 7 and 8.

## 5.1 Theoretical Foundation – Value Creation

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### Understanding Value Creation

A distinction is made between values and value. *Values*, expressed in the plural, are core beliefs, morals and ideals of individuals, the conviction that some things “ought to be.” Collectives of people, such as organizations and society, also have values. When values are commonly shared, they form a culture that underpins the activities of business organizations. They form a value chain connecting the product, the business, and the surrounding environmental issues (Emmitt et al. 2005). In construction, this chain of values frames the assessment of the project *value*, which is ultimately made explicit as project objectives and quality (Thomson et al. 2003).

Sustainability values are currently expressed as green building criteria at the level of the project’s value. This is consistent with the traditional view of sustainability as “doing no further harm,” reducing the ecological footprint, or minimizing waste. However, there is an increasing awareness of the need to transition toward sustainable prosperity, which represents an active restoring of Earth’s systems to full resilience, in order for all human beings to have abundant opportunity to pursue lives of satisfaction and prosperity (Huovila and Koskela 1998; Walker and Salt 2006; Worldwatch 2012). Making sustainable prosperity explicit in the context of the built environment can be understood as the transition from substance metaphysics and process metaphysics (Koskela and Kagioglou 2005). This is the shift from a reductionist, object oriented and outcome driven approach to one that focuses on the process. Values are thus understood in a more holistic manner, beyond the utility function of the value engineering approach.

The best opportunity to impact function and value, for the lowest cost is during the design phase is represented in Figure 5.1 (CURT 2004). The articulation of these values in the design phase of a project provides the greatest opportunity for value generation in design (Edwards et al. 2010; Tzortzopoulos and Formosa 1999). In recognition of this opportunity, the design community has developed a form of collaborative design gatherings, called design charrettes, as one approach to capture these expressed values and transform them into product solutions. This teamwork approach is increasingly inclusive of additional stakeholders (outside of the design firm) and

owners, to identify the key values for the project (Kelly and Male 1993). Kelly and Male (1993) also report the inclusion of an economic perspective in the design discussions, for a target-cost design approach. The most recent development of this approach is Target Value Design (TVD), which is characterized by the focus on value enhancement, and the commitment of stakeholders’ time and labor resources to a collaborative planning process.

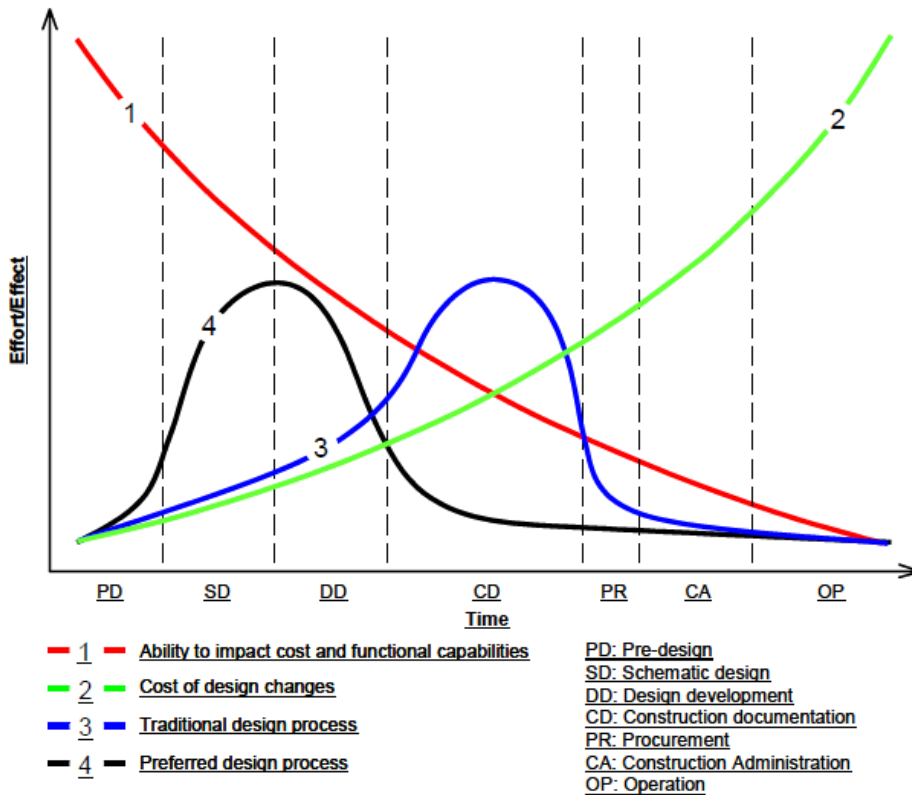


Figure 5.1 - MacLeamy Cost Curve (CURT 2004), used under fair use, 2012.

### Organizing for Value Creation

The findings from exploratory case study research, presented in Chapter 3, confirmed the correlation between the existence of explicit sustainability values at the level of the corporate enterprise (of the key stakeholders), and the articulation of sustainability values at the level of the project. This is a logical extension of the nesting of values (Figure 5.2) (Kelly et al. 2004). Inasmuch as the project is nested within the corporate business activities, so too are these

corporations nested within the triple bottom line of sustainability: society, economy and environment.

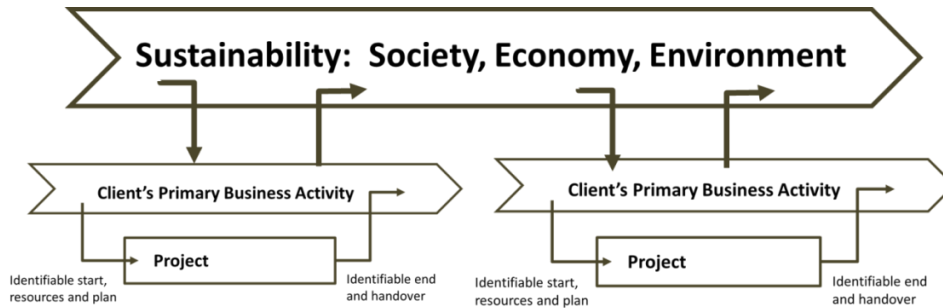


Figure 5.2 - Nested relationships, built on Kelly, Male and Graham (2004), used under fair use, 2012.

The values of each of these entities are defined in relationship to the nested entity. The overarching values of sustainability would thus “pull” the value stream through the corporate enterprise, and the project enterprise. These nested values provide the structure to develop the individual project value chain. This in turn guides the target values for all the stakeholders involved in a project. This value hierarchy created from embedding single project processes within a higher multi-project portfolio offers a strategic view of the individual project (Moussa 2000). This same hierarchy for corporations helps guide the corporate vision and values.

### Value Creation in Target Value Design

Lean thinking is often understood as the focus on “increased value, decrease waste.” The Target Value Design (TVD) process was developed by the lean community as the extension of this philosophy from the construction phase into the design phase. A question arises as to the relative contribution of the process to net value creation vs. waste elimination. For example, waste in material overruns can be eliminated to improve the cost of the project, but this does not directly contribute to the creation of value. On the other hand, in the case of an office project in Boise (Hellmund et al. 2008) a design exercise to optimize the steel structure resulted in a shallower floor beams, which allowed the building to fit in an extra floor within the existing height. This is net value creation. Can this distinction between value creation and waste management be



correlated to individual tools and practices of Target Value Design? This would first require a complete listing of the tools and practices used in TVD.

Target Value Design is an emerging practice, and the literature is typically either conceptual or descriptive research of the tactical aspects of implementing TVD on a project (Ballard 2012; Ballard and Reiser 2004; Lichtig 2010; Macomber et al. 2007; Mauck et al. 2009; Rybkowski 2009; Zimina et al. 2012). Ballard (2012) provides a very complete process map from the conception, through the business plan to the start of design (Figure 5.3).

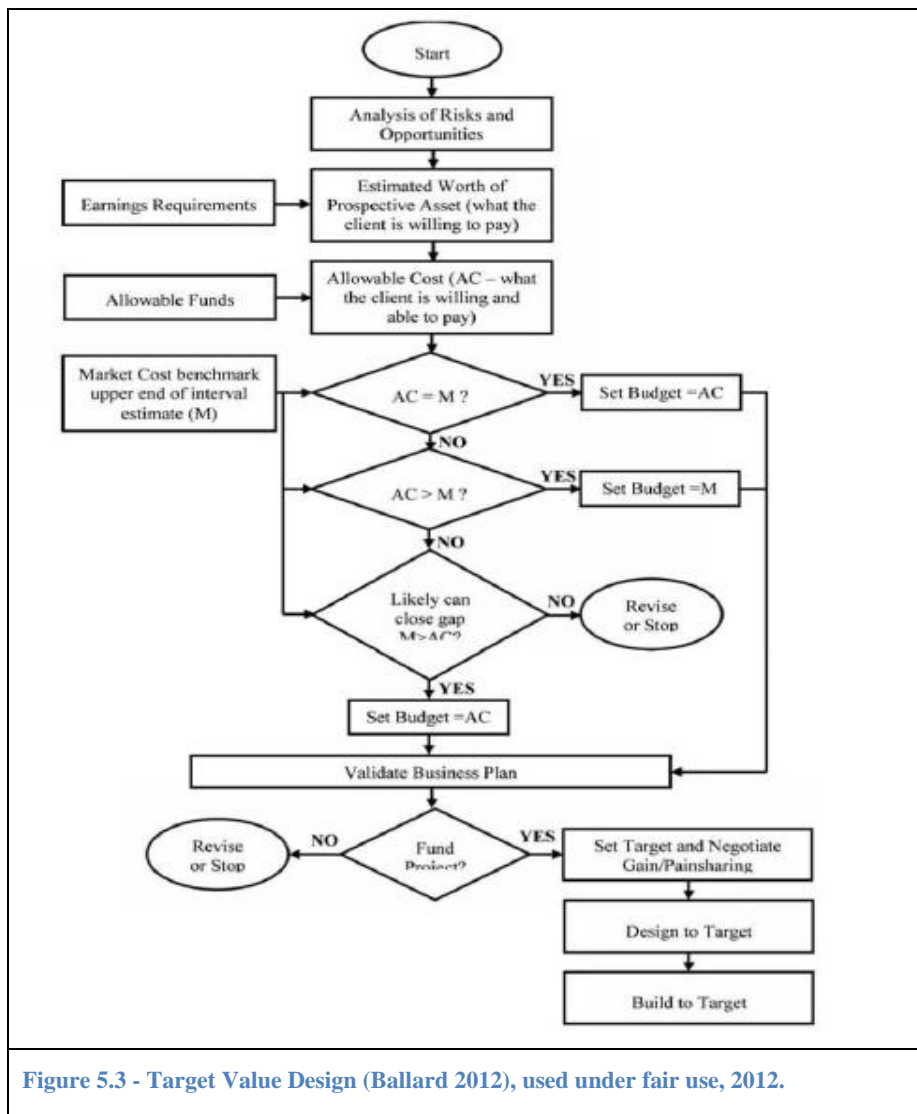
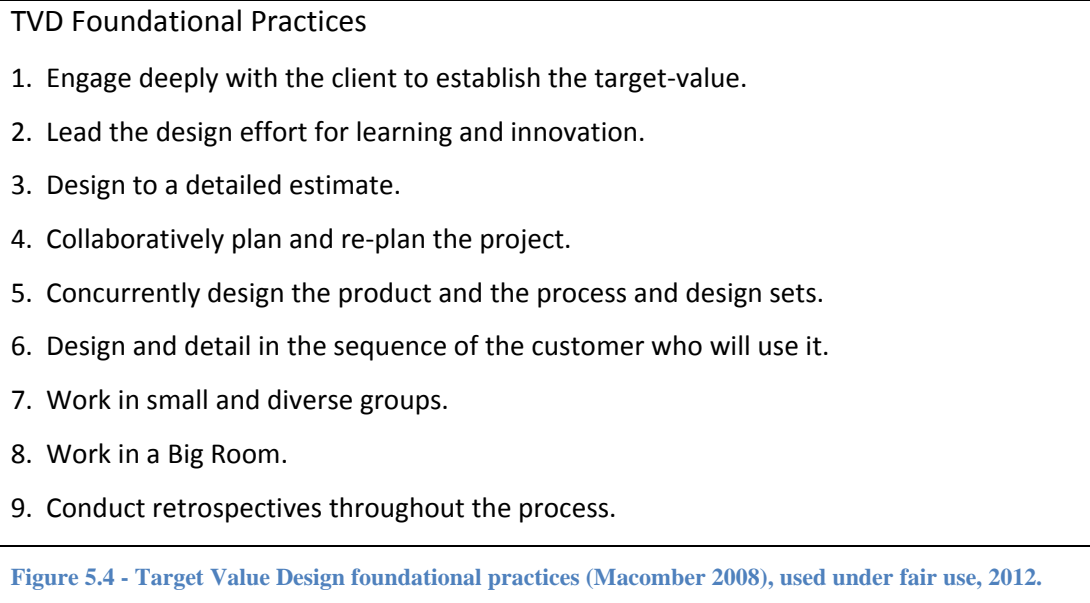


Figure 5.3 - Target Value Design (Ballard 2012), used under fair use, 2012.

Macomber (2008) picks up and outlines nine foundational practices for creating the conditions for delivering the target-value from the design processes (Figure 5.4).



Yet, Zimina et al. (2012) acknowledges that the implementation of TVD can be challenging, as there is still little understanding in the industry of what collaboration really means, in terms of actions and responsibilities on the actors. Entering into a shared risk/ shared reward contract (IPD, IFOA) can be helpful, but the absence of a systemic approach to implementation affects the ability to put the rhetoric of collaboration into action (Lichtig 2005). In addition, Zimina et al. (2012) notes that tools can be useful and even necessary, but “are not sufficient to cause the change needed in attitude and behavior.” The authors go on to say that creating a lean culture requires leadership. This research is designed to evaluate the impact of the leadership and the process of TVD on the capability of the team to deliver sustainability values.

## 5.2 Research Design – Case Study

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The research strategy was to seek out and study the leading edge practice of the Target Value Design process, with the aim of leveraging the industry innovations in value delivery through design management. By examining the value delivery of an exemplary TVD design team through the filter of the challenge level of sustainability, the limitations of the existing process could be revealed.

The collected data, survey and interview questions are analyzed to identify:

- The **Ability** of the TVD **process** (to deliver sustainability values)
- The **Capability** of the TVD **team** (to delivery sustainability values)

Together, these findings identify the key gaps in the ability of the case study to delivery sustainability, and become the practical problem area that is addressed in the research design solution, presented in Chapters 7 and 8.

### Case Study Methodology

Case study methodology is chosen to best address the contemporary events in the Target Value Design process, through observation and interviews of team members actively participating in the design process. The nature of the research is also well suited to the chosen methodology, as it includes processes and cultural, or behavioral, events which cannot be controlled by the researcher (Yin 1994). Additionally, the boundaries between the phenomena (Target Value Design) and the context (design and construction management) are not clearly evident. These are the conditions that Yin proposes are well suited to case study research, in his definitive work on case study research (Yin 1994).

Case study research is an accepted methodology within the academic community of lean in construction. Of the papers presented at the International Group for Lean Construction (IGLC) conferences between 1996 and 2009 IGLC community, 27% of presented papers were case study based, however only 1% of the research included interviews (Jacobs 2010). Case study research

is often challenged by access to projects and personnel, as well as access to information that is considered proprietary or confidential (Kibert 2011). However, this type of narrative data can provide an additional richness of targeted information, and provides insightful evidence for perceived causal inferences (Yin 1994). The case study approach allows the researcher to “observe and document causal factors, explore the details of a particular application and capture observations about how the case in question is similar or different from other projects” (Taylor et al. 2011).

The weaknesses of data collected through interviews can be tied to bias introduces from poorly constructed questions, response bias, inaccuracies due to poor note taking or recall, and reflexivity, when the interviewee gives answers based on what the interviewer wants to hear. In a study of 33 construction engineering management papers based on case study research, only 21 provided evidence for the underlying validity of the models developed (Taylor et al. 2011). Four tests have been commonly used to establish the quality of any empirical research, which are construct validity, internal validity, external validity, and reliability. The validity for this research is presented in Figure 5.5, and detailed below.

Construct Validity	Exploratory case studies Industry and academic literature review Exemplary market sector, client, case	Background Work
Internal Validity	Research protocol, Structured, open-ended interview, Explanation building through follow-on interviews	Data Analysis
External Validity	Replicable survey and interview questions Survey data coded and compiled Interview answers coded and clustered	Research Design
Reliability	Multiple data points per stakeholder group 2 methods of data collection: written & oral Interview transcribed	Data Collection

Figure 5.5 - Validity for the use of case study research methodology

The construct validity of the research was established in the exploratory case studies (Chapter 3), which provided the burden of persuasion for research into the value paradigm of sustainability in lean construction. The construct is the Target Value Design process, and the case was selected based on an exemplary market sector, client and contractor. (see Case Selection, below)

The internal validity of the case is established by following an established protocol, including the consistent application of the data instruments, the combination of closed and open-ended questions and the follow-on calls to verify researcher findings. These research instruments were pilot tested during the exploratory case studies. (see Interview Protocol, below)

The external validity is established by the replicable nature of the research protocol, survey and interview instrument, the coding and sorting, which could be applied to another case study. Furthermore, researcher bias is controlled through the sequencing of an on-line survey administered prior to any verbal interaction with the participant, thus limiting any introduced bias based on participant / interviewer interaction. The potential error in note taking is addressed through the voice recording of the interviews, and subsequent transcription of the full interview.

The reliability of the data is established by multiple data points. All three of the key stakeholder groups are represented (owner, contractor, designer), with at least two data points each participating in both the survey and interview, for a total of 8 data points. The data were collected both on-line, verbally, and transcribed. Additional data were collected to provide the background for the survey and interviews, as well as to support data analysis. These data were from internal project documents, public documents, and direct observation.

The unit of analysis was the design team, characterized by the temporary organizational structure of multi-disciplinary professionals from different organizations, brought together for the duration of one project (Ballard 2012; Otter and Emmitt 2008).

## Research Aim

The research question for the case study is: “How can Target Value Design, an integrated design management process, elicit better delivery of sustainability values?”

This will be developed as the research on two levels:

- The Ability of the TVD process (to deliver sustainability values)
- The Capability of the TVD team (to deliver sustainability values)

## Case Selection

The case study project was selected on the basis of an exemplary market sector, client and contractor. The chosen contractor has been a leader in the lean construction industry. They were a founding member of the Lean Construction Institute in 1997 and have been early adopters of many of the lean construction process, such as the contractual agreement, the Integrated Form of Agreement (Lichtig 2005; Mauck et al. 2009). More specifically to this research, the company has been the innovator of the Target Value Design process (Ballard and Reiser 2004; Lichtig 2010; Mauck et al. 2009).

The client of the selected case study project is equally exemplary. This is a health care service provided in the upper Midwest, who introduced lean in the management of their service in 2003, including the optimization of space design to programming. The client has had a long history of working with the contractor. The case chosen as the base case is the 3rd of 5 phases of a three year, \$65 million update and expansion program of a hospital. As this is a ministry-based health care service provider, the financing was through a community fund drive. The project was described in the local paper as “having a modernized look and have been redesigned to be earth-friendly and help medical staff deliver care more efficiently” (Avila 2011). This is relevant to the research as it pertains to owner’s value, driven by cost, quality of care and sustainability.

The client has more than 10 year commitment of linking sustainable design with evidence-based healthcare and lean principles, which is presented as the vision statement in corporate

documents, and is operationalized through regular patient care initiatives. The company also employs several full time lean coaches and provides a full range of “lean” training for staff, aimed at improving patient care. The owner’s construction project manager was instrumental in bringing many of the formal lean tools to the process, such as process and future state value stream mapping.

The health care industry has been one of the leading market sectors introducing lean into the process management of their services, and applying this “leaning” to the organization of space. This application of lean thinking in healthcare has been well documented, both with theoretical and empirical publications (Dahlgaard et al. 2011; de Souza 2009; Kemmer et al. 2011; Sobek and Lang 2010). The concern for patient flow is the motivation for most of the implementation of lean in healthcare, tied not just to cost reduction, but improving the quality of patient care and safety. Due to the ethical concerns of the core service of providing patient health, the lean improvements are highly scrutinized and well documented. The use of formalized tools is very prevalent, for example, value stream mapping, 5 Sigma, kaizen events, process maps, visual management systems, and some pull systems for supplies inventory (Sobek and Lang 2010).

### *Exemplary Team - Validation*

Internal validity of the exemplary nature of the stakeholder companies regarding sustainability is established through peer evaluations. Each team member was asked to rank stakeholder’s parent companies relative to their perception of the industry. This ranking was based on three questions.

- “At what level do you think most (stakeholder type) companies regard sustainability?”
- “At what level do you think this (stakeholder type) regard sustainability?”
- “At what level do you think most (stakeholder type) act upon sustainability?”

The first question established the industry baseline for that type of stakeholder. The next two questions were specific to the stakeholder company in the design team, and allowed for a differentiation between the regard and the actions. The ranking of sustainability is based on a graduated scale of corporate social responsibility levels, from the minimum regulatory requirements to an implementation based on a holistic perspective. The data is represented in

Table 5.1, providing a visual representation of the average of the weighted responses, as well as the statistical data in the last columns.

Sustainability definition: "Development which meets the needs of current generations without compromising the ability of future generations to meet their own needs."		Regulatory Requirement	Economic Justification	Environmental values	Social Values	Holistic Values	Average weighted score	Standard Deviation	Variance self-assessment avg
Contractors	At what level do you think most construction companies regard sustainability?	●					1.5	0.8	0.03
	At what level does this contractor regard sustainability?				●		4.1	0.8	0.01
	At what level does this contractor act upon sustainability?			●			3.7	1.1	0.16
Owner	At what level do you think most clients regard sustainability?		●				2.4	0.5	0.05
	At what level does this client regard sustainability?				●		4.7	0.5	0.02
	At what level does this client act upon sustainability?				●		4.7	0.5	0.02
Design Firms	At what level do you think most design firms regard sustainability?		●				2.9	0.8	0.00
	At what level does this design firm regard sustainability?				●		4.0	1.0	0.50
	At what level does this design firm act upon sustainability?			●			3.6	1.5	0.10
Trades	At what level do you think most trades regard sustainability?	●					1.4	0.7	
	Was there an exception on this project?	Name: NONE							
	At what level did they act upon sustainability?								
<b>Comments:</b> This is difficult to answer. Both the contractor and the designer are limited in advocating									

Table 5.1 - Perception of stakeholder attitudes and actions to sustainability

Overall, the peer rating of the stakeholders in the case study team were perceived to have a higher regard for sustainability than the industry average, and to also act upon sustainability at a very similar level. The highest level of agreement among the average participants was the ranking of the owner (standard deviation of .5), and the greatest variability overall was regarding the design firm’s level of action on sustainability (STD=1.5). The second greatest variability was the contractor’s action upon sustainability (STD=1.1) and the designer’s perception of their regard for sustainability (STD=1.0). The data indicated that the stakeholders’ self-assessment was similar to the group assessment, with the exception of the design firm, who ranked their firm as regarding sustainability as a social value, with the group average response indicating a lower



systems level of environmental. This slight variation might be based on the fact that the architect does not have an office in the town, thus the contractor and owner have more limited knowledge of the design firm.

In all of the stakeholder categories, the participants judged the representative companies involved in the case study at a higher level than their perception of the industry average, as indicated on Table 7.2. They also ranked themselves and their peer companies to act at close to the same level as they regarded sustainability, in other words, they believed they “walked their talk.” For the purpose of this research, this information was relevant because it validated through peer evaluation the exemplary nature of the stakeholders in this case study regarding sustainability, and eliminated as a variable any obstacle on the part of any of the stakeholders stemming from a lack of regard or commitment to sustainability.

## Research Method

### *Participants*

The study involves eight participants, who are the core team members, peer-identified, and confirmed by the owner’s project roster. These individuals have all been involved on the project since the first phase of the project, in 2005. The core team is comprised of:

- (2) client – owner, and construction manager
- (4) construction –project manager, estimator, health care industry expert, and LEED professional
- (2) designer – principal, and project manager.

Additional data were gathered from the mechanical engineer, and additional contractors who participated in some capacity on the project.

*Survey & Interview Research Instruments*

The research instruments included an on-line survey, followed by a phone interview of structured questions. These were organized to support the categories as set out in the research aim and are presented in Table 5.2, below.

<b>Survey and Interview Research Instrument Design</b>	
Data Categories	Data Collection Questions and Topics
Process Characteristics	Ranking of List of Characteristics, Open Ended Questions
Contribution to Value	Ranking of Listing of Tools, Practices
Leadership	Process Drivers, Culture Transfer
Sustainability Delivery	Aligning Value to Cost, to Sustainability, to Customer Value
Product	Workload, Time Allocation, Workflow, Process Improvements
Process	Personal Benefits, Challenges
Players	

**Table 5.2 – Survey and interview research instrument design**

The survey established a baseline of understanding of the perceptions of the team members regarding Target Value Design and Integrated Lean Project Delivery. This data were gathered in the open ended questions about the definition, characteristics and scope of ILPD and TVD.

- *S1 - Please define, in your words, Integrated Lean Project Delivery (ILPD)*
- *S2 - Is ILPD a model, a philosophy, a process, or other?*
- *S3 - What are some of the key characteristics that are necessary for the project to be considered ILPD?*
- *S4 - At what phase does ILPD start, and when does it end?*
- *S5 - Please define, in your words, Target Value Design (TVD).*
- *S6 - What are some of the key characteristics which are necessary for the design process to be considered TVD?*
- *S7 - At what point does TVD start, and when does it hand over to construction management?*
- *S8 - What is the relationship between TVD and ILPD? Can you have one without the other?*

In addition, there were two questions that asked participants to rank the practices of TVD and ILDP, based on the perception of their contribution to value, reduction of waste, or both.

- *S9 - On this project, what practices were used during the TVD process? Does this practice contribute to increased value, decreased waste or both?*
- *S10- On this project, which of the following practices were used as part of ILPD? Does this practice contribute to increasing value, decreasing waste, or both?*

The listing of the tools and practices used in this ranking was developed in several steps. First, a preliminary listing of TVD tools and practices were collected from two key references: Macomber (2007) and Zimina et al. (2012). These were validated for completeness as part of the exploratory field studies used for the preliminary problem identification (Chapter 3). This list was reviewed and expanded with data gathered on the case study, public documents of the contractor, and initial discussions with the team members at the weekly team meeting. Also, the client had an extensive in-house practice of lean process improvements, and introduced several of these into the Target Value Design process, such as the to-scale modeling of space. In addition, the contractor had several recent innovations in TVD, including the introduction of a shared risk/ shared reward contract (Lichtig 2012). The practices of Integrated Lean Project Delivery (ILPD) were identified from the contractor website, who had trademarked ILPD as a combination of IPD and Lean Construction. These practices for TVD and ILPD are compiled in Table 5.3, and comprised the list included for survey questions S9 and S10.

Macomber 2008	Zimina.et al. 2012	exploratory studies	client lean practices	Contractor and Lichtig 2012
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**Components of Target Value Design**

Modularization of Design			X		
Modeling, space validation		X		X	
Future State Mapping			X	X	
To-scale modeling of space				X	
Set-based estimating	X				
Identification of Success Metrics				X	
Weekly Meetings					X
Set-based Design	X	X	X		X
A3 Reporting		X		X	X
Costed Value Stream Mapping	X				
Explicit Project Value	X				
Choosing-by-Advantages			X		X
Design Thinking/ Ideation				X	
Big Room Co-Location	X				
Other?					

**Integrated Lean Project Delivery (ILPD)**

Just-in-time Supply			X		
Last Planner System		X	X		
Prefabrication			X		
Modularization			X		
6 Sigma			X		
Shared Risk/reward contract			X		X
Kaizen Events			X		
Partnering			X		
Takt Time Scheduling					X
Other					

**Table 5. 3 – Component tools and practices of TVD and ILPD**

The interview was structured in two parts. The first section consisted of 15 questions, and was a continuation of the survey questions, probing for understanding of the TVD and ILPD characteristics, as well as the participation of the team members. The second set of 14 questions were focused on the understanding of sustainability goals, the delivery of sustainability through

the TVD process, and the participation and leadership of team members. The interview questions were structured for internal consistency, with additional prompts for probing questions to obtain further narrative or clarifications. The author sought guidance from research methodology literature to obtain the highest quality of interview data, both in the development of the interview instrument, as well as the skills of interviewing (Lofland and Lofland 1984; Orlich 1978; Yin 1994)

### *Survey and Interview Protocol*

The survey was administered on-line (survey.vt.edu) to participants from the core team of the project, after the signing of the consent waiver as approved by the IRB, but prior to the telephone interview. The interviews were scheduled over a period of two weeks, upon completion of the survey. The interview questions were structured, some quantitative, but mostly open-ended. An interview sheet was developed to capture notes on the responses, and the interviews were recorded and transcribed, to avoid information bias in the note taking. The protocol for the interviews was established as follows:

- Establish rapport, name, confirm completion of survey and consent form.
- Reminder that the interview is tape recorded, and inform participants of right to ask the recording to stop, or to request that the recording be destroyed.
- Explain the research, aim of research, and why this case was selected.
- Manage expectations of interview format. Explain that the format will be brief questions/answers, but that the participant is welcome to volunteer more information.
- Define Sustainability for the purpose of the interview (Brundtland Report, WCED 1987)
- At the conclusion, ask again for any questions they might have, any relevant information the questions might not have covered.

The interviews were completed in full with 7 of the 8 participants. The owner completed the survey, but the first section of the interview was abbreviated due to a lack of his available time.

*Institutional Review Board (IRB)*

Human subject research for this dissertation was approved by the Office for the Protection of Human Subjects at Virginia Tech, under IRB # 12-533.

## 5.3 Review of Findings

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### Data Collection and Processing

Data were collected from several sources, in the following order of access: communications with key team members, public records, company documents, internal project documents, direct observation of weekly meetings, surveys and interviews. These data were processed as presented in Table 5.4, and detailed below.

Communications	The researcher kept a data log of the communication with the contractor and the client.
Public records	Contractor and client website material copied, on-line clips transcribed, and filed for information on the TVD practice, and the public presentation of sustainability issues.
Company documents	Lean training material from client and presentations from the contractor about TVD, both reviewed for specific TVD practices.
Internal Project Documents	Project change orders and meeting minutes reviewed for the representation of sustainability.
Observation	Observation of two of the weekly meetings, notes collected about the nature of the interactions, (reports, dialogues, critical comments allowed), and the power structure in the group.
Survey	Collected on-line. 8 open questions, 2 rating questions of a list of characteristics. Quantitative data coded, analyzed and reported in tables and charts. Qualitative data compiled, analyzed and focused with the overall topic areas of product, process, or players (team members). A spreadsheet was used for ease of data sorting. Review of data included in chapter,.
Communications and Interviews	Semi-structure questions: 15 on TVD and ILPD, 14 on sustainability, 12 more ranking questions of sustainability on design team members. Data collected on an interview form, recorded, and transcribed. Data processed as listed above for survey. Full spreadsheet of interview responses included in Appendix

Table 5.4 - Data type and processing

### *Communications*

The dialogue with the contractor and client was recorded in a communication log. The initial dialogue was concerned with the logistics for the case study implementation. Data findings were then discussed with the owner and the lead contractor, to verify the interpretation of the data, and the significance of this data in identifying the gap that informs the problem solution in the next phase of the research, presented in Chapter 7 (Table 7.1).

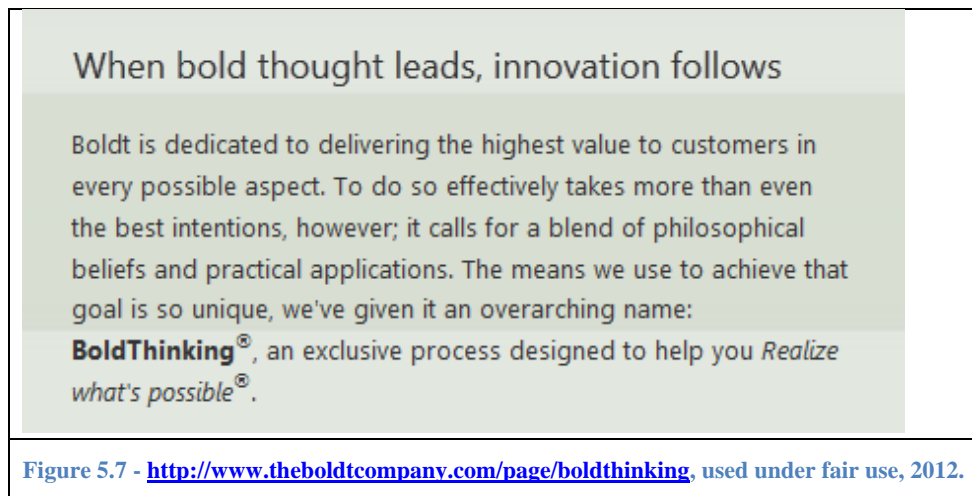
### *Public record and company documents*

Data were collected from the websites of both contractor and client. The contractor website information included video clips of employees explaining the Target Value Design (TVD) process and the Integrated Lean Project Delivery (ILPD). ILPD is the term coined by the contractor to indicate the combination of the Integrated Project Delivery (IPD) process and contract with the lean culture of removing waste and improving value (Figure 5.6).



The contractor also provided copies of PowerPoint presentations, which explained the unique aspects of the company processes and culture. For example, a presentation prepared for the AGC of America, detailed the 12 year journey in the discovery and implementation of the lean culture. The initial step was the use of the Last Planner System in the production phase, followed by process improvements in production management, lean business processes, then product

development improvements and rapid cost modeling, and finally the implementation of 3D modeling, and the road to becoming a “lean enterprise.” Another of the company website pages identified a trademarked “BoldThinking,” which was cited as an exclusive process (Figure 5.7). However, there was no internal corporate documentation to define this process.



The client was equally forthcoming in sharing internal documents. On this project, the client shared some of the internal training documents for lean practices, and examples of some of the standard tools, such as patient value process mapping.

During the initial meeting to develop the research, the owner shared the company vision wheel, which identifies the pursuit of perfection in the areas of sustainability, lean, and evidenced based healthcare, with the aim of fulfilling the corporations promise to provide personalized care (Figure 5.8). The vision statement had been developed over the course of the last 10 years, was presented in corporate documents, and is operationalized through regular patient care initiatives.





Figure 5.8 - Vision Wheel – Affinity Health Systems, used under fair use, 2012.

### *Project documents*

Project data were supplied through access to the on-line project data site. The researcher was given access to the meeting minutes, and the project change orders. These were reviewed for the nature of the discussions about sustainability. The client also provided data on the internal design process for streamlining the patient flow, a future state value stream map, and a visual representation of a typical 24 hour period of patient traffic flow for a proposed design, which was a tool for optimizing the traffic flow in the space. Data were also provided about the active learning lab, which is used for rapid prototyping. This full scale mock-up is intended to facilitate hands-on experimentation and involves a wide range of stakeholders, including nursing and other health care professionals, patients, patient visitors, cleaning staff and others. Whiteboards are used for the walls, enabling participants to draw locations of fixtures, notate heights, and ideas (Figure 5.9). This is one of the innovative practices that originated from the client’s “lean” coaches and was broadened to include participation from the full construction design team, to include aspects of constructability, heating/ cooling, and sustainability.



Figure 5.9 - Active learning labs

### *Observation*

The researcher gathered data from observation at two of the weekly meetings. The structure of the observation was open ended note taking, with a particular focus on:

- The nature of the interactions - reports, dialogues, critical comments
- The power structure in the group – leadership, parity, commitment.
- Evidence of team learning, whole systems mindsets, and mental models regarding problem solving and working through obstacles.

While the researcher was a silent observer of the meeting in progress, she was engaged in conversation with the participants during the breaks of the meetings. These dialogues provided additional information which helped provide clarification of some of the observations.

### *Survey and Interview*

The survey of 9 questions was administered online to the 8 core team members of the TVD team. Quantitative data of survey question were coded, analyzed and reported in tables. The qualitative data was compiled into a spreadsheet. The 29 interview questions were administered online upon completion of the survey. The interview generally were of one hour duration, following the structured listing of questions, some quantitative, but mostly open-ended. The researcher captured notes on a blank interview sheet, and the interviews were recorded and transcribed, to avoid information bias in the note taking. These transcriptions were analyzed for emergent themes and insightful comments, which were organized into a spreadsheet format (Appendix A). This raw data was then focused by categories of product, process, and players relative to their impact of value delivery, and the findings are presented in this chapter. The spreadsheet data was analyzed a second time through the lens of a learning organization. This analysis provides the data which is presented in the manuscript, which is Chapter 6.

### Survey Results, Summary

The survey results are presented below. Data that could be coded or quantified is presented in a table format. All other data is presented as a representation of the participant comments.

#### ***S1 - Please define, in your words, Integrated Lean Project Delivery (ILPD):***

- “Working as one cell identifying and managing risk and responsibility” (contractor).
- “Full understanding of the needs and wants of the project stakeholders” (contractor).
- “Desired outcomes and sets clear expectations for the success of the project” (contractor).
- “ILPD (vs. IPD) brings Lean process improvement into the project” (contractor).
- “Enables each team member to make decisions based on what provides value and benefit to the project” (architect).
- “Culture of continuous improvement” (owner).
- “A collaborative and collegial model that will provide a higher value project” (owner).
- “Making a project come to life” (architect).

- “Free of the old constraints - rigid contracts, legal threats, ‘that's not my job’ issues” (contractor).

***S2 - Is ILPD a: process or philosophy?***

The responses were as follows: Process (2), Philosophy (2), both (3), Culture 1. There was no clear finding on this question, but the intent of the question was actually to help prepare the participants for the next question about the characteristics of ILPD, and in preparation for question S8, which asks about the relationship between ILPD and TVD.

***S3 - What are some of the key characteristics that are necessary for the project to be considered ILPD? (vs. IPD or other)***

This was an open ended question. The responses were coded (1 count per participant per coded item, thus a maximum of 8 per item), with the results presented in Table 5.5. Additional information gained from the interview identified that many of the participants correlate IPD (Integrated Project Delivery) with the shared risk/ shared reward contractual agreement of IFOA (Integrated Form of Agreement), which was developed by a member of the lean community who had recently hired on with the contractor. However, the articulation by 5 of the 8 participants of information sharing and transparency can be understood as a culture which results from the ILPD structure.

Key Characteristics of ILPD

Information Share, Transparency	5
Risk - Identify , share and manage	4
Iterative design and estimating	2
Eliminate waste & rework	2
Collaborative team work	2
Focus on customer defined value	2
Outcome metrics identified	2
Contingency funds managed	1
Accountability for work and costs	1
Culture of respect, trust	1
Vision for project	1

**Table 5.5 – Key characteristics of ILPD**

#### ***S4 - At what phase does ILPD start and when does it end?***

The respondents were in complete agreement that ILPD starts at conceptual phase of design and continues through building operations. There is no hard hand-off between phases. One contractor even suggested: “It hopefully doesn't end but rather rolls into the next project, taking the team development and collective learning with it.”

#### ***S5 - Please define, in your words, Target Value Design (TVD)?***

- “Collaborative development of a budget based on owner expectation of value” (contractor).
- “Accepted and shared vision of what the product will be to deliver that value” (contractor).
- “Determining the scope of work that can be performed within the defined budget by assessing the greatest value each alternative would bring to the project” (owner).
- “...this budget includes design and construction costs...as design is further in the process, the budget may grow or decrease...If some budgets grow, the hope is that others decrease to keep the overall budget in line with the original goal” (architect).
- “Multiple solutions are considered for each of the major project elements, and that these potential solutions be evaluated on a best value basis” (contractor).
- “The IPD team then periodically tests that model weekly / monthly to refine the target costs for each category of material needed in the project. As more information is known about the project, costs become more certain” (contractor).
- “Working as teams to overcome issues when the targets are exceeded or want to be exceeded” (architect).
- “Changes from a discussion of what things *cost* to one of what things are *worth*” (contractor).

The interviews further clarified some of the benefits of TVD, which include a greater clarity of the project scope and goals. The general consensus is that TVD is a process, involving the identification of value, a problem solving approach to design, with several solutions, and an iterative costing to deliver the scope value.

***S6 - What are some of the key characteristics that are necessary for the design process to be considered TVD?***

This was an open-ended question, with space for short answers. Some of the characteristics are summarized and listed as follows:

- Change in thinking, focus on value (contractor).
- Clear and unified vision, value communicated and agreed upon by team (architect).
- Accountability for cost and performance, sharing of incomplete information (contractor).
- Budget aligned with target value and scope. No net increase in budget (owner).
- Design by component teams (users, designers, constructors) (contractor).
- Early involvement of contractors' major trades (owner).
- Real-time cost feedback (contractor)

***S7 -At what point does TVD start, and when does it hand over to construction management?***

This question builds on question S4, which asks about the start and end of ILPD. This question is specific to TVD as a design management process. The answers revealed some ideal scenarios vs. the existing state. Generally, the indication was that the earlier the better for the start.

- “TVD starts with the alignment of the cost to the vision” (contractor).
- “Ideally no later than project funding, may start soon” (contractor).
- “Inception of project” (architect).
- “It starts in spirit immediately but officially once the budget is approved” (owner).
- “There was no fixed handover from inception to design phase, and there is also no traditional “hard” handover to construction” (contractor).
- “TVD is not handed off, it ends when the construction ends” (contractor).
- “It is never handed over to the CM, it is always the responsibility of the team” (architect).

These statements are congruent with the observations. The contractors are already involved in the design phase, and the core team continues to hold joint responsibility for the project outcome. What happens is the shift of focus throughout the TVD process. According to one of

the contractors: “Construction management begins when the system is defined, and the detail design process begins. This is not a hard hand off but rather a continuation of process in which the primary input shifts from the constructor rather than the user.” This continuous and collaborative management may be contractually organized (IFOA), or be established despite the contract.

***S8 - What is the relationship between TVD and ILPD? Can you have one without the other?***

The nature of the relationship is presented in Table 5.6, and generally represents Integrated lean Project Delivery (ILPD) as the underlying philosophy, with Target Value Design (TVD) as the specific process.

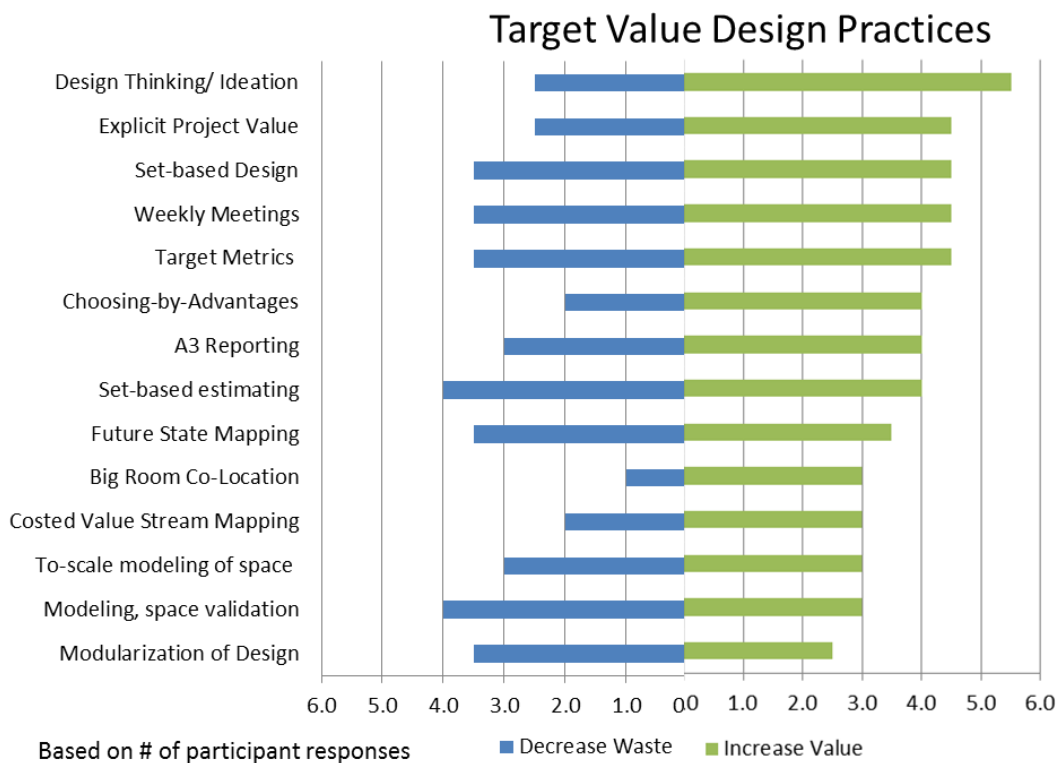
<b>TVD</b>	<b>in relationship to</b>	<b>ILPD</b>	<b>Participant</b>
process	complement	integration	Contractor
methodology	implement	process	Contractor
tool	support	culture	Owner
tool / how?	part of	culture/ why?	Owner
	inseparable		Contractor

**Table 5.6 – Relationship between TVD and ILPD**

The responses by the architects avoided the use of labels, but indicated that while it could be possible to have TVD without ILPD, this would be “disjointed,” “difficult to adopt new thinking without ILPD,” and that without the ILPD, “we often see a Guaranteed Maximum Price (GMP) at the end of design drawings or end of construction drawings.” This would essentially curtail the continued responsibility of the team, and is thus not aligned with the key characteristics of TVD.

***S9 - On this project, what practices were used during the TVD process? Does this practice contribute to increased value, decreased waste or both?***

This question and the next were designed to identify the relative contribution to value vs. the reduction of waste of individual activities of Target Value Design, and of Integrated Lean Project Delivery. The participants were asked to rank each activity as primarily decrease waste, increase value, or both, in which case the score was split evenly. The scoring of the 8 participants is presented in Figure 5.10. The bar represents the total of the participant scores given. Some participants chose to not comment on practices with which they were not familiar, such as the Big Room Co-Location. As this research is focused on value creation, the practices have been ordered by their perceived contribution to value creation.

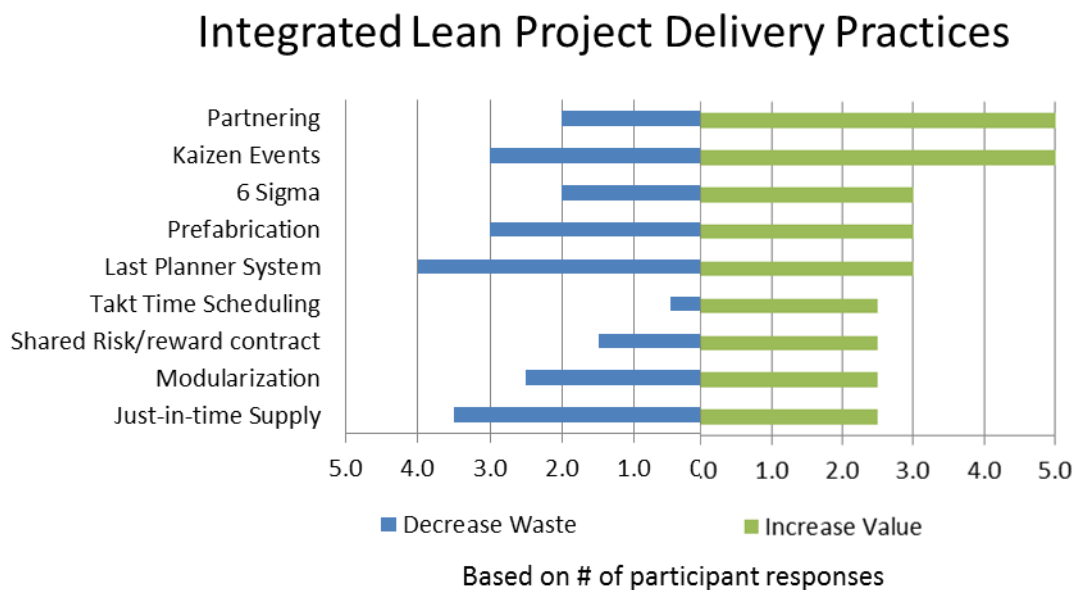


**Figure 5.10 - Value creation vs. waste reduction in Target Value Design**



The top practice identified as contributing to value is design thinking or ideation. The team had been exposed to design thinking with a workshop presented by the mechanical contractor. The next four practices selected as value contributions are explicit project value, set-based design, weekly meeting and target metrics. It is interesting that Future State Mapping, as practiced by the team, was seen as much as a tool to decrease waste as it was to increase value. Data gathered during observations of the team meeting, and an exercise of Future State Mapping confirmed that the ideation of the future was not an element of this practice, rather it was focused on the implementation. The key finding on this question is that TVD practices *can* be characterized by their contribution to value creation relative to waste decrease.

***S10- On this project, which of the following practices were used as part of ILPD? Does this practice contribute to increasing value, decreasing waste, or both?***



**Figure 5.11 - Value contribution of practices within ILPD**

This question was intended to generate some thought and dialogue from the participants to clarify what they believed was IPD. The question was scored the same as the previous, and also did not require a participant response. The bar chart presented in Figure 5.11 depicts the perception of the practice contribution to value creation relative to waste reduction. The

participants identified partnering and kaizen events as the most significant contributing practices. The owner provided a clarification that kaizen was considered to be an ongoing practice of continuous improvement. This emphasis on continuous improvement and the emphasis on partnering rather than competitive business arrangements is consistent with the original emphasis of the Toyota Management System. It is, therefore, worth noting that the shared risk/ shared reward contract is perceived as contributory to value, but not as much as other practices. This team did not operate under a shared risk/ shared reward contract, which has been developed for IPD projects. Findings from the interviews indicated that the team members felt that the value driven team culture could be implemented even in absence of this contract.

### Interview Results - Summary:

The interview questions were analyzed for emergent themes, based on insightful comments. These were organized into a spreadsheet format (Appendix A), and the answers focused by categories of product, process, and players relative to their impact of value delivery. The aim of this research was particularly interested in the impact of the players, and the process insofar as it was influenced by the players, or the team culture. A summary of the remarks is presented below, within these categories. An analysis of the findings evaluated through the lens of a learning environment is presented in the manuscript, included in this chapter (Section 5.4).

#### *Leadership and Culture*

Open-ended questions were used to identify the drivers of TVD, ILPD at the outset of the first section of the interview, and open ended questions for the “champion” of sustainability and the “keeper” of the green goals at the outset of the second section of the interview. The words “driver” “champion” and “keeper” all denote responsibility or leadership, however have distinct differences regarding the nature of the object being delivered. A “driver” implies that the process or event is determined and the “driver” provides the leadership for the implementation. These interview questions came after the survey, in which the participants had been asked to define TVD and ILPD, and identify the key tools and practices. Therefore, these were

established practices, and the interview questions were concerned with identifying the driving party in the implementation.

For the question concerning the leadership of sustainability, the choice of the word “champion” is more aligned to the aspiration of a goal, or an ideal. For the question concerning the responsibility of the green goals, the choice of the word “keeper” connotes the responsibility of delivering specific metrics or schedules. The use of a generic phrase of “green goals” was intended to keep the focus of this question on the conceptual differentiation between the ideal of sustainability and a generic concept of green building metrics, rather than a specific metric. The specifics of the metrics were identified as part of the participant answers, and were addressed in follow-on questions.

The responses were quantified, with a split count when the response contained two parties, such as “owner and team.” The results are presented in Table 5.7. The most significant finding is that none of the participants, including the architects, identified architects as drivers of either of the TVD or the ILPD process. This can be partially attributed to the fact that both ILPD and TVD originated from the contractor, but in fact one of the architects perceived the owner to be the driver of both TVD and ILPD. This, in turn, reflects the very high profile of the owner and the owner’s project manager in driving both the logistics of the design management, but also in introducing their own ‘lean’ culture and practices. These findings are significant in view of the fact that Target Value Design is a design management process, which was traditionally completed internally within an architectural firm. The very presence and participation of the owner and contractor in the design process represents a significant change, but this data indicates the recognition of a “team” as a separate identity.

	Owner	Team	Contr.	Arch.	Other
Driver of TVD	2	4	3	0	
Driver of ILPD	1	6	2	0	
Champion of Sustainability	8	1	0	0	
Keeper of the Green Goals	2	2	4	0	1 - no one

**Table 5.7 – Leadership of lean and sustainability in the core team.**

Data from the observation of the design meeting confirmed that the meeting was administered jointly in a team fashion, with different members assuming separate but coordinated responsibilities. Further data gained through the interview revealed the recognition of this emerging team approach, as well as the need to better manage the process. The owner noted that: “The outcome is really based on how you set up expectations and manage expectations to the process. The problem is when there is not a consistent understanding of those expectations, on all three major parties. As long as everybody has a clear understanding of expectations, understands the process, and abides by the process, it's pretty much a sure win.” One of the contractors confirmed a need for a “more robust validation of the process,” and the lack of a “consistent understanding of the process expectations.” Also, it was noted that “principals of organizations could do a better job within their own internal team in teaching the process off-line, not in core team meetings.” These remarks would indicate a need to make the process more explicit, which would clarify understanding, and facilitate the teaching of the lean concepts within the stakeholder groups, prior to bringing new players on-line.

On the other hand, the data in Table 5.6 indicates that sustainability was very clearly driven by the owner, while the gatekeeper of achieving the green goals was attributed to the LEED AP, who was an employee of the contractor company. One architect noted a lack of clarity on green goals, and offered the opinion that the communication about the LEED goals were poorly communicated, and that there was no one in particular as a champion of sustainability. These

interview questions prompted a fair amount of additional discussion as to who *should* be the driving force. The owner expressed the frustration that he often felt like he was the sole voice for sustainability, and that he hadn't been able to get the rest of the team to "own" this vision. On the other hand, several of the team members acknowledged that the responsibility for achieving the green goals was shared, but cited a lack of clear understanding as to what were the goals actually were. They noted that the team was very capable of delivering on explicit goals, and that ambiguous vision statements were not easily translated to actionable goals.

Another question addressed the uniqueness of the culture created by ILPD and the TVD process, and the ability to learn, or transfer, this culture. Most participant responses suggested that all teams develop a unique culture, and all of the stakeholders had participated in an integrated, collaborative environment on other job. However, through additional probing questions, the participants clarified that this particular case has a culture which was particularly high in the level of trust, in collaborative skills, and in the development of personal skills of the core team. Part of this is the unusually long duration and consistent composition of the team, due to the multi-phase aspect of the project, but also the very progressive nature of each of the stakeholders. All of the stakeholders could point to some affirmation of sustainability in their company vision, and their company's internal operations. Asked if this culture could be transferred, the participants hesitantly agreed, but stressed that the owner would really need to be on board. This was consistent with the answer on the survey regarding the ability to implement TVD without the underlying integrated culture, and the emphasis on the need to have the owner's commitment. The answer was essentially that you could implement some of the steps, but fall far short of the full benefits of the culture, without the owner's full commitment.

#### *Sustainability - Product impact from TVD*

As established in the protocol, prior to the interview questions relating to sustainability, the participants were provided with the definition of sustainability established in the Brundtland report (WCED, 1987) of: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

The responses relative to sustainability in the product could be clustered into four general categories: sustainability value definition, aligning value to cost, sustainability value increase in the product, and sustainability goals aligned with customer value.

- **Sustainability value definition** - This was one of the few areas of discrepancy of the responses among the participants, and it was a significant difference. There were distinct perspectives regarding the goals and the clarity of the goals concerning sustainability and/or green building goals. Some participants understood the goal of sustainability to be aligned with owner vision, others believed it to be aligned with the Owner's Project Requirement, and yet others pointed to green building criteria such as LEED Healthcare. While it could be expected that these would fall out along the line of the owner and architect seeing the greater vision, and the contractor looking for a green building "list," there was actually a level of ambiguity from all the stakeholders as to the alignment of the Owner Vision, the Owner's Project Requirement (OPR), and the LEED criteria. The need and impact for a unified vision is an area for future research. This information is also presented in the Manuscript #1, Table 1 in Chapter 6.
- **Aligning value to cost** - The participants generally agreed that sustainability was a value to be considered along with all others in the selection of options, and thus not itemized as a separate cost. One of the architects noted that the cost of the sustainability is essentially "baked" into all the items. On the other hand, some items that have a clear return-on-investment are evaluated on an independent financial basis, such as renewable energy equipment. Only in a few cases are items set aside as an additional cost allocation, such as a green roof, which did not have a defined return on investment due to energy or other cost savings, but was chosen for reason of improved patient care, as the patient rooms in one wing of the hospital overlook the roof. Overall, the owner commented that the higher profile of value definition, linking value to outcomes, and costing this outcomes helped to improve the overall accountability of project costs to owner value, at any point in time of the design, which made it easier to provide audit compliance documentation.

- **Sustainability value increase in the product** – One of the open-ended interview questions was: “Were there ever options which arose to exceed the stated green building goals? If so, how was this information handled?” The owner noted that: “It was key that we started with the vision and just use LEED as a standard of work tool. LEED did not put an upper limit.” Other participants echoed the sentiment that the TVD process supports the exploration of options through practices such as set-based design, A3s, Choosing-by-Advantages. A contractor noted: “As a group, we will throw out a bunch of ideas, consider them, and then see there is a way to make this fit, we are continually challenging ourselves to better design, always respectful of the budget, and patient experience.” Another contractor noted that: “The team has struggled with this and wants to find a way to implement more of these options, and yet meet a budget.” For example, the owner volunteered that there were some areas of improvement they were pushing for on other projects, such as a 100% daylit building, and the other a zero waste food service. This is consistent with previous data identifying the owner as the principle leader of sustainability, and this data would indicate that the team was willing to incorporate these ideas into the project, given the cost and other outcome parameters.
- **Sustainability goals aligned with customer value** - The participants’ responses were reflective of the previous question about the nature of the sustainability goals. The participants who had indicated the project sustainability goals were reflective of the owner vision also perceived an alignment with customer value. However, those participants who had identified a disparity between the stated LEED goals and the more ambiguous owner vision of sustainability pointed to this disparity in response to customer value. A few responses indicated that the alignment of the project goals with the corporate goals should be better defined and capture, in order to share the information with outside stakeholders, such as corporate boards, or the public.

#### *Sustainability - Process impact from TVD*

Most of the interview questions were concerned with the impact of the TVD on the design management process, with regard to the delivery of sustainability.

- **Workload** - The overall workload is not considered to be affected by either the TVD process or sustainability, once the initial adjustment is made.
- **Allocation of Time** –While the total duration of time in design was reduced, it became more front-end loaded, and more concentrated. This meant that team members would work on fewer projects at any one point in time, and stay concentrated. It also carried a certain level of stress of weekly deliverables.
- **Workflow** – The flow of work is greatly affected by the TVD process. It is more continuous, intensive, transparent, sharing, and based on problem solving and collaborative work. There was an observation from the designers that the rapid pace of decision making precluded the ability to “think things through” and that decisions lacked synthesis. An analysis of the data identified a possibility of shifting the “synthesis” thinking time from a solo exercise of the architect to a team exercise.
- **Process Improvements** – The challenge is to keep the process from slipping back into traditional roles and patterns. For example, the team can be gathered in the same room, yet process design documents in a traditional way, with architects and contractors “tossing the document over the wall” to each other for the next phase, rather than actually working on the document together. In an integrated process, team members would need to participate pro-actively in the design discussion, looking for ways to contribute and for ways in which their trade may impact or be impacted by the design options. For example, the lead estimator realized that there were opportunities to actively participate in generating, evaluating and selecting design options, by leveraging the estimating data.
- **Process Tools** – Several were specifically mentioned, such as the Choosing by Advantages tool, which supports the team working through a collaborative process in making a selection among several options. Due to the advanced level of sophistication by the client in the use of lean process tools, the team interactions were marked by a higher use and awareness of lean tools.



### *Sustainability – Team member impact from TVD*

- **Personal Benefits** - The overall nature of the comments regarding the Target Value Design process were of a positive impact on the players and their ability to contribute to the process. “I have more confidence in the outcome, more confidence in our ability to meet the budget,” “reduces stress,” “can sleep at night,” “having everyone at the table from the beginning, everybody understands, it’s like a dream.”
- **Personal Challenges** - Participants noted that the TVD process is dependent on a culture of trust and dedication to value delivery, and that it is not easy to change cultures. People in the construction industry are used to working behind closed doors, finishing up their work, and the delivering in a written format. Participants noted that not everyone can adapt to the nature of open communication and the sharing of partial information. Also, a few of the participants noted that there was an initial increase of angst and stress from the continuous expectations of weekly deliverables, but that this decreased over time, in an inverse relationship with increasing levels of trust and comfort with the process.

## 5.4 Discussion

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The data from the surveys and interviews pointed to a general consensus among the team members regarding the positive benefits of Integrated Lean Project Delivery as an underlying philosophy, or culture, and the practice of Target Value Design as the design management process. ILPD creates a culture of trust, open information exchange, financial transparency, and shared risk. TVD is value driven and collaborative, and improves the confidence of the team in their ability to meet the budget. Key findings are presented according to the original focus of the research, to identify how Target Value Design can elicit better delivery of sustainability values, both from the level of the ability of the TVD practices and process, and the capability of the TVD team.

## TVD Practices / Tools

- Target Value Design practices **can be characterized** by their contribution to value versus the reduction of waste. To the best of the researcher's knowledge, this research had not previously been done. The significance of this finding is in the application of TVD for design teams who have successfully passed the threshold of delivering minimal value, and are seeking for opportunities to design added value. The top practices that are perceived to help create and align value with project goals are: design thinking/ ideation, explicit project value, set-based design, weekly meetings and target metrics. While the last three are current practice of the case study TVD process, the design thinking and setting explicit project values, especially for sustainability, are less well developed practices, and have implications for the delivery of sustainability.

## TVD Process

- In TVD, as a continuous value management, the **accountability** for cost and performance is **redistributed to the shared responsibility of the team**. This is done through an iterative design and estimating process, collaborative decision making, and increased information exchange and transparency. While this increases the workflow and the pace of the design decisions, it also improves the clarity of the information and the confidence in the cost estimate of the project at any given point in time. A future area of research is the development of value management skills by individual members of the design team.
- The **collaborative design management** of TVD **increases the expectations** for all of the team members to **participate in the design decisions**. This is a considerable deviation from the traditional design responsibilities and pace, which allocated longer lengths of time for the architect to consider design options and synthesize information. A future area of research is the possibility of leveraging the collective design abilities and innovation of the team to provide the function of synthesis of design concepts.
- In the case study, the TVD process created an identified "team" entity, which was considered to be the driver of both the TVD process and the ILPD culture. This occurred even without the formal legal recognition of a shared risk/shared reward contract wherein

These findings are significant change from the traditional leadership of the design management process as the design firm. A future area of research is the change in responsibility and leadership as a result of a “team” entity leading the design management process.

### TVD Team

- The **owner’s support and endorsement** is considered to a **key to implementation of TVD**, and as such, the owner is the most likely stakeholder to transfer this practice to additional projects. A future area of research is the understanding of an owner’s role, responsibilities, skills and impacts on the TVD process.

### Gap in the Delivery of Sustainability

Sustainability can be seen as a **goal**, the **cause** for change in the A/E/C management process, and the **challenge** level that reveals the limitations of the current management system in delivering that goal. In this case study, the TVD process seemed to be working well overall, as the team was able to meet the commercial terms of cost, schedule and quality. Yet, the greater challenge of delivering the sustainability vision as expressed by the owner revealed the limitations of the current TVD process and / or team, since there was an identified gap between the owner’s vision of sustainability and the delivered results of green building goals.

This gap can be understood in three areas:

- **Ownership of the Sustainability Vision** – The team relies on the owner as the champion of sustainability and doesn’t take individual ownership of the sustainability vision. The complexity of sustainability calls for a redistribution of the responsibility for the design of sustainability to all of the team members, and for a visionary approach to sustainability to become embedded in the underlying culture of the project. This redistribution also represents the opportunity to develop skills to contribute to the creation of sustainability value. In the case study, the example was given of the estimator who contributes to value

through the Quality Cost Index, and demonstrates the ability to relate the design of sustainability to his own work.

- **Explicit Sustainability Values** - Making corporate sustainability values of the owner explicit at the level of the project could help the team identify actionable values and objectives. Recognizing that project values are nested, or shaped by the corporation sustainability values helps to align these values, and communicate the realization of objectives to outside stakeholders. Introducing the practice of design thinking could be used to make the values explicit, and provide regular intervals for creativity and innovative solutions to address the challenges of sustainability.
- **Unified Vision** – Creating a unified vision would help provide clarity of the sustainability goals. The process of problem solving through design thinking exercises can create the dialogue to help understand the challenges of sustainability develop solutions and agree upon them as a team.

This chapter provides the specific problems areas and opportunities that provide the basis for the design of the intervention workshop, described in Chapter 6.

## 5.5 References

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## Chapter 6

### Manuscript #1: Design Management of Sustainability Values: A Learning Organization Perspective

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The manuscript document is presented in the following pages, in the format as prepared for submittal to the Architectural Engineering and Design Management (AEDM) journal, published by Taylor & Francis. The reference style is APA .

The journal requirements are an article length of maximum of 7000 words, abstract of 200 words, and 5- 10 keywords.

The manuscript is based on evaluation of the case study data. The topic is the capacity of the design team to deliver sustainability through the Target Value Design process, as evaluated through the lens of a “learning organization.”

# **Design Management of Sustainability Values: A Learning Organization Perspective**

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# **Design Management of Sustainability Values: A Learning Organization Perspective**

The issues of sustainability are complex and intertwined, blurring traditional stakeholder boundaries, calling for a design process that supports innovation and learning. The purpose of this study is to investigate the challenges faced by a design team in identifying and delivering sustainability values. This is developed through case study research of an exemplary design team and project, practicing Target Value Design (TVD), an integrated design management process that aligns client value delivery with target costing. The capacity of the design team is evaluated through the lens of a ‘learning organization.’ While the Target Value Design process supports value delivery from an organizational perspective, the evaluation of the findings points to two key conditions that affect the delivery of sustainability solutions beyond the current green building criteria. First, the need for articulation of explicit sustainability values in order to build a shared vision. Second, a mind shift toward a whole systems approach in order to identify trans-disciplinary opportunities for innovative solutions. The focus of this study is on the role of the design team, and has practical implications for the management of complex sustainability projects, and for human resource development.

Keywords: Design management, sustainability values, learning organization, whole systems approach

## **Introduction**

The demand for sustainability is increasing and will continue to grow, supported by owner demand and legislation targeting net zero energy goals (McGraw-Hill Construction, 2011). The current sustainability paradigms are largely represented as a formulaic approach to green building (du Plessis, 2012), but the reliance on an aggregation methods does not support a systemic understanding that could break through the cost barrier and reduce costs through synergies or elimination of redundant systems (Hawken, Lovins and Lovins, 1999). Attaining higher levels of environmental performance requires the design team to consider the building as

an integrated system within the larger context of global sustainability issues, which in turn shapes a more integrative design approach and the blurring of traditional knowledge boundaries (Laszlo and Cooperrider, 2007).

The approach taken in this research was to study an exemplary design team practicing the integrated design management practice of Target Value Design, and to analyse that team's capability to identify and deliver sustainability values. The data gathered about the team are evaluated through the lens of a "learning organization," which includes the practices of systems thinking, unified vision, mental models, team learning and personal mastery. Sustainability is both the goal and the challenge that reveals the limitations of the current system in the delivery of that goal. While the Target Value Design process supports value delivery from an organizational perspective, this study will focus on the human factor in the design management process.

### **Design Management**

Implementing sustainability in building projects often requires complex design analyses, energy modelling, and more detailed component integration, according to Horman et al. (2006). Rekola, Mäkeläinen, and Häkkinen (2012) note that designing for sustainability entails a "comprehensive understanding and command of multilevel, interconnected, and sometimes contradictory requirements and the ability to collaboratively create new innovative solutions that fulfill these demanding requirements." Tzortzopoulos-Fazenda and Cooper (2007) propose that this additional project complexity is one of the main drivers behind the innovations in design management. The design activity, previously the domain of one individual in a "black box" manner, must now be performed by a multi-disciplinary team, necessitating an increased degree of transparency and established procedure (Schön, 1983).

Design management, as the management of the process of design, is a nascent discipline in the architecture and construction industry. Existing empirical research reveals an emphasis on the organizational structure of the design practice and the management of the design product (Sebastian, 2004). Mills and Glass (2009) propose that there is little understanding of the role of the actors in the design process. Even the role of the design manager, already poorly defined in a traditional design process, is rendered more ambiguous in the new contracting and delivery models. This is supported by Mitchell, Frame and Coday (2010), who identify a theoretical dichotomy between the cyclical nature of the design process in contrast with the linear nature of the construction process. This incongruity of process expectations is rendered even more complex with the increased membership of a design team in integrated project delivery, in which the design process is even more distorted from its traditional flow.

This ambiguity of roles creates problems in implementation. Egan (2004) made it clear that sustainability will not be immediately adopted without adequate training for the personnel expected to implement it. In turn, the precursor to skills training is a better understanding of a) the effects of sustainability on the balance of power between developers, designers and construction companies (Rekola, Mäkeläinen and Häkkinen, 2012), and b) the types of new competencies and understanding of sustainability that is needed by the actors involved.

### **Systems Thinking and Learning Organizations**

A key to the understanding of sustainability may lay in the very interrelated systems nature of sustainability itself. Fernandez-Solis (2008) postulates that the intertwined, dynamic, complex character of the building construction is the arena where one can observe a paradoxical co-dependency of product (what is, being, artifact) and process (the becoming of what should be).

The process of managing sustainability in design and construction can be understood as a system

of interdependencies, where each project is unique to the customer and the situation.

The fundamental concept of systems approach is as old as the Aristotelian world view that the whole is more than the sum of its parts. This view was displaced by Descartes' reductionist approach of breaking down complex phenomena into elementary parts, which worked well, insofar as observed events could be split to isolable causal chains, with only two variables. However, "it is a fact of observation whenever we look at a living organism or a social group" that "order or organization of a whole or system transcends its parts when these are considered in isolation" (Von Bertalanffy, 1972). In the late 1920's, biologist Bertalanffy proposed a "general systems theory" of the organism, to include information of the "coordination of parts and processes." This provided the foundation of understanding of biological ecosystems, and sustainability as a complex, self-organizing system. Bertalanffy (1972) proposed that one part of this "systems philosophy" is concerned with "the relations of man and his world, or what is termed *values* in philosophical parlance." This humanistic concern of the original general systems theory marks a difference to mechanistically oriented systems theorists, and Bertalanffy emphasizes that it is the re-orientation of thought and world view to a "system" paradigm that matters.

The key challenge to transforming an organization to a mental model of a whole systems approach has less to do with the goals of the transformation than with the role of people, both as actors in the process and in the social system surrounding the process, according to Dervitsiotis (1998). One approach to this organizational change is to start by building the learning capacities in the organization. According to a study by Chinowsky, Molenaar, and Realph (2007), in order for the construction industry to adopt a learning organization culture, the concepts of "continuous learning and personal advancement must become fundamental operating concepts within

organizations at every level and throughout every project and business process.” The basic premise of “planning to learn” was first introduced by Michael (1973), and was later expanded to Senge’s (1990) concept of a learning organization, comprised of five practices: personal mastery, mental modes, building a shared vision, team learning, and systems thinking.

A distinction is made between a learning organization and organizational learning. Senge (1990) describes a learning organization (LO) as a continuous process of aligning and developing the capability of the team to create the results its members truly desire, while Örtenblad (2001) explains that organizational learning is the activities going on in the learning organizations. While these concepts are clearly related, one point of distinction is the target audience. In a LO, the focus is on the entity doing the learning, which can be understood as either the individual the organization (Argyris and Schön, 1978), or a community of practice impacted by the collective learning (J. S. Brown and Duguid, 1991). The learning organization is like an ideal school, which is focused on improving the ability of students (the entity) to learn. In contrast, the focus of the study of organizational learning is the phenomenon of the learning activity itself, the action taken to develop and refine cognitive maps, for example, the Argyris and Schon “theories-in-practice” (1974).

### **Application to Construction**

While the concept of the learning organization has become widespread in management circles, literature references to a whole system approach and learning organizations in construction is relatively limited, according to Love et al. (2004). Studies, such as the discussion by Fernandez-Solis (2008), present construction as a complex system of independent or autonomous agents that are in a constant state of flux and thus require self-modification and learning. However, Butcher (2011) points to the paucity of research into the *customer* benefits from becoming a learning

organization in the UK construction industry. Chinowsky et al (2007) notes that the focus on job-site production often overshadows any process improvements, for example increasing the capacity to learn, however Raiden and Dainty (2006) find that there are no major obstacles to construction organizations adopting many elements inherent in a learning organization approach. One of these elements is a whole systems approach to problem solving. Kerzner (2009) presents the systems approach from a project manager's perspective as a "logical and disciplined process of problem-solving," while Schön (1983), in *The Reflective Practitioner*, offers it as a theoretical starting point for understanding how architects "think on their feet" and reflect on action. Love (2004) notes that while some organizational learning does occur in construction problem-solving, the obstacle to creating the synergy proposed by whole systems approach is a mindset that is primarily focused on correcting errors, rather than preventing them. Changing the mind set to a preventative solutions-oriented mode can foster the continuous improvement and support a customer oriented and value-added strategy (Garavan, 1997). The shared "problem solving" mindset and the resulting collective action become the building blocks of the learning organization.

What remains unclear is the application of these findings to the temporary inter-organizational structure of a construction project. Most of the current studies are conducted from within the perspective of the intra-organizational company perspective, and acknowledge the difficulty of generalizing the findings to the dynamics of inter-organizational construction project teams (Chan, Cooper and Tzortzopoulos, 2005). Indeed, Chan et al. (2005) suggest that much of the empirical research represents the learning organization as a lens to "understand the real world." The real world of a design team was described by Groák (1994) as a "temporary coalition in a turbulent environment," which is made more turbulent with the addition of new

stakeholder groups in the in integrated project delivery design team. Tatum (1984) confirmed that project management is not established in a systematic method due to pressures for immediate decisions and the manager's time constraints. This only increases the turbulence and can impact the product outcome. This lack of rational management models has been a concern that has been addressed by the lean construction community with the introduction of the Last Planner System for construction management, and the development of the Target Value Design process for design management.

### **Target Value Design and Learning Organizations**

The Target Value Design process has several areas of similarities with a learning organization, both fundamentally and in practice. Target Value Design draws from its roots in Toyota Project management in the commitment to continuous improvement for the delivery of value (Macomber, Howell and Bargerio, 2007). This is operationalized in a process of value alignment to the business proposition, and a practice of future state modeling and value stream mapping (Ballard, 2012). This can be understood as Senge's (1990) concept of "shared vision" and a shared "mental model," which can be developed as a result of a shared risk/ shared reward contract (Lichtig, 2010). In Target Value Design, team learning is facilitated by weekly team meetings or co-location, scale modeling of space, set-based design, and the reporting and decision making methods that are based on collaborative efforts (Macomber, Howell and Bargerio, 2007). A systems approach is facilitated by the broad membership of the design team to include permanent representation of constructability and owner needs, and regular involvement of other stakeholder groups representing community interests and user groups.

The point of departure for this research is to build upon the knowledge about the characteristics of design/ construction teams as learning organizations, and identify the relevance to the delivery of sustainability.

## **Research Design**

The aim of this study is to investigate the challenges faced by a design team in identifying and delivering sustainability values in construction projects. The research strategy is to identify and study an exemplary design team practicing Target Value Design, an integrated design management process that aligns client value delivery with target costing. The capability of the design team to deliver sustainability through this process is evaluated through the lens of a “learning organization.”

Target Value Design (TVD) was initially developed within the lean construction community as an adaptation of target costing to construction projects (Macomber, Howell and Bargerio, 2007). TVD is emerging as a complete design management process, “used to structure and manage the project definition and design phases of construction projects with the goal of delivering value to customers within their conditions of satisfaction, which typically include cost and time, but may include other conditions as well” (Ballard, 2012). It is characterized by active owner involvement and high degree of stakeholder collaboration, an iterative design process, and a shift in the design focus from pure cost to a discussion of worth.

The case study was selected for the exemplary nature of the team and stakeholder parent companies. The contractor of the selected case study is one of the industry leaders in lean construction, and a lead innovator of the Target Value Design practice (Ballard, 2012). The health care client has more than a 10 year commitment of linking sustainable design with evidence-based healthcare and lean principles, which presented in the corporate vision statement



and operationalized through by several full time lean coaches through lean training for staff and “kaizen” events aimed at improving patient care. The owner’s construction project manager was instrumental in bringing many of the formal lean tools to the process, such as future state value stream mapping. The architect was also well versed in lean management, and had recently completed a Six Sigma training with the owner representatives. Not only did this further augment their individual lean training, but it helped create a more cohesive team culture.

The unit of analysis is the design team, characterized as the temporary organizational structure of multi-disciplinary professionals from different organizations, brought together for the duration of one project. Central to the advantage of this case study selection was the unusually long duration of the team entity. This core team had been together for almost 4 years over the course of three phases of construction, which provided the opportunity to improve upon the design management process with each successive phase. This is unusual in an industry more often characterized by short duration gathering of independent professionals, with little opportunity for knowledge capture, much less process improvements (Tan, 2010). In addition to the advantage of time, this team was also able to bridge some of the traditional conflicts between stakeholders, due to the commonality of the lean thinking culture in each of their parent organizations. This is relevant according to Zuo and Zillante (2005), because project culture has a significant impact on the smooth processing of construction information.

The case study methodology provides a phenomenological perspective of the individuals’ experiences working with the Target Value Design process, and their representation of the management of sustainability in this process. The research data were gathered from an on-line survey and telephone interviews with each of the 8 core team members, including at least two each of owner, contractor and designer, with additional representation from the green building

specialist, and an additional contractor specialist. An interview sheet was developed to capture notes on the responses, and the interviews were recorded and transcribed. Validity is established through the recording and transcribing of the interviews, the coding and compiling of the data, and explanation building through follow-on interviews. The semi-structured interview format was identified as the best way to discover what was truly important to the participants. This inductive approach was chosen for greater exploratory freedom in the research domains of integrative design practice and the holistic approach to sustainability. The data was coded, sorted and focused by the overall categories of the questions, and then by emergent themes. The data were then evaluated through the lens of the principals of a learning organization, to shed some light on the capacity of the team in delivering sustainability.

The data from these interviews were augmented with the use of observations and review of public and project documentation. Background data included public documents from internet websites, lean training material provided by both client and contractor, and previous academic literature on the Target Value Design process as practiced by the contractor. The researcher also observed two of the design team meeting, in order to gather data about the nature of the interactions between the team members, and the power structure in the group.

## **Findings**

The data revealed a high level of agreement from the participant as to their understanding of the process of Target Value Design, the implementation and their participation. There was only one area in which the participants diverged in their responses, and this was in the understanding of the goals of sustainability on the projects. This divergence of understanding is explored through the evaluation of the findings through the five practices of learning organizations.

## *Unified Vision*

The identification and explicit articulation of value and the creation of wealth has been a primary theme in “lean” literature, starting with the Womack and Jones publication of lean thinking (1996), which promoted value specification as the first of the five lean principles. Similarly, the Target Value Design process stresses the importance of aligning the business case to the explicit client value proposition, yet Kelly (2007) points out the difficulty of articulating of value with any metric beyond the traditional cost/ utility equation. Sustainability values are even more elusive and difficult to make explicit, as they invariably trigger a life cycle chain of impacts and transcend traditional industry boundaries.

In this case study, there was an ambiguity in the explicit understanding of the sustainability goals. As presented in Table 1, participant perceptions of sustainability goals ranged from the vision of sustainability as expressed by the owner, to the Owner Project Requirement document, to the LEED criteria. Thus, there was a difference between the more philosophical or fundamental concepts of sustainability and the understanding of sustainability goals as LEED green building criteria. The differences were not linked to any stakeholder professions, but seemed to be related to the level of involvement with the project of any given team member. For example, Owner 2 (O2) and Contractor 4 (C4) were the two primary project managers, and thus were more highly aware of the high level goals for the project, including the owner vision of sustainability. On the other hand, both of the architects identify the sustainability goal as the green building metric.

Table 1. goes here

Interestingly, there was some level of frustration expressed by the owner (O1) and contractor (C2) that the individual team members didn't "own" the sustainability vision. Data from the interviews clarified that these stakeholders believed the Owners Project Requirement (OPR) adequately expressed the sustainability vision, and that this document would be at the center of design decisions. However, when asked, none of the participants could locate a copy of this document, even while all participants voiced their support for the owner's commitment to sustainability. These findings suggest that the "knowing" and agreement with a sustainability vision is insufficient to provide a basis for suitable project decisions. Jorgensen and Emmitt (2009) offer the explanation that all participants need to be involved in the creation of this vision in order to be motivated to act upon it. Kibert (2011) proposes that there is a difficulty in the expressing of a sustainability vision as actionable goals, since "ecological design is in its infancy and sorely needs articulation."

### ***Mental Models***

Senge explains mental models as the "deeply ingrained assumptions, generalizations, or even images that influence how we understand the world and how we take action." The call for a mind shift of mental models in construction has been voiced both in the UK and the US (Latham, 1994; Miller, 2009). Eliminating mental barriers determines how (in what manner) actions are executed. A shared belief is essential for cross-functional collaboration. Where a reductionist and protectionist stance was closely tied to the traditional low bid contracts, the emergence of the shared risk/shared reward contracts (Consensus Doc 300, IFOA) supports increased collaboration among project participants (Lichtig, 2005). This shift from risk management to problem solving during the conceptual design phase can provide the trust and social psychological support needed for open communication and commitment to problem solving

(Sebastian, 2004).

In this case study, the contractual model did not include a shared risk/ shared reward clause. However, the research participants confirmed that a culture shift can take place anyway, in spite of the type of contract, as long as the owner is on board. Table 2 presents the participant comments about the impact of TVD on the team culture and on the work load/ flow. Participants reported an increase in confidence and less angst from arguments and uncertainty, although a few participants noted a temporary increase in stress, mostly due to the change of pace of the design work.

Table 2 goes here.

The team describes itself as “cohesive,” “working as one cell,” and “sharing ideas, experience, and performing the project free of the old constraints of rigid contracts, legal threats, ‘that’s my job’ issues.” When asked how the team handles opportunities to exceed stated green goals, the participants were in agreement that such options could and were considered as a group, and that the team is continually “challenging itself to better design, always respectful of the budget, and patient experience.” When asked in an open-ended question to identify the driver of the TVD process, 4 out of the 9 respondents identified the “team” as the entity which was responsible not only for the design process, but also the underlying integrated project delivery culture. This mental model of team identity is a significant shift from the mental model of competitive individuals in a more traditional construction environment.

### ***Team Learning***

Beyond the willingness to collaborate and work toward a common goal, there are specific design

management skills that can be cultivated to enhance the team's ability to work together. Weekly face-to-face meetings or work co-location greatly enhances the knowledge creation by tapping into tacit knowledge (Snowden, 2002). In addition to the formal information exchange, informal dialogue is important because the "interaction enables understanding, stimulates sharing of expert design knowledge and encourages team building" (Otter and Emmitt 2008). It is particularly important to gain some cross-over knowledge, in view of the enlarged membership of the design team in an integrated design process. For example, the inclusion of the owner in the design process is often marked by initial adjustment phase as they get comfortable with the flow of design process (Siva and London, 2012). There is also a need to create a common dialogue to bridge the classic discrepancy between the architect perspective (aesthetic-holistic) and contractors (scientific) approach (Dammann and Elle, 2006).

In this case study, data gathered through observation and interview indicated that there were several process improvements that supported team learning. The iterative design approach changed the pattern of information processing from the traditional pattern of work in isolation, and handing over completed information in a written form. Instead, team members are asked to share partial information for collaborative discussions and decision making, in real-time on a weekly basis at the team meetings. In addition to the more formal meetings, there is also dialogue between sub-groups, or pairs of stakeholders, to gain an "empathetic" perspective on the topic under discussion. The owners in this case study did *not* have need for an adjustment, or learning curve to the design process, since they already have previous experience participating on a design team and have gained considerable knowledge of design and construction issues. On the other hand, the architect and contractor had an opportunity to learn from the client, who had a comprehensive and sophisticated process of "lean" design for patient flow and patient care. The

entire design team was invited to participate not only on site visits, which is a typical activity of traditional design management, but also on rapid prototyping exercises, where the design team joined the health care user groups for a shared learning-by-doing experience in the design of the facility around the construct of patient care.

The team also uses a collective decision management tool, called Choosing-by-Advantages (CbA), which helps guide the team through a process of discovery about the relative advantages of options being considered at that point in design. For example, during one of the observed design meetings there was a discussion about the placement of an elevator. Several options were presented, their relative advantages discussed along with the implications on patient care, safety, construction and design. These options were considered in a CbA exercise, wherein the architect established the decision factors, the owner identified the relative level of importance, and the contractor supplied the pricing and constructability. This allowed for the exploration of multiple options, supported team learning that crosses traditional knowledge boundaries, and facilitated consensus for the final decision. The benefit to the client was the ability to shape and articulate the client value through the discussion. It was also helpful for the contractor to understand the drivers behind the design. “I know a lot more of the drivers behind the design, so during construction I know why we can or can't do things.” (C4)

The team discussions about sustainability were primarily based on the sub-topics that are can be part of sustainability, without consideration of their impacts on the holistic concept of sustainability. The topics were typically the cost/value decision of green building materials or mechanical systems function. The participants in the topics were typically delimited by the related stakeholder responsibilities. For example, the lead mechanical designer sponsored a design thinking workshop for the design team, with the goal of helping the team recognize the

systemic nature of energy efficiency issues and the greater impact on sustainability issues. Data gathered from an interview with the sponsoring contractor, and confirmed by the owner, indicated that the team members responded favorably to the workshop content, and were able to contribute some innovative ideas, albeit still within bounds of their own discipline. However, the owner noted that there was no transfer of this innovative thinking after the workshop to the general project discussion. Energy efficiency was seen to be the domain of the mechanical contractor. This contractor suggested that any such future workshop would need an additional component to help participants become aware of the learning, and a component at the end that would transfer the learning back to the “real world” work.

### ***Personal Mastery***

It has long been recognized that people contribute directly to the project outcome, but there is less awareness of the idea that people can indirectly affect the project through their impact on the process (Fernandez-Solis, 2008). For example, in a continuous value management process such as TVD, the value delivery of a project is influenced by the value management skills of each team member. In this case study, there were several instances of personal mastery and innovations in value analysis and management. The lead estimator developed a Product-Quality-Cost model, which allows him to determine a quality rating that relates individual design projects in comparison to an average of baseline projects. This takes the basic function of cost-estimating and adds a component of value, in the form of a quality rating that can inform the design decisions. The contractor also noted that there is an opportunity for an estimator to take an even more pro-active role, and serve as a resource in the design process. This same opportunity was advocated 25 years ago by Tatum (1987), as a means of improving constructability during conceptual planning.



The design firm was equally innovative in the mastery of skills for greater design efficiency and value management. They had recently reverse engineered the lean manufacturing process, in order to apply it to their knowledge management process. This included a human resource component, in getting the right people on the team, but also included a process component. At the outset of design, the architect would identify design set points, which needed to be decided upon and “frozen” in order to avoid redesign work. For example, a major component, such as the stairs, would be developed early in design, based on considerations of traffic patterns and design aesthetics. Once this decision was made, it would not be readdressed, and the other components of design would conform to this decision. This more robust process of design development helped the owner to articulate and identify the relative value of each of the components in order to identify the most important ones for set points. It also helped the team identify the dependencies related to these set points and organize their own work accordingly.

### ***Whole Systems Thinking***

The construction process is intertwined, dynamic and complex, yet “design and construction management is often fragmented to the point that subcontractors are generally unaware of important building system interactions” (CBC, 2011). Thus integral innovations, no matter how cost efficient or promising in terms of energy saving potential, are unlikely to be implemented unless project professionals are also integrated to some degree. The greater the degree of integration, the more likely the integral innovations will be accurately implemented. Sheffer and Levitt (2012) propose that mediating the integration of the design and construction team members, both vertically and horizontally, can significantly increase the rate of adoption of innovations. Kleinsman (2006) explains that collaborative design is influenced by “mechanisms that create shared understanding,” these being at the interface, or boundaries, of the groups of

actors (or the trades), as well as between the design team and the organization. Only when truly “wicked problems” are posed, of such complex social-environmental nature that they defy the existing slate of solutions, that a whole systems thinking is triggered and traditional boundaries overcome (V. A. Brown, Harris and Russell, 2010).

While there are many methodological approaches to systems thinking, this research accepts the fundamental concept expressed by Von Bertalanffy (1972) as the re-orientation of thought and world view to a “system” paradigm. Specifically, this research is interested in the impact of this whole system worldview on the design of sustainability. In this case study, a few of the participants exhibited a disposition to this interconnected thinking, both through the nature of the questions and comments made during the weekly meetings, as well as from input volunteered during the interviews. For example, the designers had expressed a potential problem area in the TVD process of not having the time to synthesize concepts and work through concept models. One of the other participants volunteered that the *team* capabilities had not really been tapped as a creative and critical review body, which could provide the multi-disciplinary input to help with the architect’s stated need of synthesis.

An example of a problem that was solved by a whole systems approach was the patient care goal of having zero transfer of infectious diseases. This was presented as a significant current problem in health care facilities. The problem was first viewed from a medical viewpoint and proposed solutions including more physical controls and sanitizing procedures. Then, the design team was asked to look at this problem from alternative perspectives. The mechanical contractor, who was the sponsor of the previously noted design thinking workshop, introduced a more whole systems approach to the problem. He led a discussion that first examined the

methods of disease disbursement, determined that there were different levels of risk per patient type, and finally recognized that most of the risk was from diagnosed infectious disease patients. While this was not a significant number of patients, there was considerable benefit from isolating them from the rest of the patients. This was achieved by creating a separate clinic, with a separate entry that could access existing patient processing staff. These examples demonstrate the potential for problem solving through a systemic consideration, tapping into the creative potential of individuals and combined team abilities. What is also noteworthy is that the discussion was led by the mechanical contractor, but the solution was ultimately a design decision which was then supported by the mechanical isolation of the space.

## **Conclusions**

The purpose of this study was to investigate the challenges faced by a design team in identifying and delivering sustainability values. The research strategy was to identify and study an exemplary design team practicing Target Value Design, in order to leverage the innovations of the lean construction community in value management through design. The complex challenges of the delivery of sustainability served as a filter to reveal the limitation of the current TVD process. The capacity of the design team to deliver sustainability through this process was evaluated through the lens of a ‘learning organization.’

This data from the case study confirmed the selection of the design team as an exemplary innovator relative to value management and design management. Most of the stakeholders were developing personal mastery of value management skills, the team learning was enhanced by a solutions-oriented mental model of several of the team members and the experience and commitment of the owner, and cohesiveness of the team was evidenced by the recognition of a “team” as an identifiable entity driving the TVD process.

As anticipated, the challenges of sustainability did reveal the limitations in the current systems and identified the gap in the capability of the team to deliver sustainability, and the corresponding needs:

- The ownership of the sustainability vision is not distributed, and remains primarily with the owner. This can be partially understood by the inability of the team members to relate the sustainability values to their own work, and the limitations of their own mental models to discussions within their own discipline. This can be identified as a need for the team to learn how to function in a trans-disciplinary mode and whole systems mental model.
- The TVD process and team capability supports the deliver the explicit values, but the explicit values as stated in LEED does not capture the full extent of the owner's vision of sustainability. There is a need to render the owner's vision of sustainability more explicit, as an articulation of actionable sustainability goals. While this may provide difficult, any level of clarity which is rendered during discussion will help close the gap in the goals. This level of discussion calls for an understanding of the system nature of sustainability and an ability to design and innovate in this whole systems mental model.
- The discrepancy in the understanding of the sustainability goals for the project hampers the ability of the team to develop a unified vision of sustainability. Developing a unified vision is a collaborative practice of articulating and discussing values and goals in order to gain a team consensus. In this manner, the vision becomes collective knowledge and embedded in every design decision. Addressing this gap is dependent on the previous two gaps: an explicit

understanding of the goals, and the abilities of the individuals to relate their work to these goals. Only then can a discussion of a unified vision be presented.

The author recognizes the limitation implicit in the selection of an exemplary case study of an emerging practice of design management. While this approach captures the innovations developed in practice, the findings are not intended to indicate a hierarchy of variables for the purpose of implementation, and is, as such, not generalizable to common practice, but can contribute to a theoretical understanding of a value driven design process.

The recognition of the link between whole systems approach, sustainability, and collaborative design management has a potentially significant impact on teams who have established very aggressive goals of sustainability. A future area of research is the potential for creating a facilitated process to help teams gain the skills needed to understanding the system nature of sustainability, experience a whole systems mental model, and use this mindset to design and innovate solutions to sustainability.

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Table 1. Perceptions of sustainability goals

What are the goals on this project related to sustainability, and how were they stated?	
Participant Answers:	Participant ID:
Stated as Vision, LEED was a work tool for accountability	O2, C4
Stated as Metrics, in Owners Project Requirement	O1, C1
Stated as Green Guide for Healthcare, then LEED	A1, A2, C3
Goals ongoing and evolving. Metric was LEED	C2
Participant Coding: <b>O</b> wner, <b>A</b> rchitect, <b>C</b> ontractor and participant number	

Table 2. Differences in Target Value Design culture and impact on workload

Impact of TVD on team culture and on work.	Participant
“Higher confidence level on budget, reduces user angst, a lot less argumentative.”	O2
“More rigorous, fewer surprises.”	A1
“More exacting, demanding of real-time work.”	A2
“More intense, higher value use of time, higher level of contribution.”	C1
“More efficient, clear expectations, so less stressful.”	C2
“TVD changes the culture from the old report-out method of communication.”	
“Requires continuous communication, observations, and feedback. The reward is more confidence, more control over the details and the budget.”	C3
“The open forum of communication reduces the angst.”	C4
Participant Coding: <b>Owner, Architect, Contractor</b> and participant number	

## Chapter 7

### Cultivating a Whole Systems Approach in the Design Team

#### Chapter Summary

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The preceding chapter presented the case study describing the capability of the Target Value Design team to elicit better delivery of sustainability. The topic of the first manuscript was the evaluation of this case study data through the lens of a learning organization. The findings identified a gap in the capability of the team to adopt a mental model of a whole systems approach in order to make explicit the values of sustainable prosperity and develop a unified vision. This provided the basis for the core of the constructive research, which is an innovative solution to the problem, and is the topic of this chapter. The specific research question is: “How can design teams gain an understanding of the systemic nature of sustainability, and how can this understanding impact the design process?”

The first section of this chapter provides a review and recap of the constructive research method as it has been applied to the overall dissertation work, in order to provide the foundation for this portion of the research, the design of a solution. The proposed solution is an intervention method. The second manuscript, presented in Chapter 8, is a discussion of the design of the intervention method itself, and a testing of the method through a workshop experiment. Included in this chapter is the raw data from the post-workshop assessment.

## 7.1 Constructive Research Method



The previous chapters presented the literature review, scope refinement, and case study analysis to establish the parameters of the real world problem for the action research portion of the constructive research methodology. Information on the overall constructive research methodology was presented in Chapter 1, and is depicted in Figure 7.1. This chapter presents a more detailed description of the application of the method to the steps taken for this research. This information is provided as the background to the design of the intervention method, which is the topic of the second manuscript.

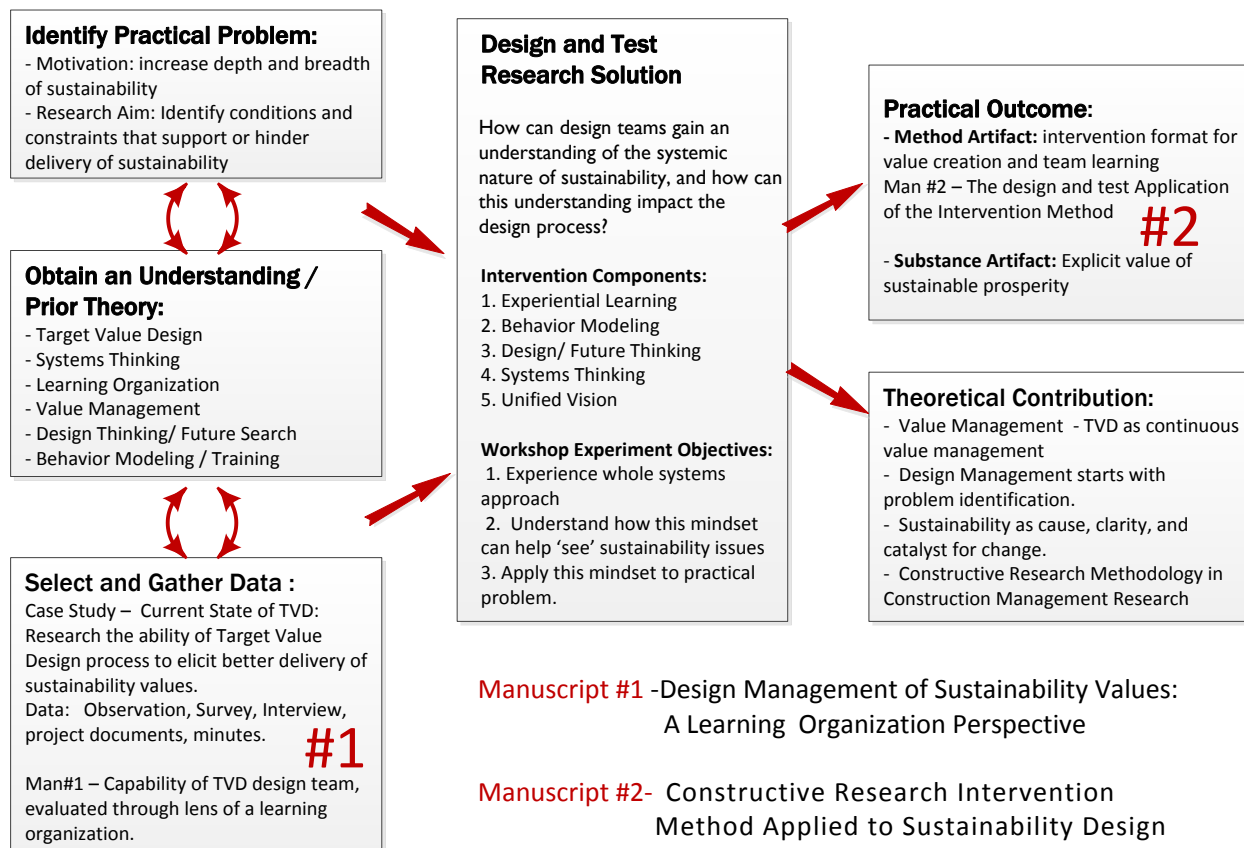


Figure 7.1 – Constructive research method

### *1. Find a Problem*

The first element of the methodology, identifying a practical problem area, was presented in Chapter 1. The research problem, or overall aim, is the need to increase the delivery of both the depth and breadth of sustainability. The overall approach to the doctoral work is a causal analysis, looking for the root cause, which, if addressed, would bring the greatest opportunity for change. As part of the investigation in the early phases of the doctoral work, the scope of research has been narrowed to the construction design *process*.

### *2. Obtain an Understanding*

The next step in the constructive research method is to obtain an understanding of the stated problem both in practice and in theory. Chapter 2 provided the theoretical foundations to gain an understanding of the research area. The approach for this application was to use descriptive research to gain understanding from practice. Three case studies were conducted, establishing the burden of persuasion to support further research into the paradigm of value as the leverage point for sustainability in lean construction (Taylor et al. 2011). The findings, presented in Chapter 3, pointed to the importance of the human factor (the actions of the design team), and the importance of the commitment from the owner and the contractor to the creation of value. Literature studies identify that value creation is more closely identified with the design phase, as the highest opportunity to effect a change with the lowest cost implications (MacLeamy Curve, CURT 2004). These findings shaped the first phase of the dissertation research and narrowed the scope to a study of Target Value Design, as a leading practice that combines the focus on value creation within the design phase.

Finding a practical problem and obtaining an understanding is an iterative process. The development of this solution should be seen as “profound cooperative teamwork, into which both practitioners and the researcher contribute, based on the input information of both practical and theoretical origin” (Lukka 2003). There was a level of refinement of the problem definition in this research, as a result of the knowledge gained during the data collected through discussions with the owners, internal and public document, and the interviews conducted as part of the case study. Table 7.1 provides the chain of evidence for the scope refinement (Taylor et al. 2011).

Data source/ date	Scope Refinement of Practical Problem
From literature and previous research	Scope of research: Human agency of sustainability values in the Target Value Design process. Ground in data from case study to probe for potential problem areas.
01/26/2012 Tel; Scott Morton, Boldt	Identify client as exemplary practitioner of Target Value Design process. Discussed interest in research area of sustainability delivery.
03/02/2012 Tel; Gary Kusnierz, Affinity	Gary discusses “design to Ideal” concept, and the desire to increase level of sustainability in project. Possible problem area: limitations with LEED, and lacking awareness of sustainable prosperity / vision beyond green.
05/23/2012 Pilot study with MSU students	Pilot study – Facilitator training in design thinking. Exercise for student to design an eco-system, and gain awareness of the systemic nature of sustainability, the link between waste and resources.
05/30/2012 Observation - case study weekly design meeting	Observe a discrepancy between explicit LEED green goals, and general awareness of broader sustainability vision. Doesn’t seem to be a problem of awareness of vision. Possible problem area: a limitation of the Target Value Design system? Explore the representation of sustainability in the TVD process.
06/01/2012 to 06/11/2012 Additional data mining from website and company documents	BoldThinking, ILPD (Integrated Lean Project Delivery) and TVD (Target Value Design) were not explicit practices, but were accepted concepts. Thus, no explicit practice to analyze regarding the handling of sustainability values or green building. Research would need to include a benchmarking of perceptions and practices regarding TVD and ILPD. Modify survey and interview questions to probe for this.
06/11/2012 to 06/25/2012 Interviews with case study design team	Survey and interview questions designed to probe for perceptions of actor / peer commitment to sustainability, characteristics of the ILPD and TVD process, representation of sustainability, and relationship with company vision. Confirmed gap in understanding between green goals and sustainability vision, but doesn’t seem to be a lack of willingness or basic acceptance of sustainability values beyond green .Gap - lack of experience/ mental model of whole systems approach,
06/25/2012 Follow-up calls to owner, stakeholders	Refine objectives of workshop to: 1. Experience a whole systems view, 2. Understand how this mindset can help identify sustainability issues and solution sets 3. Apply this learning in a collaborative manner to address a practical problem of sustainability.

**Table 7.1 - Scope refinement of practical problem**

### 3. Gather Data

The problem identification defined the scope as the practice of Target Value Design, with a particular focus on the representation of sustainability. While previous studies have documented the organization, commercial terms, and operating processes of Target Value Design, this research focused on the role of the human agency, in their individual skills and collective abilities. The next step of the research is to gather data about this topic are. The methodology was a case study, and the data from the survey and the interviews are presented in Chapter 5, and the manuscript in Chapter 6.

### 4. Design and Implement a Solution

Underlying the success of any intervention is the importance of addressing the right question. A diagnostic approach would identify the root causes of the original problem, and then reframe these as needs that can be linked to possible actionable solutions. An example of this diagnostic approach is presented in Table 7.2, with the sample data from the case study presented in Chapters 5 and 6. The table shows the process of converting the root causes identified in the case study, reframing the problems as needed, identifying possible actionable solutions, and finally identifying the theoretical knowledge base needed to gain understanding of these solutions.

	Identify Root Causes	Frame the Needs	Propose Solutions	Theoretical Foundation
1	Team relies on owner as champion of sustainability, and doesn't "own" the vision	Improved " <b>ownership</b> " of sustainability vision - help team members relate sustainability values to their own work.	creative exercise in systemic nature of sustainability, and transfer of mindset to a trans-disciplinary approach to the design environment	whole systems thinking behavior modeling
2	Owner frustrated that LEED doesn't capture full vision of sustainability.	<b>Explicit</b> sustainability values -to be open-ended and challenging, but also explicit and actionable	create method to make sustainable prosperity goals explicit	design thinking
3	Team split in agreement on green goals, some LEED, others cite energy requirements in the OPR	<b>Unified</b> vision, <b>embedded</b> sustainability values, developed and agreed upon as a team.	identify process, timeline and visual communication to align sustainable vision with green building criteria	unified vision

Table 7.2 – Problem conversion to solutions



In reviewing these causes, needs and solutions with the owner and contractor, the decision was made to structure the solution as an intervention design. A final column identifies the theoretical foundations of the solution areas. The academic resources for each of these theoretical foundations are presented in Table 7.3, and reviewed in the second manuscript in Chapter 8.

<b>Organized by Theory</b>	
Behavior Modeling	Button (1996); Dweck(1998, 2006); Kirkpatrick (1967); Taylor et al.(2005)
Training Programs	Alarez (2004); Gardner (1970)
Whole Systems Approach	Von Bertalanffy (1972); Checkland (1981); Dettmer (1997); Martin (2005);
Design Thinking	Brown (2009)
Unified Vision	Kusnic-Owen (1992)
Collaboration	Sebastian (2007)

Table 7.3 - Theoretical foundation of intervention workshop

### *5. Assess Practical Usefulness*

The practical problem that has been addressed by the design solution is the need for the team to have the capability to adopt a mental model of whole systems thinking, in order to make sustainability values explicit at the level of regenerative design, and develop a unified vision of project goals. This is an ambitious goal, as Kibert (2011) has pointed out the difficulty inherent in the articulating of this level of sustainability, since “ecological design is in its infancy.” This lack of practical interpretation is echoed by Clegg (2012), in a special edition of the Building Research and Information Journal on regenerative design, who state that: “many of these collected papers are long on theory and short on practical examples” (Clegg, 2012). Clegg goes on to say: “As a practitioner, what interests me is the transfer of the sound (if sometimes convoluted) theory into practical applications. Two key questions are: What are the impediments that are likely to arise? What is the methodology for how these impediments can be overcome?” This research was aimed at addressing Clegg’s questions of bridging theory and practice.

In this case study, these practical contributions are both the intervention method and the substance outcome of an attempt to identify one such explicit sustainability goal. The intervention design and testing through an experimental workshop is presented as the second manuscript, in Chapter 8, and data from the post-intervention assessment is included in Section 7.3. The attempt to articulate explicit regenerative design goals is the substance outcome of that workshop experiment, and is presented in the concluding chapter of the research, Chapter 9. This chapter also includes the contributions to theory.

### *6. Assess Theoretical Contribution*

While there is considerable innovation that originated in practice, practitioners do not typically have the time or background to understand the direct application of the more theoretical knowledge. Academic research can provide a more profound theoretical knowledge, but it is the combination of practical and theoretical knowledge that is inherently apt to narrow the gap between practice and research (Lukka 2003; Womack and Jones 2005).

The full cycle of the design science research is reached when the researcher is able to “explicate the theoretical contribution of the project, i.e. reflect the findings back to (potentially existing) prior theory” (Lukka, 2003). In contrast to the explanatory sciences, the design science research is implemented in a real-world, contextually situated case, with little control over the variables. Indeed the effectiveness is studied within its intended context of application, and the more general means-end relations are reviewed for the structural and process relationships which get revealed in this creation of a new reality (van Aken, 2004). Van Aken defines these causal relationships as “technical rules,” but notes that the identification of that rule does not mean that “every aspect of it (and of its relations with the context) is understood.” Typically, several aspects keep their “black box” character and testing within the context is still very necessary to account for its effectiveness. (Viitanen et al., 2010). Design knowledge is built up through the reflective cycle, and analyzing its effectiveness through the cross-case analysis, in order to gain insight in the indications and contra-indications for the application of that rule and hence also in its application-domain (van Aken, 2004). In this research, the “black box” is the design of the product (building), which falls outside of the scope of this discussion.

These “technical rules” are the theoretical contributions of the research. These contributions are intended to either to modify our existing understanding of means-end theories, or to propose new theories. This level of theory development in this research is considered as mid-range (Holmstrom, Ketokivi, & Hameri, 2009) or a substantive theory that establishes the theoretical relevance of the research. A development of formal theory would constitute future research. Through additional empirical research, it would establish the theoretical and empirical examination of relevant contingencies, a more formal representation of the design solution (intervention method) in multiple contexts, and begin to build hypothesis about cause and consequence

The contribution to the theory areas of design management, sustainability, and value management will be discussed in Chapter 9.

### Researcher Training

In constructive research, it is characteristic that the researcher’s empirical involvement is explicit and strong (Lukka 2003). Having an impact is one part of the method itself. Thus, the solution is experimental by nature, and the implementation is regarded as a test instrument. The researcher’s role in this workshop experiment is as a facilitator. This required skills in training, design thinking, and a whole systems approach. The researcher had experience in training and whole systems design from previous employment in the construction industry. She gained the requisite skills in design thinking from collaborative work with an academic colleague, who had training from the Stanford design school approach, and arranged for the researcher to run a design thinking workshop with a student group at Mississippi State University. This workshop topic was the whole systems approach to the concept of sustainable prosperity as it applies to the built environment. There was no formal review after the workshop, but the researcher was able to gain experience in facilitating this topic area. The researcher also hosted some design thinking workshops for students at Virginia Tech.

## 7.2 Design and Test Research Solution

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The findings identified a gap in the capability of the team to adopt a mental model of a whole systems approach in order to make explicit the values of sustainable prosperity and develop a unified vision. This provided the basis for the core of the constructive research, which is an innovative solution to the problem.

This addresses the second research question: “How can design teams gain an understanding of the systemic nature of sustainability, and how can this understanding impact the design process?”

### Research Design – Intervention Method

The design of the intervention method is the topic of the second manuscript, which is Chapter 8 of this dissertation. While the design of an innovative solution in constructive research is typically unique to the identified problem, the nature of this intervention design and the more universal application of the stated needs lends support to the recognition of the intervention as a stand-alone “method,” which could have broader applications beyond the existing case.

### Intervention Test - Workshop Experiment

A characteristic of the constructive research approach is that it includes an attempt for implementing the developed solution. The intervention method is tested through the implementation of a workshop experiment.

The workshop objectives were:

- 1) Experience a whole systems approach,
- 2) Understand how this mindset can help identify key sustainability issues in the built environment
- 3) Apply this learning to address a practical problem of sustainability.

Some observations of the workshop are included in manuscript #2, in Chapter 8. The assessment of the workshop follows.

### 7.3 Review of Findings - Workshop Experiment Assessment

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The success of the intervention was captured in two evaluation instruments. The first was a review exercise held at the conclusion of the workshop. Called “Plus/ Delta,” this is a common practice of the lean construction community, which facilitates participant articulation of the positive aspects of the event (Plus), and the elements that could benefit from a change (a Delta from the current state). This group discussion is typically led by someone other than the discussion facilitator or the trainer. In this research, the owner led the Plus/ Delta exercise.

The Plus/Delta for this intervention workshop, as seen in Figure 7.2, indicate a generally positive immediate reaction, both to the format and the content. The recommendations for changes were all directed at the final step of the workshop, which was Value Stream Mapping. The group developed some good concepts in this last step, but was lacking the easy flow of ideas from earlier steps. There could be several reasons for this. The timing of the workshop did not allow for much time to practice, or gain proficiency in the whole systems mindset. Also, the tool that was used was Value Stream Mapping, which the team has associated for the past four years with the value of patient care. Thus, it was difficult for the team to apply this tool to a value such as water, which was outside of the human-centric perspective. Recommendations for future implementations include a full day for the workshop, and a modification of the tools.

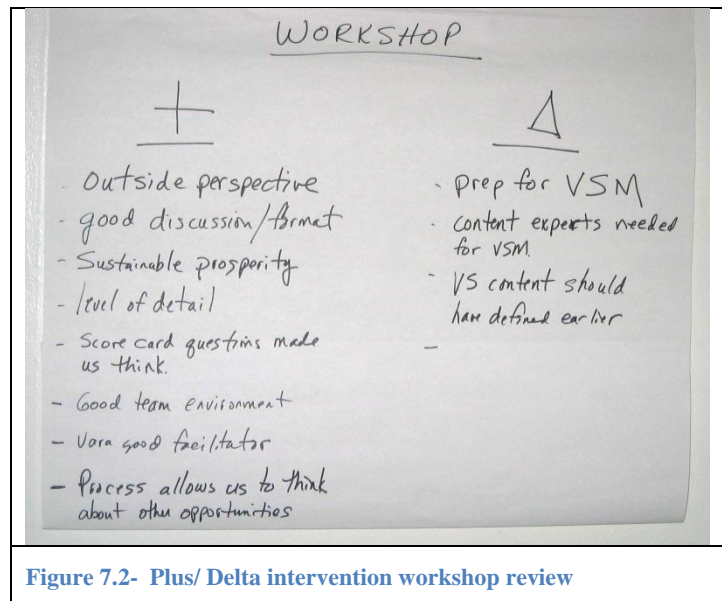


Figure 7.2- Plus/ Delta intervention workshop review

The second evaluation was an on-line survey. The statements were developed based on recommendations from training effectiveness and evaluation methodology (Alvarez et al. 2004; Cheng and Hampson 2008; Montesino 2002) to address the following areas:

- 1) Reaction to Workshop,
- 2) Perceptions of Learning,
- 3) Perception of performance change,
- 4) Perception of skills application to practice.

The survey was made available to participants at the conclusion of the workshop, and was completed within a week, with 75% survey response rate. The responses to the 26 statements were captured on a Likert Scale, aggregated according to four sections of the evaluation, and averaged for each participant. The variances in the data were calculated to identify the following:

- Consistency of responses to individual statements – the standard deviation of all responses to any single statement was calculated, and is listed next to the statement in the second column of each table.
- Consistency among participants for each of the statement sections- the standard deviation of the averages of all participants is listed next to the average of all participants.
- Consistency of responses within any one stakeholder set – the standard deviation of the responses within any one stakeholder set is listed next to the averages per stakeholder set, within each of the statement groupings.

Survey results are presented in Tables 7.4 and 7.5.

Coding for Participant Response	AVG - all Participants	Consistency of responses (1)	AVG Owners	AVG Contractor	AVG Designer	AVG Trade
1 Strongly Disagree						
2 Moderately Disagree						
3 Neutral						
4 Moderately Agree						
5 Strongly Agree						

1) Reaction to Workshop						
The workshop was informative	4.33	0.52	4.50	4.33	4.00	0.00
The workshop was engaging	4.89	0.33	5.00	4.67	5.00	5.00
The workshop length was appropriate	4.78	0.44	5.00	4.67	4.50	5.00
The facilitator conveyed information clearly.	4.67	0.50	5.00	4.67	4.50	4.50
The facilitator was well prepared.	4.89	0.33	5.00	5.00	4.50	5.00
Consistency of participants avg. responses (2)	4.74	0.45	4.90	4.67	4.10	4.88
Consistency of responses within stakeholder set (3)			0.22	0.24	0.35	0.25

2) Perception of Learning						
Taking on an eco-system persona helped me to experience a systems-thinking mindset	4.56	0.73	4.50	4.00	5.00	5.00
Expressing sustainable prosperity as a value stream makes it 'actionable' for building design	4.00	0.71	4.00	3.67	3.50	5.00
Sustainable prosperity value streams are holistic, and will always impact multiple systems	4.33	0.87	5.00	4.00	3.50	5.00
The expression of sustainability as sustainable prosperity value streams is different from the current understanding of sustainability	4.56	0.53	5.00	4.33	4.00	5.00
Consistency of participants avg. responses (2)	4.36	0.57	4.63	4.13	4.00	5.00
Consistency of responses within stakeholder set (3)			0.48	0.27	0.71	0.00

- (1) Standard deviation of the responses listed next to statement
- (2) Standard Deviation of participants listed next to totalled participant averages
- (3) Standard deviation of responses averages for a particular stakeholder set

Table 7.4 – Post workshop survey – sections 1 & 2

The first section of statements assessed the participant reactions to the workshop (Table 7.4). This data validated the results from the Plus/Delta review that was conducted at the conclusion of the workshop. The average response of the participants is high, a 4.74 out of 5 on the Likert scale. The participants agreed overall that the workshop was informative, engaging, and the length was appropriate. In addition, the facilitator was viewed as well prepared and conveyed information clearly. All questions have variances of .52 or lower, indicating consistency of

responses within the question. A variance of .45 among all participant averaged responses also establishes a consistency between participants. The consistency of response within the stakeholder set is established by a variance of .35 or less.

The second section was the participants' perception of learning (Table 7.4). The average response was also above 4, with a score of 4.36. The variance of responses between questions is somewhat higher, between .71 and .87. A review of the raw data indicates a scoring of 3 on the second and third question by one of the architects and one of the contractors. Since there are only two architects within that stakeholder set, this also shows up a variance within the designer stakeholder set (variance of .71). These two individuals participated within different subgroups during the workshop experiment, thus there is level of learning does not seem to correlate with the variation in the subgroup experiences during the workshop. However, these same participant scored the first and last question higher on the scale (4's and 5's), bringing their average scores up to 3.5 (contractor) and 3.75 (architect). This is reflected in the .57 variance of participant average responses.

The next two sections of the survey addressed the perception of transfer of the workshop learning, first as performance change and then as skills application to practice (Table 7.5). The overall score for the perception of performance change was 3.94, which is the lowest among all sections. This is partially affected by the inadvertent phrasing of one of the statement in a manner in which a lower score is better: "Designing to sustainable prosperity goals would take more time and effort initially." The lowest scoring statement is: "With some experience, designing to sustainable prosperity goals wouldn't take any more time than designing to the current levels of sustainability." The highest score was for the statement: "Designing to sustainable prosperity values would be fun and challenging." This would indicate that the participants enjoyed the challenge of the design task. The workshop was relatively short and the team did not have much time to gain mastery of the skills. This could possible change with more time.



	AVG - all Participants	Consistency of responses (1)	AVG Owners	AVG Contractor	AVG Designer	AVG Trade
Coding for Participant Response						
1 Strongly Disagree						
2 Moderately Disagree						
3 Neutral						
4 Moderately Agree						
5 Strongly Agree						
<b>3) Perception of performance change</b>						
Using the process trigger cards will be a good way for me to quickly evaluate decisions for their 'fit' with sustainable prosperity values	4.11	0.78	4.50	3.67	4.00	4.50
Designing to sustainable prosperity goals would take more time and effort initially	3.89	0.93	4.00	4.67	2.50	4.00
With some experience, designing to sustainable prosperity goals wouldn't take any more time than designing to the current levels of sustainability	3.44	0.88	3.50	3.67	4.00	2.50
The understanding of sustainable prosperity could change how I define my work.	3.67	0.50	4.00	3.67	3.50	3.50
Designing to sustainable prosperity values would be fun and challenging.	4.44	0.88	5.00	3.67	5.00	4.50
Designing to sustainable prosperity would keep me engaged more in the	4.00	0.87	5.00	3.33	4.00	4.00
With the understanding of sustainable prosperity, it would be hard to NOT include this concept in all of my work	4.00	0.71	4.50	3.33	4.00	4.50
<i>Consistency of participants avg. responses (2)</i>	<b>3.94</b>	<b>0.34</b>	<b>4.36</b>	<b>3.71</b>	<b>3.86</b>	<b>3.93</b>
<i>Consistency of responses within stakeholder set (3)</i>			0.56	0.45	0.75	0.73
<b>4) Perception of skills application to practice</b>						
The systems thinking skills introduced in the workshop apply to my work in TVD	4.56	0.53	4.50	4.33	5.00	4.50
Identifying sustainable prosperity values streams at the beginning of project design would be a good way to establish get clear goals of sustainability beyond LEED	4.89	0.33	5.00	5.00	4.50	5.00
This could change who would be the champion of sustainability property.	4.11	0.93	4.50	3.67	4.00	4.50
This could change the nature of discussion of sustainability in the TVD process	4.22	0.67	4.50	4.33	3.50	4.50
This could trigger a lot more inter-systems discussions.	4.33	0.87	5.00	3.67	4.00	5.00
It is possible that the goals of sustainability could drive the design	4.33	0.87	5.00	4.00	4.00	4.50
Designing with sustainable prosperity in mind would drive a lot more innovations	4.33	0.87	5.00	4.33	3.00	5.00
Designing to sustainable prosperity goals could reveal more synergy between systems.	4.44	0.73	4.50	4.33	4.00	5.00
The concepts of sustainable prosperity could change the type of commissioning information as a feedback for future projects.	4.11	0.93	4.50	4.33	4.00	3.50
Sustainable prosperity value streams can enhance the patient experience.	4.22	0.67	4.50	4.33	4.00	4.00
<i>Consistency of participants avg. responses (2)</i>	<b>4.36</b>	<b>0.44</b>	<b>4.70</b>	<b>4.23</b>	<b>4.00</b>	<b>4.55</b>
<i>Consistency of responses within stakeholder set (3)</i>			0.26	0.39	0.53	0.50

- (1) Standard deviation of the responses listed next to statement
- (2) Standard Deviation of participants listed next to totalled participant averages
- (3) Standard deviation of responses averages for a particular stakeholder set.

**Table 7.5 – Post workshop survey – sections 3 & 4.**

It is also notable that this third section had the lowest standard deviation among the sections, indicating a high degree of consensus. This workshop experiment was only 4 hours in length, which precluded the ability to fully develop the prototype and fully test in the real world application. This might indicate a limitation of expectations of performance change depending on the time allowed for the final elements of the intervention.

The final set of questions was related to the perception of skills application to practice. The average participant response was again above 4, with a score of 4.36. Though there were higher variances between responses in the questions (.93 and .87), the low variance within stakeholder sets would indicate a consistency of response within the stakeholder sets. Thus, the data can be evaluated as it is presented, aggregated within stakeholder sets. The lowest score is for the statement: “Designing with sustainable prosperity in mind would drive a lot more innovations” that was scored a 3, neutral, by the designers set. There could be several reasons for this response, including limitations of structure, cost, or implementation. This could also stem from the time limitations of this experiment, wherein the activity of prototyping was very brief.

In summary, there is a high level of agreement on questions related to the concept of sustainable prosperity values, the application to developing clear goals beyond LEED, the impact on the stakeholder work, and the workshop experience. Questions with lower scores (still above 3.3) are related to the transfer of the skills to the work environment, as this is typically the most difficult aspects of any skills training. This would point to a need to include more time for prototyping and transfer of the learned skills to the work environment.

## 7.4 Discussion

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This research demonstrated the opportunity to use an intervention for a specific “problem” to generate a more comprehensive learning organization change. The grounding of the method in a real-work problem helps to anchor the learning, and the skills can be reinforced through

application to other real-world problems. This differs from an approach of general behavior modeling or team building workshops that are intended to change team culture, but are disconnected from real project issues.

Future work can identify additional applications of this intervention method to other types of problems in the construction process, and further refine the method to improve the transfer of skills.

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## Chapter 8

### Manuscript #2: Constructive Research Intervention Method Applied to Sustainability Design

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The manuscript document is presented in the following pages, in the format as prepared for submittal to the journal *Engineering, Construction and Architectural Management*, Emerald Publishing. The reference style is Harvard.

The journal requirements are a title of not more than eight words, article length between 3000 and 5000 words, a structured abstract of 250 words, and up to 10 keywords.

The topic of the manuscript is design of the Intervention Method, and the testing of this method with a workshop experiment.

# Constructive Research Intervention

## Method Applied to Sustainability Design

### **Abstract -**

**Purpose** - The ‘wicked problem’ of sustainability provides the motive for change to a whole systems worldview and also reveals the limitations of the current fragmented design approach.

**Design approach** - The research proposes that an intervention can serve to break the isolation between the project disciplines through the introduction of a whole systems approach. This paper presents the design of the intervention method, including the theoretical foundations supporting the implementation plan. The intervention framework aligns the learning models from diverse disciplines, such as experiential learning cycles, design thinking, behavior modeling, systems thinking and unified vision. This integrated approach leverages the creative design activities to capture the learning potential for individual skills and team building.

**Findings** – The intervention method is tested through a workshop experiment. Post-workshop data suggests that the intervention structure provides an effective framework that is sufficiently robust and versatile enough to adapt to individual workshop circumstances.

**Research limitations** - The research acknowledges the limitations from the testing of intervention method through a single workshop experiment.

**Originality/value** - While interventions have previously been used in design for project improvement, this intervention design has a combined focus on process improvements and skills development. The unique approach of aligning multiple learning disciplines creates a flexibility and adaptability that suggests the potential for a broader application.

**Keywords:** sustainability, intervention, whole systems view, mindset, design process

**Article Type:** Research Paper

## **Introduction**

The combination of three industry trends – declining resources, radical transparency, and increasing expectations of sustainability has redefined the corporate marketplace (Laszlo and Zhexembayeva, 2011). Companies are under severe pressure to embed sustainability into the very core of their business activities (Dervitsiotis, 1998). In the construction industry, the expectations have moved beyond a “bolt on” approach to green building, or even a “reduced footprint” approach, to a design goal of regenerative sustainability that aims to actively restore the Earth’s systems. The problems at this level are complex and intertwined, and call for a shift to a mental model of “holistic living systems worldview” (du Plessis 2012). Thus, the challenges of sustainability can accelerate the shift to an integrated design approach, which Cole (2012) believes will create a “more cooperative professional exchange between design team members and the blurring of traditional knowledge boundaries.” In a symbiotic manner, this increase in whole systems thinking has in turn been identified as the key for creating value in sustainability development (Laszlo and Cooperrider, 2007).

## **Background**

### ***Learning To “See” in a Whole Systems View***

The intent to create value is inextricably linked with the ability to “see,” or envision these values within a whole system. Dweck (1988) proposes that the ability to envision an outcome is based on a person’s mindset, “the implicit theory about the characteristics of other people, places, and things that will predict the goals they adopt vis-a-vis external variables.” “Inclusive visioning” and “breakthrough thinking” were identified as essential skills in the Egan Review of Skills for Sustainable Communities (2004). This ability to vision a future state and make lateral connections is also voice by Von Bertalanffy (1972) in his initial paper on general system theory, in which he emphasized that it is “the re-orientation of thought and world view to a system paradigm that matters.” Checkland (1981) recognizes this worldview as a deterministic perspective of a culture, who “will only take purposeful actions that seem obvious to the people who constitute the culture.” For something to be obvious, it must first be seen. Rifkin (2004) proposes that this ability to see, or become aware, can be gained by extending the fundamentally empathetic human nature to the biosphere itself and life on Earth.

### ***Synergy between sustainability and whole systems view***

Sustainability, whole systems views and the design process can have a very co-dependent and synergistic relationship (Mills and Glass, 2009). Sustainability issues are holistic and intertwined by their very nature, and similarly, buildings are also nested systems, both internally and as entities interacting within the surrounding systems – ecological, economic, and social (Kelly, 2007). While these statements may seem obvious, the design and management of both buildings and sustainability systems often persist in a linear, fragmented manner, which causes waste and lost opportunities for value creation (Abidin and Pasquire, 2007). This condition of cognitive dissonance is tolerated until challenged by a “wicked problem,” which demands a solution that lies beyond the boundaries of the current process (Buchanan, 1992). Such is the problem of sustainability at a regenerative level (du Plessis, 2012). Taking a whole systems approach can also overcome the traditional segregation of the trades and the shift of responsibility for sustainability to a “green building” professional, which absolves the rest of team from taking ownership of the issues (Gluch and Raisanen, 2012).

### ***Behavior change through structure change***

While the ability to “see” in whole systems manner helps to identify the problems, achieving a high performance outcome also requires a change in process. According to a study by Otter and Emmitt (2008), the most effective medium to facilitate improved efficiency and performance at a team level is dialogue. Design meetings are seen as complementary functions, provided the interaction was managed to enable team learning, transparency of information and shared decision making. However, the temporary nature of the organizational structure of construction presents several challenges to this proposed team learning. Chinowsky et al. (2008) cites the problems inherent in project teams that are regrouped on every project, are expected to move quickly from formation to collaboration, and are sometimes limited by contractual barriers to free exchange of information. How can these challenges best be addressed?

Gluch and Raisanen (2012) propose to develop whole systems awareness in the group through an intervention approach, as a way of breaking the “isolation” between the organizational units and raising awareness of the contradictions hidden at the boundaries of activity systems. Dweck



(2006) also encourages challenging existing patterns of behavior and replacing the underlying structures as a means of effectively managing the creation of group culture. Dervitsiosis (1998) and Senge (1990) emphasize the need to establish connections early in the development of the team, in order to yield the highest performance improvement and catalyze a more dynamic communication network.

### ***Intervention as a Learning Model***

Midgley (2003) proposes that a systemic intervention can be used as a purposeful action by an agent to create change in relation to reflection on boundaries. The use of the adjective “systemic” serves to differentiate from the concept of an intervention as a “flawlessly preplanned change” and to introduce a reminder that in all systems there is uncertainty and nonlinear interaction. Martin et al. (2005) reports on examples of an intervention model designed to explore the issues and solutions to sustainability. Martin’s intervention was structured on five overlapping themes: 1) principles of sustainability, 2) introduction to systems thinking, 3) future perspectives, 4) benefits of sustainable development and 5) action planning. Similar characteristics of future state planning and synthesizing systems alternatives into a coherent whole can be found in creative workshops in other domains. Visioning workshops have been used by futurists in the social and political arena (Jungk and Mullert, 1987); design thinking practices were developed by the Hasso Plattner Institute of Design at Stanford University (“Stanford d.school”) for use in industrial design. While the focus of these workshops is on the design of the object, individual learning is inextricably linked to the reflection on the substance of the workshop (Martin et al. 2005).

### **Design Approach**

This research proposes that an intervention can serve to break the isolation between the project disciplines and facilitate the ability of design team members to address practical problems of sustainability through the introduction of a whole systems approach. While other studies have reviewed the benefits of interventions for improving project outcomes, for example through value management or design charrettes, the point of departure on this research is the focus on improving the process and the participant skills. The intervention framework aligns the learning models from diverse disciplines, such as experiential learning cycles, design thinking, behavior

modeling, systems thinking and unified vision. This integrated approach leverages the creative design activities to capture the learning potential for individual skills and team building.

This paper presents the intervention method, the theoretical foundations and the testing of the method through a workshop experiment. The research recognizes the contributions of this intervention to the design process, but resists any identification of this method as an attempt to make the process of design explicit (Simon, 1998).

### ***Constructive research methodology***

The selected research methodology for this paper is constructive research, as a part of design science. The mission of design science is to develop knowledge for the design and realization of artifacts to be used in the improvement of the performance of existing entities (van Aken, 2004). The “method artifact” is an innovative solutions meant to solve real world problems, and is inherently creative and experimental in nature (Lukka, 2003). The researcher is interested in developing “a means to an end,” wherein either the means or the end, or both, must be novel (Holmstrom et al., 2009). Furthermore, the development of this solution should be seen as “profound cooperative teamwork, into which both practitioners and the researcher contribute, based on the input information of both practical and theoretical origin” (Lukka, 2003). The constructive research methodology is well suited to the construction industry as it addresses the pragmatic aspect by addressing real life problems, while grounding the work in academic knowledge. In this research, the design of the intervention method is the “method artifact” of the constructive research.

### ***The Method Artifact***

While the design of an innovative solution in constructive research is typically unique to the identified problem, the nature of this intervention design and the more universal application of the need for a “whole systems” approach to design supports the concept of the intervention as a stand-alone “method,” which could have broader applications.

The effectiveness of the intervention method is based on its ability to provide an effective framework that is both sufficiently rigorous and versatile enough to adapt to individual workshop circumstances. This will be partially evaluated as a reflection of the post-workshop feedback and

partially from a narrative of observations of the workshop event. The research acknowledges the limitations from the testing of a single experiment.

## **The Intervention Method**

### ***Preparatory Work – Problem diagnosis***

Underlying the success of any intervention is the importance of addressing the right question. Alvarez (2004) suggests conducting a training needs analysis, and consider individual, organizational, and task needs. The objective is to identify the fewest problems that, if addressed with the appropriately selected and designed intervention, would yield the greatest individual and organizational results (LaBonte, 2003). In his seminal work on intervention theory, Argyris (1970) recommends an “organic” relationship with the client, “one that provides for increasing client influence in all phases of the diagnosis.” The objective is for the client to maintain ownership of the problem and the solutions.

### ***Theoretical Foundation to Learning Models***

The origin of the intervention was based on prior work, which identified a practical problem. At its core, this was a need for a team to be able to adopt a mental model of whole systems thinking in order to understand and design solutions for complex problems. The complex problem was sustainability at a level of regenerative design. The action of learning these whole system thinking skills collectively strengthens the cohesion of the team, and the action of working collaboratively on a solution to a practical problem builds a unified vision of both problem and solution.

The intervention method is designed as a framework that aligns the learning models from diverse disciplines: experiential learning cycles, design thinking, behavior modeling, and systems thinking and unified vision (Figure 1). The theoretical foundations for these disciplines are presented below and are followed by a discussion of the characteristics of the intervention method.

Figure 1 goes here

### *Experiential Learning*

The underlying strategy for the intervention was to use the mental model of a whole systems view to address a practical problem of sustainability. The challenge was to design a method that moves from generalization to implementation. An even greater challenge was to accommodate the “learning-in-action” component of the skills acquisition. This approach most closely resembles an experiential learning cycle, which Greenaway (2007) defines as "a structured learning sequence that is guided by a cyclical model." The learning cycle used for this intervention is based on the core components from the Kolb (1984) cycle, Act-Reflect-Abstract-Apply, with the addition of a crossing over within the cycle, between application and reflection (Figure 2). This addition represents the activities of rapid proto-typing. The basic learning cycle strategy is to alternate experience with abstraction, and reflection with activity. This enables all types of learners to experience their primary mode of learning, and anchor this knowledge with the complementary mode. The steps of reflection and abstraction increase the level of awareness.

Figure 2 goes here

### *Behavior Modeling*

Behavior modeling training (BMT) has become one of the most widely used, well-researched, and highly regarded psychologically based training interventions. The approach, based on Bandura’s (2001) social learning theory, differs from other training methods with its emphasis on well-defined behaviors (skills), modeling and practice opportunities, and active steps to maximize transfer. An essential component of BMT is that desired behaviors (skills) are described to trainees, and coded to learning points provided prior to and during modeling. These points are often captured in take-away cards, or similar, to trigger a rehearsal of the modeled behavior at a future time (Taylor et al., 2005). A study of training evaluation and effectiveness proposes a model for evaluation that includes measures for post-training attitudes, cognitive learning, training performance, and transfer performance (Alvarez et al., 2004). Cheng and Hampson (2008) suggest that the transfer of training is improved when the participant retains free agency to the behavior modeling, insofar as they have a choice of what skills/ behavior to transfer. This keeps the goal focused on learning, rather than expected performance goals. In

their seminal work, Dweck and Leggett (1988) recognize that while underlying personality variables can affect cognition and behavior in the motivation for mastery, she also acknowledges the potential that a group with a “growth” mindset (belief that skills can grow with experience) can influence individual member’s mindsets, through dialogue and learning (Dweck, 2006).

### *Design Thinking / Futures Thinking*

Design thinking and future thinking helps to address how to proceed toward a solution, once the problem is well defined. Ackoff (1981) suggests an ends-planning approach, aligning the organization vision with an idealized future state, which “pulls” the design from the present state. The construct of design thinking represents a full integration of problem ambiguity, the iterative process of solution generation, and the discursive aspects of discovery and communication (Monson and Novak, 2012). Current design thinking approaches (Future Search – Ford, IDEO, and Stanford) are typically oriented to an object outcome, but a similar approach was used in futures workshops to identify ideal states of social structures (Jungk and Mullert, 1987). Additionally, de Blois and De Coninck (2008) propose that implementing design thinking as an organizing process can improve the level of participation by all the stakeholders.

### *Unifying Vision*

A final opportunity within this method is the capture of the collective group knowledge, and the synthesis of the experience into a unifying vision (Kusnic and Owen, 1992). The process involves the recognition of the multiple frames of the participants and a search for value and connection across these frames to generate a single unifying vision. It is particularly relevant to create dialogue to reach mutual understanding in the environment of distributed responsibility of a collaborative design process (Otter and Emmitt, 2008).

### *Understanding the Intervention Method*

The intervention method is designed as a framework, with the experiential learning cycle providing the “pulse” to which the remaining disciplines are aligned. There are several aspects of the intervention structure that are worth noting. First, there were sufficient similarities between the learning models of the disciplines that allowed them to easily be aligned in the framework. Second, while the intervention method identifies a series of actions, there is no attempt to “harden” these actions into defined steps. Instead, the framework, as presented in

Figure 1, is intended to help design a workshop and identify the potential for cross-discipline implementation at any one point in time. Third, the framework presents a complete life-cycle of an idea, from the problem identification to production, but any one workshop does not necessitate the inclusion of the full cycle of events. An individual workshop may represent only a portion of that life cycle, but this framework helps to keep that portion in perspective with the preceding and follow-on activities, which might have already occurred or could be scheduled to occur at another time or in another manner.

This intervention method has several distinctive characteristics. These are discussed below.

### *Focus on process and skills improvement*

While interventions have previously been implemented as design charrettes at the outset of a project design for gathering ideas for *project* improvement, this intervention design is focused on *process* improvements and *skills* development. Thus, it can be implemented at any time during a project and with any combination of participant members, for example, a team of constructors and tradesmen. It is also distinctive in the ability of the teams to participate in the design of their own process improvements, instead of the more typical top-down approaches. If the new process results in the identification of a need for specific skills, this ownership of the process provides both the motivation and the feedback for the development of the skills.

### *Aligning learning models across disciplines*

This intervention method integrates learning models from several disciplines that have very little traditional industry cross-over. For example, to the best of the researcher's knowledge, a design thinking workshop is not typically concerned with a behavior modeling change. Equally, there is little cross-over with the other disciplines, other than unifying vision, which is related to systems thinking within the concept of a learning organization (Senge, 1990). The benefits of this multi-disciplinary approach are many.

First, this integrated approach leverages the creative design activities to capture the learning potential for individual skills and team building. The team can be focused on the problem solving activity, while the nature of the activity alignment with the experiential learning cycle

and behavior modeling provides the structure for a learning experience and skills development. Also the structure of the workshop facilitates the grouping and regrouping of the team as necessary to build team cohesion, and gain a unified vision.

Second, the structure of the intervention as a framework provides the adaptability both in the design of a workshop implementation, and during the workshop itself. The overall approach of the intervention method is adaptable to practical problems that require a whole systems mental model for the designing of the problem solution. The specific content of the workshop is then designed in response to the pace and the prompts provided by the learning models in the framework. As noted above, it is not critical that all the steps be included, or that the complete cycle of the intervention be included, as long as the logic of the experiential learning cycle is respected. Equally, during the implementation of the workshop, the framework provides the facilitator with the ability to emphasize different disciplines across the alignment as individuals or groups have different learning needs. An example of this is provided in the data on the intervention test.

### **Testing the Intervention Method – a Workshop Experiment**

This intervention model was tested through a workshop experiment. The design of the topics of the workshop was tailored to the needs of the workshop participants, a design team practicing Target Value Design, an integrated design management approach with an emphasis on value delivery. The challenge of delivery of sustainability values at the level of regenerative design had revealed a gap in the capability of the team to work and design from a whole systems view. The data also pointed to the remnants of a fragmented design culture, and the lack of “ownership” by individual team members of the client’s vision of sustainability. An intervention workshop was chosen as a purposeful action that could introduce a whole systems approach by providing an environment and activities for participants to cross over traditional boundaries, challenge existing behavior, and have sufficient opportunity for dialogue about problem definition and solutions design.

The specific aim of the workshop experiment was to: 1) experience a whole systems approach, 2) understand how the mindset could help identify key sustainability issues in the built

environment, and 3) apply this learning in a collaborative manner to address the practical problem of sustainability. For the purpose of this workshop, the definition of sustainable prosperity was based on the concept proposed by Worldwatch International, which is differentiated as a shift from just preventing further degradation of Earth's systems to actively restoring those systems to full health (Worldwatch, 2012).

### ***Observations***

The experiment was run with 12 members of the design team, most of whom had worked together for over four years. While this precluded the need for socialization and rapport-building, it did carry forward an entrenched hierarchy. To overcome the potential social barriers, the team was divided into three groups with an equal distribution of the stakeholders types (owner, contractor, designer, trade) for the creative work portion of the workshop. These are arbitrarily named A, B, and C. Despite this equalized membership of each group, they developed the creative portion of the work in distinctly different ways. A sample of the observations is presented to reflect the work on the first aim of the workshop: experiencing a whole systems approach.

The first activity of the workshop was to draw a simple water ecosystem (evaporation, condensation, precipitation) and introduce a hospital, a garden, and a house. For the experiment, the groups were to treat their eco-system as a closed loop, or a small isolated world. The groups were instructed to identify the value stream of water within this system, with the intent of identifying an ideal state. The team members had prior experience in these concepts and understood the intent of the exercise. The groups were given large sheets of paper, markers and miscellaneous stickers. Group A embraced this first task with large scale drawings of the eco-system, arrows showing the connections of the elements, and a discussion about the flow of water through these components. Group B approached the problem analytically and wrote down lists of component attributes. Group C was heavily dominated by one member, who drew a schematic of the plumbing and sewer lines of the buildings. The other participants of that group had written down some ideas on sticky notes to add to the drawing, but the nature of the drawing precluded their participation. This established a baseline of existing design approaches.



This second exercise was to anchor the learning, as the groups reported out their top ideas to the full team, and could reflect and observe each other's work. The next exercise was designed to trigger a whole system view, by introducing the abstraction through an empathetic experience. The participants were asked to transcend their "human" mental models and create an "ideal state" through the eyes of different ecological elements, such as birds, old-growth forest, or even the ozone. This idea was inspired by Benyus's (1997) work in "biomimicry" and built upon the empathetic nature of human beings (Rifkin, 2009). The implementation of this exercise was again different in the three groups. Team A adopted these personae with ease, and the nature of their discussion reflected a heightened level of awareness of the impacts of water at many levels of systems. Team B greatly benefited from this exercise to break past mental boundaries, and started linking the components and recognizing the interdependencies of water. For Team C, the empathetic experience helped them to shift their mental model from a representation of water through mechanical equipment to the impact and use by human beings and the impact of this on the other ecological elements.

The workshop continued through the exercises, as described in Figure 1. Understanding the alternating nature of the learning cycle components was helpful for the facilitator in order to respond to the different needs of each of the groups. For example, in the next exercise, where designing to a future state becomes the central focus of the activity, the facilitator could tailor her interaction with each of the groups to emphasize related components of the other disciplines in the intervention framework. Group A was ready to develop multiple scenarios (design thinking), Group B was discussing the applications to the industry practice (behavior modeling), whereas Group C was gaining awareness of a whole systems approach through discussion (systems thinking).

In constructive research methodology, the role of the facilitator is explicit and strong, and having an impact is one part of the method itself. This workshop experiment was the first testing of the intervention method and thus an experiment for the facilitator herself. The role alternated between the teacher and administration of the workshop actions, coaching to encourage participants in the exercise intent, and then the facilitation of the reflective discussions. The skill

level of the facilitator is a strong component of the success of the workshop in achieving the design aims.

### **Assessment**

The effectiveness of the intervention design method is based on ability of the method to identify an appropriate solution for a well-defined problem and provide an effective framework that is both structured and versatile enough to adapt to individual workshop circumstances and meet the workshop objectives. This can be partially evaluated as a reflection of the post-workshop survey and partially from a narrative of observations of the workshop event, as they apply to the specific workshop aim.

The contents for the survey were developed in four sections presented in Table 1, based on recommendations from training effectiveness and evaluation methodology (Alvarez et al. 2004; Cheng and Hampson 2008). The reaction to the workshop was gauged by 5 statements about the workshop implementation (informative, engaging, appropriate length) and the facilitator (clearly conveyed information and well prepared). The perception of learning was based on the participant reaction to 4 statements about the key learning points of the workshops, such as the understanding of eco-system persona as a trigger to experiencing a systems thinking mindset, the understanding of sustainable prosperity as holistic concept and the impact of expressing this concept as an actionable value stream. The perception of performance change was developed by 7 statements regarding the perception of implementing sustainable prosperity goals in their work, the nature of the change, and the impact on the scope of work. Finally the perception of skills implementation to practice was based on responses to 10 statements concerning the introduction of systems thinking skills and the introduction of explicit sustainable prosperity concepts.

Table 1 goes here

The survey was made available to participants at the conclusion of the workshop, and was completed within a week, with 75% survey response rate. The responses to the 26 statements were captured on a Likert Scale, aggregated according to four sections of the evaluation, and

averaged for each participant. The variances in the data were calculated to identify the following:

- Consistency among participants for each of the statement sections- the standard deviation of the averages of all participants is listed next to the average of all participants.
- Consistency of responses within any one stakeholder set – the standard deviation of the responses within any one stakeholder set is listed next to the averages per stakeholder set, within each of the statement groupings.

The overall response to the statements was positive, with an averaged ranking between moderately (4) and strongly agree (5) for each of the statement sections. The variances of these averages ranged from .34 to .57, which establishes a validation of consistency within the participants for each of the survey sections. Overall, the statements regarding perceptions of performance change were slightly lower than the other sections, but conversely had lower standard deviation, indicating a high degree of consensus. This workshop experiment was only 4 hours in length, which precluded the ability to fully develop the prototype and fully test in the real world application. This might indicate a limitation of expectations of performance change depending on the time allowed for the final elements of the intervention.

An additional measurement was the average response within each stakeholder set, and the consistency within that set. The highest variances were within the designers on the second and third section and the third statement for the trades. Further investigation of the data revealed that this was more reflective of the very high scoring on most of the statements (5 – highly agree) relative to a few with a neutral (3) score. Also, both of these sets only have two participants, so are highly variable with each respondent. Overall, the post-workshop assessment suggests the intervention structure provided an effective framework that was sufficiently robust and versatile enough to adapt to the individual workshop circumstance.

## **Conclusions**

The indeterminate nature of constructive research is that it is experimental in nature. The test of this intervention method was administered in what might be considered ideal conditions, in that

the design team already had a very highly developed set of interpersonal and communication skills. They were also well versed in sustainability, motivated by an owner with a visionary approach to sustainability, and have some experience in the concept of “designing to the ideal.” While the researcher acknowledges the limitations from the testing with a single design team, each subsequent testing of this method will help to add to the understanding of the opportunities, the limitations and the relevant or essential components of the learning cycle that are needed to achieve the desired outcome.

There are several distinctive benefits to the multi-disciplinary aspect of the intervention method. The first benefit is that the activity of behavior modeling is uncharacteristically combined with design activities. The learning outcome of a mental model shift is operating concurrently with the practical outcome of the stated problem area, and leverages the creative design activities to capture the learning potential for individual skills and team building. This resolves the tension that often exists between human resources development (training) and production (output). The second benefit is that the alignment of the disciplines provides an effective framework that is sufficiently robust and versatile enough in both the designing of a workshop and during its implementation. It provides the facilitator with the tools necessary to respond to emerging conditions during a workshop, but also depends on the facilitator skill in being aware of the necessary adjustments and in providing the appropriate feedback or process changes to respond to the circumstances.

Finally, both the method of the intervention design and the workshop experiment revealed the opportunity for simple eco-system design to be part of the solution to the very complexity of sustainability problems. The very act of drawing simple eco-systems, such as the cyclical system of rain and evaporation, are easily understood and provide a good “mental trigger” for experiencing the whole systems approach mental model. In turn, this mental model allows the participants to “see” past their respective disciplinary boundaries and helps them to work collaboratively toward systems solutions.

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Intervention Method					Application of Method	
Experiential Learning Cycle		Design Thinking	Behavior Modeling	Systems Thinking	Unified Vision	Workshop Experiment
<b>Prior to workshop</b>		Identify the problem, need/opportunity, cause/impacts, constraints, stakeholders, observations	Map existing mental model, challenge validity of having one sole mental model		Understand context and desired outcome (# of visions and frames, # of decisions and decision makers)	Decision-maker/ stakeholder/ team commitment and participation, resources (room, time, food, materials), identify problem, and systems impact of problem. Identify possible leverage points, design workshop actions.
<b>Act</b>	Concrete Experience	Exploration, Brainstorming, build creative framework	Trust-building, establish rapport	Experience systems thinking from a known entry point	Gain understanding, establish status quo	Start in small groups, introduce eco-systems through a water eco-system w/ a hospital, house and garden. Have them draw a big picture, identify links between elements
<b>Reflect</b>	Observe, Anchor	Observe, Point of View	Gain confidence from positioning			Groups report out top ideas
<b>Abstract</b>	Abstract, Revise	Ideation, develop empathy	Push beyond personal boundaries, gain flexibility in shifting mental models		Boundary spanning	Return to small group, add empathetic experience (as non-human persona in the eco-system).
<b>Apply</b>	Active Experiment	Multiple scenarios, develop selection criteria	Behavioral rehearsal, transfer alternative mental model to industry domain	Awareness of systems thinking through application	Multiple frames creation	Design a Future state - Eco-systems process map of ideal solution to problem area
<b>Reflect</b>	Reflect, Observe, Anchor	Reflect, collaborate, harvest best ideas	Learning point		Sharing of multiple frames	Report out - groups sell the systems ideas to each other
<b>Abstract</b>	Futures Transfer	Selection, Integrative thinking to focus on design set (s)	Mental model anchoring through connection to solution	Anchoring thorough awareness	Search for unifying value & use to develop a single unifying frame	Team discussion, synthesis / analysis, Combine ideas to 'elegant' solution, process map as prompt tool
<b>Apply</b>	Reflect	Rapid prototype, solution sets, make ideas tangible (iterative after testing, w/ more ideation)	Test and challenge new mental model with 'reality' check from own discipline		Gain team member commitment/ ownership from the connection	Prototype the solutions sets (systems, processes, products)
<b>Reflect</b>	Test	Test to learn, internal review, value analysis, align with vision	Extend and test alternative mental models		Validate w/ decision maker's frame	Test to learn through a value stream mapping of water, current state to future state.
<b>Apply</b>	Apply	Refine, focus prototype, align value expectations	Anchor behavior through practice, attitude, free-agency	Improve agility in systems thinking through practice	Gain team member commitment/ ownership from the connection	End of workshop.
<b>Reflect</b>	Test	Test (iterative w/ prototype			Validate w/ decision maker's frame	(longer workshops would continue with activities)
<b>Transfer</b>		Execute the vision, engineer the experience			Gain decision-maker buy-in	
		Implement, document, communicate				

(Kolb 1984); (Argyris + Schon 1973); (Greenaway 2007) (Brown 2008); (Martin+Katz 2009); (Hasso-Plattner 2011) (Taylor et al. 2008) (Senge 1990) (Kusnic-Owen 1992)

Figure 1– Intervention method and workshop experiment



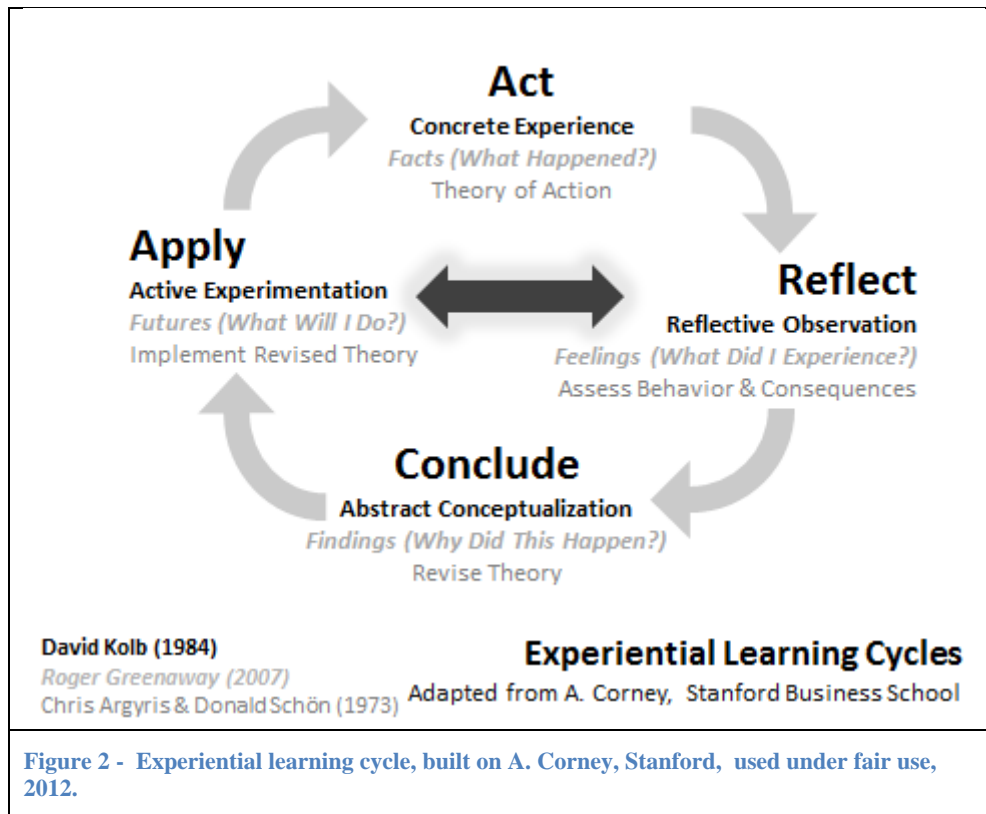


Figure 2 - Experiential learning cycle, built on A. Corney, Stanford, used under fair use, 2012.

	<b>AVG - all Participants</b>	<i>Consistency of participant responses (1)</i>	<b>AVG Owners</b>	<i>Consistency of Responses within Owners (2)</i>	<b>AVG Contractor</b>	<i>Consistency of Responses within Contractors</i>	<b>AVG Designer</b>	<i>Consistency of Responses within Designers</i>	<b>AVG Trade</b>	<i>Consistency of Responses within Trades</i>
Coding for Participant Response 1 Strongly Disagree 2 Moderately Disagree 3 Neutral 4 Moderately Agree 5 Strongly Agree										
Reaction to Workshop	4.74	0.45	4.90	0.22	4.67	0.24	4.10	0.35	4.88	0.25
Perception of Learning	4.36	0.57	4.63	0.48	4.13	0.27	4.00	0.71	5.00	0.00
Perception of performance change	3.94	0.34	4.36	0.56	3.71	0.45	3.86	0.75	3.93	0.73
Perception of skills application to practice	4.36	0.44	4.70	0.26	4.23	0.39	4.00	0.53	4.55	0.50

(1) Standard deviation of the averaged participant responses per statement section

(2) Standard deviation of statement averages for a particular stakeholder set

**Table 1 – Post-workshop evaluation**

## Chapter 9

### Summary

#### 9.1 Review of Research Methodology

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This research was catalyzed by the need for increased sustainability in the construction industry, and was the cause for my return to academia. Thus, the initial research approach was an immersion in academic theory to explore the boundaries of the topic and identify a potential scope. Various methodologies were assessed, but were deemed insufficient or too limiting to my research approach. This approach was an iterative review of literature and practice through a root cause analysis, continually refining the problem area to identify a core condition or constraint that could serve as a lever to improve the delivery of sustainability. While case study research seemed to be a possible methodology, it did not present the opportunity to design and test a solution. For me, the point of the research was not just to identify the problem, but also to try to solve it. The other seeming mismatch was the scientific approach of controlling variables and experiments. Construction design is a unique, one-off situation in which variables are not easily controlled. And finally, innovations occur in creative environments. The research strategy was to identify a leading edge of industry innovations, in order to leverage the experimentation in industry with the research contribution from theory. Thus, the research was already in the area of industry experimentations, and by very definition, not easily comparable or controllable. And finally, I had recognized relatively early in the work that integration and collaboration was a better environment to the delivery of sustainability, in contrast with the Taylorist approach to fragmentation and linear design approaches. Thus, the research method needed to also align with an integrated systems approach.

I am highly indebted to my colleagues in the International Group for Lean Construction (IGLC), for hosting a summer seminar that introduced me to design science and the constructive research methodology. This methodology provided the framework that fit well with my concept of

research and the origination of the research in a practical problem. Not only does the methodology call for a foundation in theory, but also supports the iterative refinement of the problem area. In this sense, it aligned well with the philosophy of the lean community, which stresses the framing and understanding of the problem prior to designing a solution. In addition, this methodology introduced the expectation of contributions not only to practice, but also to theory. As a result, the research gained an additional depth of analysis and understanding.

The motivation for the research was the increased delivery of sustainability, and this provided the filter for all of the research as well as the design solution. However, what emerged as the more significant finding than the explicit articulation of sustainability was the development of an intervention method. This was first identified during the IGLC summer session by several of the professors who recognized the intervention as the “method” artifact of the constructive research methodology. While the design of an innovative solution in constructive research is typically unique to the identified problem, the nature of this intervention design and the more universal application of whole systems thinking suggested the recognition of the intervention as a stand-alone “method,” which could have broader applications. This outcome was not expected at the outset of the research, but has potentially a broader impact than any specific sustainability deliverable.

The researcher acknowledges the limitation of the single exemplary case and the limitations from the single testing of an experimental method. Design knowledge is built up through testing and reflection with a context, and assessing the effectiveness of the solution through cross-case analysis, in order to gain insight in the opportunities and limitations of the method. However, these limitations to the contribution to practice do not impact the contribution to theory.

## 9.2 Contribution to Practice

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The contributions to practice of the constructive research were twofold: a method artifact and a substance artifact.

### Method Artifact – Intervention Method

The method artifact of the research is the intervention method, which was presented as Manuscript #2 in Chapter 8.

The method artifact also holds potential for applications that could transcend the original industry application. A simple eco-system model provides the ultimate catalyst for a whole systems approach to problem framing and problem solving, and thus becomes the portal for the shift in mental models. However, this new systems mindset is conducive not only to resolve the ‘sustainability’ problems, but is also a more creative and innovative mental model from which to resolve other types of complex systemic problems. This workshop method has been identified as a unique combination of future thinking, design thinking, whole systems thinking and behavior modeling that could be used for a wide range of problem sets. Even within the industry, it was suggested as a method that could be applied in larger construction projects to help teams of field contractors identify creative ‘systems’ solutions to improve the constructability of an installation process.

### Substance Artifact - Explicit Sustainability Values

One of the practical problem areas that shaped the design of the workshop experiment was the need to make values of sustainability explicit, at the level of regenerative design, or sustainable prosperity. In the workshop experiment, this was the specific aim of the final exercise of abstraction and represented the application of the learned skills to the original problem. The

success of this aim is not determined in the proficiency of the outcome at this first attempt, but in the ability of the intervention method to bring the awareness of the learned skills to the problem. In this workshop experiment, the team was able to capture the lessons learned from several of the previous steps, and identify the difference between the current state value stream, and the future state value stream. In Figure 9.1, the current state is represented as a straight chain from 100% of the water inflow from treated water, a single use, and then 100% of the outflow water going to the sewer. This represents costs in water treatment both incoming and outgoing, and transportation costs. The future stream of water has an identified goal of entirely eliminating the wastewater flow to the sewer discharge, and reducing the percentage of municipal (treated) water as part of the total water intake. This would eliminate all costs of sewer treatment, and minimized the costs of incoming water treatment. As the figure shows, additional water can be harvested or recycled, and water can be used multiple times within the building.

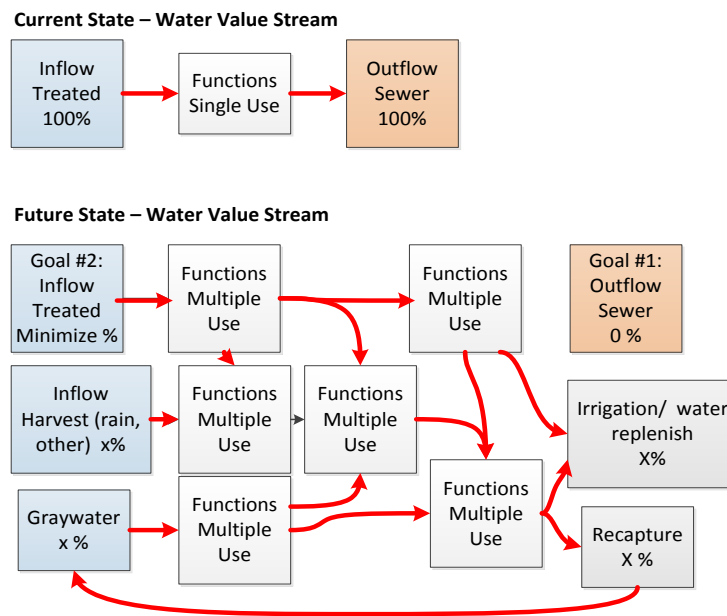


Figure 9.1 - Application of method to real-world problem

This contribution is significant on merit, and in the potential development of the substance artifact. It can be understood as an explicit articulation of the vision of sustainability that might have been stated as the “the responsible use of water for current needs without impacting the ability of future generations to use water.” Additional expressions of this goal regarding water

could be related to the amount of water available or needed for ground water replenishment in dry areas, or the redirection of water in wet areas. The initial success of the intervention method in helping make sustainable prosperity values explicit within a 4 hour workshop is promising.

### 9.3 Contribution to Theory

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The research contributes to theory in the area of design management, value management and sustainability.

#### Design Management

This research contributes to the understanding of problem identification and problem solving as the first step of design management. This emphasis can be traced to the origins of lean in Japanese manufacturing, where ‘the important element in decision making is *defining the question.*’ While this key philosophical distinction did not always carry through in applications of lean in manufacturing in the U.S., it has been a cornerstone of lean management applications in healthcare, and is a distinguishing factor of the developments in lean in construction. The philosophy is operationalized in Target Value Design in the formalized phase of aligning the project values and cost with the owner’s business case. The emphasis is on designing the right product for the right purpose at the right price. This emphasis on value provides an environment of creativity and exploration in design, where there are no predetermined specifications.

A parallel can be drawn to the methodological approach used for this research. Design science has at its core the creation and testing of a design solution, in which the findings are assessed relative to the original design problem. This level of reflection, if not accountability, provides the motivation for a more thorough problem investigation. While not all design science research would have the heavy emphasis on problem framing exhibited in this research, the methodology does provide a greater opportunity than the more probabilistic research methodologies.

## Value Management

The case study findings of the implementation of Target Value Design (TVD) breaks with prior tradition of value management as discrete events, and introduces the theory of value management as a continuous event. This also has practical implications on the identification and training for value management skills. The approach to value is also distinct in TVD. The goal of traditional discrete value engineering events is the minimization of value loss. However, TVD can also be managed for the creation of value through the continuous awareness of the value proposition, and the implementation of the TVD practices that have been characterized as having a higher contribution to value creation than to waste minimization.

## Sustainability

Sustainability, as it has been expressed in the built environment has been filtered through the materialistic and mechanistic (functional) aspects of the industry, and has resulted in an approach of reducing the impact of specific materials or systems. However, sustainability as understood from the perspective of biological and natural sciences has identified the need for a regenerative approach to sustainability to not just reduce further harm, but to actively restore eco-systems. This research contributes to the recognition of the limitations of the “do no further harm” approach to sustainability, and the need for the articulation of specific sustainability values at the level of regenerative design, or sustainable prosperity.

These findings also suggest a theory that sustainability, at the level of regenerative design, is the “wicked problem” that reveals the limitations of the existing linear, segmented design approach. It proposes that the sustainability, as a dynamic complex system, can best be understood from the mental mode of systems thinking, and that the act of understand an ecological system (i.e. a component of sustainability) can provide the catalyst for the mental shift to a whole systems view.



## 9.4 Reflections

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The original motivation for this doctoral work was the need to make a meaningful contribution to the implementation of sustainability, at the level of regenerative design, or sustainable prosperity. As such, there was perhaps more time spent in problem definition, in the study of existing fields of knowledge, and in the mastery of this knowledge. The pivotal point in the research was the discovery of the constructive research methodology, which put all the components into perspective and helped organize the work. I believe that I have achieved my original research goal, and that the findings are significant and meaningful to both industry and theoretical knowledge. The specific research aim was to identify the core conditions and constraints that support or hinder increased delivery of sustainability in the built environment. The key findings that address the research aim can be summarized as follows:

1. People - At their core, design and construction are activities that rely on the interaction of people. The key condition of a successful design environment is the membership of the design team, the commitment and capability of the team members to envision a future state, and create actionable process map.
2. Process – After people, the next most important condition is the process that they develop. The integrated of design process elements can result in continuous value management, and a whole systems approach will facilitate a true collaborative design management. Practices and tools can be selected to support this process improvement.
3. Intervention method - This research tested out an intervention method that can contribute to a design outcome, but has greater merit in the ability to contribute to points 1 and 2. The intervention can create cohesion in teams, introduce whole systems thinking skills for futures thinking and help team members cross over traditional discipline boundaries.

Finally, this dissertation provides a solid body of knowledge for future research of my own work, and to serve as a point of departure for other researchers to make a contribution toward the increased delivery of sustainability.

## Appendix A - Case Study Interview Responses

	TVD and ILPD	Owner - 1	Owner -2	Architect - 1	Architect - 2
1a	Who is driver of TVD?	Contractor	Owner, Core team - different than component team	Contractor	owner
1b	Who is driver of ILPD?	Core Team	same	Core Team - call it IPD light - not contractually IPD	owner
1c	Is Culture Unique to this project	Each project has a unique culture	yes - unique to the process	Not unique to team	yes - to this combination of contractor, designer and owner
1d	Can it be learned?	Yes	Learn, do, teach. Yes, but not instantly. Need Leader/owner to be driver.	Yes - best if Owner is primary driver - otherwise can be done - but impacts the outcome.	Yes - TVD portion – contractor as driver, ILPD – the architect and owner as drivers.
2	What do you see is the biggest difference between your experience with TVD and previous design processes?	(omitted due to lack of time)	When the process isn't followed, there's a lot of user angst, a lot of rework, storming rather than norming, a lot more argumentative, lack of trust that the process is actually going to work.	Flow of work - set up different milestones. More rigorous - especially at the beginning. Getting consistent and constant pricing, tighter. Reduces redundancy in process. Fewer surprises.	lot more design decisions based on budget impacts; owner understands what they're spending their money on much earlier. It's almost like seeing this real-time, weekly.
3	How does TVD design impact your work?	(omitted due to lack of time)	More allocation of time and people up front, but then overall if you look at the total amount of time, it's less. It's much more valuable time spent up front than all the rework at the end. If we don't put more time up front, we suffer. If we do it we get really results.	More front-end loaded, more info from owner. Less redraw, less rework. Total design time shorter (from 24 wks to 18) + documentation. Also CbA - great tool. Architect establishes factors, Owner identifies level of importance, Contractor adds pricing.	Technology has enabled us to send little bits of information, drawings, PDFs, and send stuff quicker. This ability to relay more information in real-time allows for more people at the table also results in hundreds of e-mails, and weekly expectations. It is more stressful. A constant barrage instead of being able to close your door and design.
4a	On this project, were there measurable results within your work which resulted from the TVD process?	(omitted due to lack of time)	big one for me is audit compliance. It absolutely helped me align my thought process, and the documentation of the budget. We are on budget, audit compliant, the users are completely happy with their space, we met all the process goals, so we created the value they ask for and for the budget they gave us, with more scope, and it was on schedule.	Lessons learned - Owner's Vision and Future State Value Stream need to be aligned. Need to lock down certain key items - ie elevator. Develop a process: Baseline Design.	I don't think we could have done the whole project as fast as we did. We are working much faster.
4b	Are there other major benefits to you? (relate to stakeholder role: clients, architect, etc.)	(omitted due to lack of time)	yes it's that confidence level. I don't have to worry at night that things are where they need to be. On other projects where it's not followed, it takes me days of stress to get everything manually audited back to where I think it needs to be.	True IPD contract, owner assumes the risk - fewer legal issues, more productivity. Less time, but charged hourly, more compact. More accountable.	This ability to communicate more information in real-time allows you to communicate with more people on the project. From the very beginning, everybody understands, it's like a dream. We're all at the table.
5	What are some of the drawbacks of TVD, obstacles to be overcome, potential pitfalls	Challenge to get team members who understand value creation, and to keep this a central focus.	More documentation upfront (not necessarily negative, just is), not the easiest thing to understand at first, it's a culture change, so it is painful. It creates more angst because decisions are in real time, arguments happen almost weekly, because a decision needs to be made real-time, to pass on to component team	Make sure the target cost is accurate to client, (not just RS Means) to level of quality, and challenges the team.	There are a lot less technological limitations. It's this constant information flow. We're all working together, but it's happening so fast, there's not a synthesis sometimes. You don't understand all the parameters or impacts. The push is for PowerPoint presentations, beautiful rendered images on a daily basis. It's not possible.
6	Do you have ideas for improvements?	Lots of talk and sometimes lack of action - do VSM, identify waste elimination - but people slip back into traditional delivery methods. Principals of organizations could do better job within their own internal team in teaching the process off-line, not in core team meetings.	.....	Luxury of pre-design time to properly investigate open issues. Can do the homework and math to investigate more models. More time in scope development. * Contract - not as advanced as the process. .... there is 'no precedent' - because there shouldn't be any lawsuits! Generally speaking, we just disregard the contract.	is there a way of doing both? This could maybe be handled in scope development..in the old days -had a year to develop a project like this, really got to think about it, sometimes at a deep level, but it was sort of an internal thing. Design was quiet and a lot more relaxing. You had a chance to take deep breaths. Now I feel like I'm a be buzzing around, it's not a solo venture anymore. I think things move too fast.

Highlight Color, Represents Impact on Value Delivery

Green: Impact on Product

Blue: Impact on Process

Yellow: Impact on Players (Actors)

Case Study Interview Responses (cont.)

	Sustainability	Owner - 1	Owner - 2	Architect - 1	Architect - 2
7a	Who is the Champion of Sustainability ?	Owner	Owner	Owner - level and how certify.	Owner - a strong voice
7b	Keeper of Green Building Goals?	Core Team	Owner	Contractor	Contractor - keeper of goals
8	What were the goals on this project related to sustainability, and how were they stated (ie what format?)	Stated in the OPR, as metrics	Goals are stated in owner's vision, then LEED was a standard of work tool for accountability.	Started as Green Guide for Healthcare, because LEED wasn't equipped to recognize Green Goals beyond LEED.	Were stated as Green Guides for Healthcare, then switched to be a pilot program for LEED for Healthcare.
9	Were there ever options which arose to exceed the stated green building goals? If so, how was this information handled	e.g. In lean healthcare, lean method aimed at optimizing ft2. TVD process helps to handle this.	It was key that we started with the vision and just use LEED as a standard of work tool. LEED did not put an upper limit.	LEED doesn't always recognize - frustrating to owner.	example - acoustics. Used Target Value Design process to decide if it was worth reaching the next level. Decided there was not the value for this project for improved patient care.
10	When, in the TVD process are these goals discussed? LEED and/or other	At the beginning. Don't set out target certification levels (LEED), these come as a result of the work.	at the vision, and throughout	very late in this project. Didn't have formal goals of sustainability, are more stringent with OPR on next phase.	throughout
11	How are sustainability goals represented in the target value cost?	Represented throughout in cost model from Contractor	green and building it right was an advantage to be weighed against other advantages when allocating resources.	built into each of the components, other than cost for LEED documentation, or commissioning.	achieving sustainability in our target value is baked into all of the decisions.
12	Are the sustainability goals a specific cost item, or is this included in all decisions?	see above	included in all decisions, but there was a minimum level from the green guide for healthcare, and then set higher goals - such as zero waste-stream.	see above.	The cost for materials is incorporated within the budget of that component. There is also a line item cost for administering LEED
13	How are sustainability goals related to customer value?		Decisions are based on what is right for the patient and is right for the environment.	Didn't have OPR, but knew sustainability was part of mission. Team understood these as integral. Discussed - "what is sustainability?"	Many owners have an OPR, that is developed at the inception of the project. Often boilerplate, but this one had X amount of energy reduction. Those goal should really be stated at the beginning.
14	Would you describe the goals in this project as a prescriptive green building goals, or a philosophical underpinning of sustainability goals?	More philosophical, because they don't target a prescriptive set of things want to do	Both, there were certain minimum goals, but there was never really a ceiling put on.	Both - Set metrics when can, but long term values discussed. Client gave metrics on which to base cost model.	Underlying theme – supposed to look for opportunities.
15	Have any of the energy or green building outcomes been commissioned, and is there a feedback loop to the core team with the findings?	yes - will have advanced commissioning , and post occupancy review.	yes	has been no feedback.	I don't think that our group is good at documenting and memorializing before we move on. We do an awful lot of repeat investigations. The problem is that is team members change, we lose critical pieces of information. I see us sometimes having to relearn some things, in all topics.
16	How do the sustainability goals affect your work? Allocation of time? Resources?		Just part of work	Not anymore - now just ingrained, part of the process.	It takes more time to find those materials.
17	Does your company have a vision statement? Does it include sustainability?		Absolutely, have taken it all the way to ISO 14000 Certification to drive environmental sustainability through the system.	Not in the mission statement, part of our core values.	Not aware of one. I'm sure our need is the clients meeting the clients need, and if that include sustainability, then we want to be there.
18	What percent of your work has sustainability goals?		all	80-90% - not all LEED	almost every project now. It wasn't that way even five years ago.
19	Lean is often described as increased value, decrease waste. Did any of the sustainability goals serve as the framework of value by which waste was defined?	Cultural Impact: "Do it right the first time."	Lean is not a formula, it is a culture. As the philosophy of lean, you only want to use what you need to provide the maximum value you can, not just use resources because they are there.	Yes - in the broad concept of sustainability - make sure building serves the occupants for an indefinite period of time.	don't know. Can't answer that question.

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Blue: Impact on Process

Yellow: Impact on Players (Actors)

Case Study Interview Responses (cont.)

	TVD and ILPD	Contractor -1	Contractor - 2	Contractor -3	Contractor - 4
1a	Who is driver of TVD?	Owner - w/ Core team	Team - everyone has some skin in this, but starts with owner.	Contractor- Quality value estimating	Core Team
1b	Who is driver of ILPD?	Leadership Core Team: Owner, Contractor	Team - but have a process	Will Lichtig (understanding of ILPD as a contract)	Contractor
1c	Is Culture Unique to this project	No have seen on other projects	Different for every team	not really - IFOA contract capture essence, team work ILPD inspite of contract	No - have seen it elsewhere
1d	Can it be learned?	yes, maybe a better word is developed	Certainly	yes - are learning / testing	Yes - but some personalities are better at working together, and more freethinkers
2	What do you see is the biggest difference between your experience with TVD and previous design processes?	you start w/ expected (allowable) target cost as opposed to develop cost based on scope.	The high level of knowledge of process in the team's makes it flow smoother, could make it more successful	budget result of design not meet owner business model. The old process, of architect designing in a silo, then throwing it over the wall to the contractor to price, then value engineered - (really cost-cutting) resulted in product less than desired.	team, and the open communication and thought processes, and the sharing of information and ideas. We are not off doing our own little thing.
3	How does TVD design impact your work?	much more intensive because it is a continual process. There is a time commitment to the project, to attend and participate in meetings and the design process, respond on a real-time basis, and just listening, and learning. More time in planning, less time reacting. Value added time.	Having experienced group of people makes the process easier make things smoother. When they understand sustainability and LEED, you don't have to explain everything	Saves time overall, but more pro-active time up front, aligning people's vision and less time spent fixing problems and trying to maintain the value.	Being involved in the process during the design, I know a lot more about the project before I even start. I know the drivers behind the design, so later during construction I know why we can or can't do things. It's just great we know everything before hand.
4a	On this project, were there measurable results within your work which resulted from the TVD process?	were able to capture some information that helped us understand where that project ended up in comparison to other projects. Needed to have a more robust validation project process, in terms of the scope of the project specifics, to understand what the primary issues were in the costing.	TVD process didn't get additional credits, but improve flow of info within the team, it's a timesaver because the team addresses questions right away and the TVD process questions are answered right away you don't have to wait a long time for a decision,.	Goal: eliminate design rework. This was by minimize rework, by capturing discussions earlier.	It helped with communicating upstream. It's a lot easier for me when I'm doing stuff in construction if I already know the team. I'm not just some guy coming in later saying hey we have all these problems, and the team looks at you and says how come?
4b	Are there other major benefits to you? (relate to stakeholder role: clients, architect, etc.)	Not so much accounting or legal, but that people have to be involved. Traditional roles really get change. E.g, we haven't really looked at estimators as a resource in the design process, looking at a broadening of skills.	Yes as LEED AP. You have a captive audience on a weekly basis, is you don't always have that luxury in a project. This is more efficient and less stressful.	More control over outcome, more confidence in ability to meet the budget, detail out work better when work hand-in-hand with incomplete info w/ designers	In the old lump-sum contract, the fighting over change orders was so hard on project managers. This TVD process does not eliminate all the issues, but with the open form of communication, it reduces the angst.
5	What are some of the drawbacks of TVD, obstacles to be overcome, potential pitfalls	Pitfalls are really in how you set up expectations and manage expectations to the process. Problem is when there is not a consistent understanding of those expectations, on all three major parties. As long as everybody has a clear understanding of expectations, understands the process, and abides by the process, it's pretty much a sure win.	If there was any, maybe there is too much information shared on the financial component. But don't want to give someone a hard number, and have them go out and figure out how to spend that money. Instead of having them identify systems and price it out you wonder if they have given you the best price.	Requires more communication, sharing of incomplete information. People like to work 'in a shell,' complete their thoughts for a report-out. It's challenging to change the culture. Requires continuous communication, observance, and feedback. More work upfront.	It challenges your time allocation, and the sequencing of our work. It is hard to be involved in multiple projects when you have to be involved in meetings. Our managers and VPs have to understand that. Few projects, with more intense time involvement.
6	Do you have ideas for improvements?	have more data behind our cost modeling, so that we have a surefire evaluation of what we are doing compared with the markets doing. Being able to articulate the process and the benefits to help people who are on the fringes of this, for example hospital administrators, to gain a better understanding of the process and view it with the same confidence as we have within the team. Better awareness of the 'why' and the lessons learned.	maybe there is a way to combine the TVD process and some range of the financials versus hard numbers? WE don't do this process on all projects, but everybody that is involved in the project thinks it is wildly successful	Big Room concept - but logistics don't work, since not everyone lives locally.	... none that come to mind.

Highlight Color, Represents Impact on Value Delivery  
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 Blue: Impact on Process  
 Yellow: Impact on Players (Actors)

Case Study Interview Responses (cont.)

	Sustainability	Contractor -1	Contractor - 2	Contractor -3	Contractor - 4
7a	Who is the Champion of Sustainability ?	Owner	everyone understood sustainability	Owner - driver and challenge	Owner
7b	Keeper of Green Building Goals?	LEED AP for documentation, Construction Manager for implementation.	LEED AP	Owner- but team works on items	didn't have a very strong LEED specialist involved – no one in particular
8	What were the goals on this project related to sustainability, and how were they stated (ie what format?)	owner project requirements (OPR) an owner expectations in terms of sustainability as it ties into the mission of Affinity and Ministry Health. LEED points set project specific, not dollars chasing points.	goals were ongoing, and evolving. LEED Healthcare.	Started as Green Guide for Healthcare, then LEED.	CTQs by Affinity were great. The LEED - didn't do a good job with stating the targets upfront. I came in about halfway through.
9	Were there ever options which arose to exceed the stated green building goals? If so, how was this information handled	Options considered, evaluated by A3 type process, compared to budget. The team has struggled with this and wants to find a way to implement more of these options, and yet meet a budget	As a group, we will throw out a bunch of ideas, consider them, and then see there is a way to make this fit, we are continually challenging ourselves to better design, always respectful of the budget, and patient experience.	none specific, but if saw opportunities to exceed metrics, tem would jump on them. Mindset of not just meeting the standard, but setting the standard.	LEED things were poorly communicated.
10	When, in the TVD process are these goals discussed? LEED and/or other	After the project was funded, before serious schematic design planning started. The OPR was in place and relatively unchanged from phases one and two.	Do a real good job of walking through these things at the beginning of design, then occasionally revisited when someone gets an idea further along in the process.	during early review of conceptual cost model - ie. discussed fuel reduction of 30%	LEED things were poorly communicated, and knew there were overall project metrics, but not discussed.
11	How are sustainability goals represented in the target value cost?	Only represented as we compare 'allowable cost' with previous Affinity projects, or to allocate specific funds for specific purposes.	Just part of the everyday project costs.	test some concepts, fit into cost model. There are allowances.	Minimal impact on cost.
12	Are the sustainability goals a specific cost item, or is this included in all decisions?	Some cost specific cost items and not in all decisions, but it does play into majority of them, from a culture standpoint. But to say it is a driver, or the driver, would be incorrect.	not a line item, it's a discussion of the best solution	In all decisions, plus contingency. Value determination w/A3s and CbA.	just component of decisions. Only one example of an item that had a high price tag on it, the rest really didn't have much impact on our target value cost
13	How are sustainability goals related to customer value?	Owner sticks to his guns on LEED. LEED provides diligence of process, and a documentation of the things that you do there specifically for sustainability. And maybe that's the real value of it.	directly in the OPR	Owner + team assembled owner project requirements (OPR). Some sustainability goals were specific, others just guidelines.	Definitely something we should do, but I'd say we dropped the ball on this one.
14	Would you describe the goals in this project as a prescriptive green building goals, or a philosophical underpinning of sustainability goals?	LEED is more of a tool we use to make sure we do the right thing	Probably a mix.	prescriptive, specific metrics provided by the client.	both
15	Have any of the energy or green building outcomes been commissioned, and is there a feedback loop to the core team with the findings?	Energy use is being monitored. Construction waste was monitored. All the material usage was monitored and recorded. Adjustments are being made accordingly, ans they see how the building is performing. Feedback – yes,	third party commissioning, feedback shared with the team, and the team works actively with the commissioning agent to identify the problem, the source of the problem and engage with the architect engineer or contractor to find a solution. this is the continuation of the ILPD process, this time the commissioning agent is the lead.	yes some, but full commissioning after Phase IV goes on-line.	Commissioned, and again – poorly communicated and managed. And that would be coming from us, the construction and engineering team.
16	How do the sustainability goals affect your work? Allocation of time? Resources?	Doesn't really matter. It requires more time from the project manager, to ensure documenting and implementation to actually achieve the goal. In design, added time/ effort to continue to push for the added information, why are we doing this, and what is expected outcome.	only took more time when people didn't understand the process or what needed to do to satisfy the credit intent. Now there is no extra document needed. You create construction documents, and those are about 90% of the information.	Positively. Keep us on our toes to explore new technologies and materials, looking at quality, test to specifications	I don't see that it's a big deal, to the normal levels. If it's over and above, I would need the allocation of time
17	Does your company have a vision statement? Does it include sustainability?	Yes, sustainability is separate from corporate vision statement.	yes, and yes	Not sure if a specific document, but mindset in all of our work.	pretty sure it does say sustainability - nope - will have to add that in.
18	What percent of your work has sustainability goals?	90 - 100% of healthcare market	at least 75%	All	70% and growing. Expect is with larger customers and/or projects.
19	Lean is often described as increased value, decrease waste. Did any of the sustainability goals serve as the framework of value by which waste was defined?	influence yes . Lean on the project was focused more on staffing issues and patient flow than it was sustainability.	The efficiency of making the best use of everything guides the process, which is people efficiency in building efficiency.	Waste is relative to something - yes.	Definitely on the Affinity lean process side, but have a hard time thinking of examples on the construction side.

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