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Lean by Design: The Synthesis of Lean and Design Thinking

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***Abstract* – The Boeing Company utilizes both Lean and Design Thinking methodologies to maintain and strengthen competitive advantage. While these practices support Boeing's vision to out innovate the competition, there is a significant opportunity being missed. Lean and Design thinking are complimentary methodologies. Exploiting the synergy that exists between the two practices can have a multiplying effect that can help propel Boeing forward as it enters its second century. This article documents a recent pilot workshop within Airplane Programs where these methods were blended for the first time. This paper provides an overview of the key elements of the two methodologies and sketches a vision for how to achieve both productivity enhancements and innovation simultaneously.**

Index Terms – **abduction technique, Community of practice, Continuous improvement, cost reduction, creative abduction, customer empathy, Customer-centric, efficiency, engagement, Gemba, Human Centered Design, innovation, Innovation Paradigm, innovative solutions, Integration, Kaizen, Lean, Lean +, Design Thinking, Lean by Design, methodology, out-innovate, productivity, quality, Second Century, synergies, synthesis, Value Stream Map, waste elimination**

I. Introduction: Achieving the Boeing Vision

Lean Global Enterprise. These words are familiar to most Boeing employees. They are included in Boeing's vision statement and described as a core competency. Employees encounter the idea of working in a Lean manner on a daily basis. While Boeing hosts Lean training, Lean workshops and a Lean+ toolkit, not every problem or opportunity lends itself to a strictly Lean approach. In general, Boeing's Lean+ toolkit is a comprehensive collection of tools that support "kaizen[1]" (continuous improvement) activities. The toolkit also contains useful resources that support the discovery, reduction, and elimination of hidden waste that exists in Boeing processes. In short, Lean helps employees do *what* they are already doing in a more productive manner. So, how do employees figure out *what to do* in the first place? Two additional lines found in Boeing's vision statement refer to "leading with innovation" and "detailed customer knowledge and focus." Taken together these two concepts call upon employees to continuously improve their insight into the challenges customers face and to use this new insight to design visionary goals. The goals will lead to innovations that customers will value and reward. "Leading with innovation" further implies the goals employees set for themselves to enable enhanced customer value must go well beyond what would-be competitors dare to imagine. In a leadership message about the start of Boeing's second century, John Tracy, retired chief technology officer, writes:

"We may be approaching the start of our second century, yet our ultimate goal remains the same: We must safely, efficiently and effectively out-innovate our competitors in order to grow and sustain our business and make the world a better place... by out-innovating our competitors; we will continue to deliver for our customers…" (*Boeing Frontiers*, December 2015-January 2016, p. 7).

Adding Design Thinking to Boeing's improvement repertoire enables the breakthrough combination of productivity improvements to reduce costs, and innovation on possibilities that open revenue streams not yet imagined.

This paper will familiarize readers with key elements of the Design Thinking mindset and methodology and will compare and contrast Lean and Design Thinking to uncover synergies. Because Lean practices are so deeply embedded in our culture, we do not detail them to the same extent in this article. Those already familiar with Lean methods can help facilitate the melding of Lean and Design Thinking in service of Boeing's vision to out-innovate the competition. Finding the synergies and blending the strengths to maximize and leverage both is clearly an opportunity Boeing must exploit. Research indicates the comparison and blending of these two methods may represent a gap in scholarly and practice literature. Understanding this gap is advantageous for optimizing results. Adding Design Thinking to our current enterprise efforts to be Leaner in thought and action adds an intentional innovation agenda to how work is done at Boeing. The goal of this article is to encourage stronger dialog between Lean and Design Thinking practitioners and to find ways to unify these methods.

The following section summarizes what we believe to be the first formal attempt at intentionally synergizing Lean and Design Thinking to address a production problem. This is real-time information about a pilot workshop conducted by the Lean and Design Thinking experts for the authoring team just one week prior to publication of this article. Following this evidence for practical application, a high-level discussion of the pertinent elements of each methodology ensues. We argue for intentionally blending the methods and tools. There is an opportunity for increased business value through equipping Lean and Design Thinking facilitators with this blended method for addressing complex problems. This is an early step toward finding a way to capture the potential value. We are in innovation mode!

II. Finding a Way

Flight Managers, Traveler Managers, Group Coordinators, and others from airplane programs at both Everett and Charleston have experienced problems with the Lock Out Tag Out (LOTO) safety procedure as part of the overarching induction processes that manages the transfer of airplanes out of the factory. The airplane LOTO ownership transfer process shepherds aircraft from the factory to the traveler stall, then to the final stall on the flight line. Aircraft ownership changes throughout the process. Confusion about ownership, configuration, and LOTO hazardous energy status increases complexity. The aircraft takes various paths as it moves from the factory to the field. In Everett it is known as "crossing the bridge" between the Everett main factory and the Paine Field flight line.

Traveler Managers and Flight Managers were determined to look for solutions. Safety issues suggested a user-centered approach would be important to understanding the interrelationships among the multiple job roles involved. Their focus on process improvement suggested a Value Stream Mapping workshop would be appropriate. An enhanced Design Thinking and VSM workshop was proposed and accepted by the stakeholders, with two of the authors of this paper serving as facilitators – one a Design Thinking Boeing Designated Expert (BDE) (Liz Juhnke) and one a Lean BDE (Steve Dalton).

Workshop objectives:

- Develop a shared point of view relative to the issues and recognize the need for change.
- Understand which areas of the induction process are difficult to carry out safely and effectively.
- Understand areas of the induction process where LOTO-related activities need improvement.
- Define a common future state LOTO process across airplane programs.

The authors' objectives from a case study perspective:

- Assess the impact and feasibility of synthesizing Value Stream Mapping (VSM) and Design Thinking methodologies into a formal workshop format.
- Assess ways to blend the methods and tools to escalate potential solution generation and/or generate more holistic outcomes.
- Demonstrate the synergy that exists between VSM and Design Thinking methodologies as complementary and enriching methods.
- Identify potential barriers to successful application of this innovative approach.

The workshop utilized standard VSM workshop preparation activities augmented with deep context exploration and user-centered observations of each role. This included observation of late-night transfer processes and interviews documented in accordance with Design Thinking methodology. Value- and non-value-added activities were identified and affinitized. Additionally, a Value Stream service map documented critical steps in the process.

The workshop kicked off with an "Empathy Map" activity that helped all participants understand the unique perspectives and points of view they brought to the workshop. Next, participants validated the Current State process flow based on user research conducted prior to the workshop and they identified problems. Participants then formed into small groups to *Ideate* or solve selected

problems using brainstorming methods to develop creative and unique ideas. Participants developed their ideas through low-fidelity prototyping. Then each group shared their ideas with the larger group. Ideas that are feasible, viable, and desirable were identified. From the prototyping exercise, the team created a Future State Map to visually document their vision for an ideal LOTO process, which everyone validated.

This high-level summary of the workshop does not do justice to the transformation in thinking that occurred, nor to the rich collaboration between the Lean expert and Design Thinking expert that created seamless method integration. We want the readers to feel our enthusiasm for this innovative approach to solution finding. We came into the planning stage of the workshop with a belief that blending the methods would bring added value. We left the workshop knowing that it was true, and, more importantly, the workshop participants agreed that this workshop delivered enhanced outcomes in one-day – so we achieved both faster and better!

The following sections introduce Design Thinking to those who are new to this approach, and discuss Lean practices with a focus on contrasting and comparing methods. We attempt to paint a picture of what we are calling *The Boeing Way*. We believe the synergy of Design Thinking, an innovation methodology, and Lean, a productivity improvement and operations optimization methodology, is exactly what is needed at this time in our history.

[Figure 1 and associated text in this section have been removed for trade secret protection]

III. Design Thinking - Background

The Discipline of Design, which guides purposeful creation, has been described and discussed in scholarly literature since the days of the Bauhaus School (Gropius, 1935). The discipline evolved from a craft paradigm to an industrial paradigm thereby uniting art and industrial design. In the 1950s, Buckminster Fuller was famously credited with the following statement that became the rallying cry of what he called the Design Revolution: “You can never change things by fighting the existing reality. To change something; build a new model that makes the existing model obsolete” (Fuller, 2008). At that time, the design process was generally executed by design specialists who iterated through the processes of engagement, insight, analysis, synthesis, and judgment, working for and with a client in a particular industry segment. With the emergence of collaborative forms of people engagement in the workplace, this practice changed. Change began with the early group processes like T-Groups or Training Groups[1], Sensitivity Training, and eventually the emergence of Quality Circles (Grace and Rowland, 2007).

The confluence of the following phenomenon shifted the playing field and expanded the field of design beyond professional designers:

[1] T-Groups use interaction, role playing, and other techniques to gain insight (Crosby & Associates, 2012)

- A fully interconnected workplace.
- Open and real-time global knowledge.
- The tools to mine and apply that knowledge.
- Perhaps especially, the realization of the power of a committed group of people iterating on a shared vision

Scholars and practitioners across disciplines worked to describe the relevance of this ubiquitous but little understood field of inquiry (Archer, 1965; Lawson, 1980 & 1994; Cross, 1984 & 2006; Buchanan & Margolin, 1995; Orr, 2002; Nelson & Stolterman, 2003; Ackoff, Magidson, & Addison, 2006). The development of human-centered design standards (ISO 9241-11:1998, ISO 9241-210:2009, and ISO 26800:2011) introduced a broad definition of usability, closely aligned with business objectives and laid out fundamental principles for designers to follow in system design contexts. These include:

1. Ensure the project integrates the users' wants or needs and the environment in which they work or live.
2. Ensure designers know who the users are and how the system should fit into their lives or their work.
3. Make the demonstration of usability (in the broad sense of quality-in-use) the objective of the design team.
4. Form a flexible team that will understand and address all aspects of the users' experience with the system.

The Design Thinking learning curriculum had its origins in a program that was started at Stanford University in 1958 by engineering Professor John Arnold in collaboration with Bob McKim (Emeritus, Engineering) and Matt Kahn (Art). It was a joint program between the departments of Mechanical Engineering and Fine Arts. It was funded in 2005 by one of the co-founders of SAP, Hasso Plattner, who named it the Hasso Plattner Institute of Design, but it came to be known simply as the *d.school*. The international design consultancy firm IDEO practiced, tailored and democratized the creative design process, resulting in the mindset and methods called Design Thinking (Brown, 2009; Martin, 2009; Kelley & Kelley, 2013) (Fig 2). A teachable curriculum was developed and refined through Stanford's d.school.

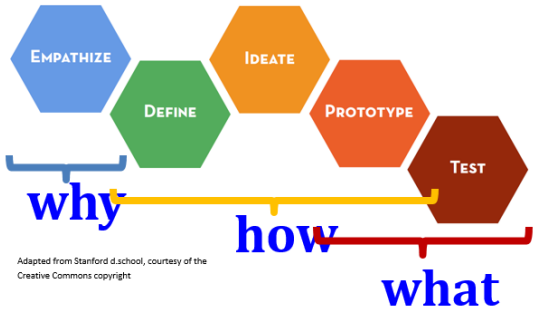

Figure 2. The Design Thinking Innovation Paradigm

The d.school offers an immersion style summer program called Bootcamp that is open and free to the general public. The curriculum material is available on the d.school's web site along with video commentaries and lectures posted by the faculty. Boeing practitioners have developed courseware based on a blending of the d.school and IDEO models. These tools are rich in their diversity and in their ability to change employee thinking about determining what is best to pursue in an innovation context. Also the methods are disciplined in their structure and produce repeatable results with minimal variation when used by different teams.

III. Design Thinking: New Leadership Technology

The deeply collaborative Design Thinking methodology, with its human-centered focus, enables the shift to customer-centricity and resonates with changes already underway in work re-design. It also resonates with diversity and inclusion initiatives focused on the business value of bringing a variety of perspectives to bear on a subject. For IT teams, it aligns perfectly with the Agile method of software development that iterates through quick cycles to deliver solutions incrementally while deeply engaging the end users/customers throughout. Design Thinking synthesizes these approaches to address the intersection of the three main innovation inquiries; what is desirable, what is feasible, and what is viable (Kelley & Kelley, 2013) (Fig 3).

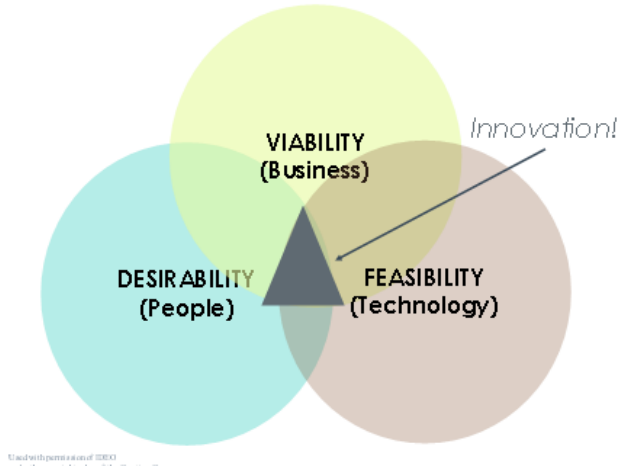

Figure 3. The Addition of Desirability to Solution Attributes Leads to more Innovative Solutions

While Lean methods apply to business optimization, streamlining processes and eliminating waste, Design practice is focused on business transformation and is driven by innovations in all areas of the business. "Design is a synthesis of creativity (imagining new things) and innovation (bringing those new things into existence)" (Nelson, 1994, p. 23). Twenty-first century businesses embrace design methods as a way of accessing and leveraging the creative consciousness of employees. Figure 4

shows the d.school Design Thinking process flow as taught inside Boeing, with key actions at the various phases, against the backdrop of a reference framework.

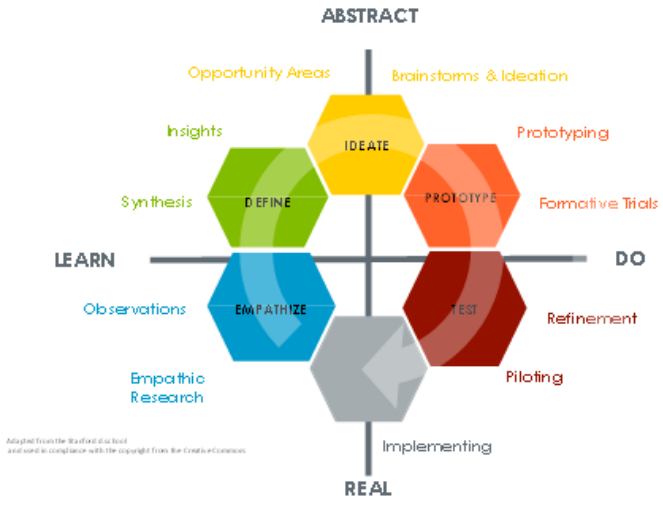

Figure 4. Design Thinking Methods Iterate in a Continuous Feedback Loop to Foster Innovation

Design Thinking, usually introduced through a workshop format, follows a qualitative, collaborative, and human-centered methodology. It iterates through a process that begins with ethnographic research and gathering insights on the problem or opportunity space that is the focus of the work. Through this research, team members develop a shared empathy for the context of work and especially for the stakeholders. This structure, and the habits of behavior the structure drives, will naturally transform, over time, a fragmented work environment characterized by silos of thought and activities, to a holistic culture that embraces whole systems design as a leadership imperative. Working within such a human-centered work environment, teams are better able to achieve a shared point of view or common vision within their team and with all their stakeholders. This, in turn, nudges the enterprise toward enhanced organizational structures that reinforce the systemic transformation cycle. This represents a new model of workplace leadership that encourages a shift in mindset and employs modeling and non-verbal communication media as a global language. Synthesis and pattern formation perform as thinking tools, and a build-to-think learning paradigm is leveraged to create rapid, low-fidelity prototypes. These prototypes facilitate experimentation with various solutions; they drive out insights and shared meaning for more adaptable and flexible results. Additional business value is generated as these new workplace behaviors blend with the latest research in Talent Management that describes work environments attractive to Millennials (Graen & Grace, 2015). This confluence of new behaviors contribute to the emergence, over time, of a culture of innovation. This is in direct support of the Culture to Performance initiative from Boeing's new CEO and is supported by the Academy of Management as the path to workplace transformation (Gruber, deLeon, George & Thompson, 2015).

Design Thinking is also inclusive of a systems paradigm (aka Systems Thinking) and shares principles with the systems sciences, such as:

- Holism as a methodology.
- Integration as a direction.
- Humanism as a task and responsibility.
- Openness as an ecology.
- Purposefulness as behavior.
- Choice as a driver.
- Multidimensional as structure.
- Counter-intuitive as an understanding,
- Emergence as a property (adapted from Gharajedaghi, 1999).

As the complexity of technologically advanced systems increasingly must interoperate in a System of Systems context, architects and engineers must learn to shift their mindsets to encompass a whole systems paradigm. Design Thinking shifts mindsets. Design Thinking is particularly effective in situations where there are multiple dimensions to consider, layers of meaning that challenge linear logic and many gaps in understanding. To address this complexity, Design Thinking employs an alternate form of logic that augments traditional scientific reasoning. It is more dynamic and thus more applicable to our rapid and continuously growing knowledge base.

"[This] logic of discovery. . . [represents] a dynamic logic applicable to cases of arguments in which knowledge is growing . . . [distinguishing] between the process of conceiving a new idea, and the methods and results of examining it logically" (Walton, 2005, p. 19). This logic of discovery, known as *abduction*, is an "intelligent guess based on what is known at some given point in an investigation" (p. 21). In the process of "creative abduction, the task is to generate plausible hypotheses" (p. 22) or *good guesses* that can then be shared and refined and ultimately turned into value-added solutions through the design process.

Abductive logic has been identified as "the only way a new hypothesis can be introduced in an inquiry" (Hintikka, 1998, p. 511). As such, it is a unique instrument. Abduction is a different modality from the traditional forms of scientific logic. "Deduction proves that something must be; induction shows that something actually is operative; abduction merely suggests that something may be" (Walton, 2005, p. 6) (Fig 4) and should precede the other forms of logic in scientific argumentation. When there are not enough criteria to assure an accurate deduction, abductive reasoning uses an incomplete set of observations and concludes the best possible explanation (Orsi, 2016). This has interesting implications for automation technology, especially robotics

and artificial intelligence (Josephson & Josephson, 1994, p. 20).

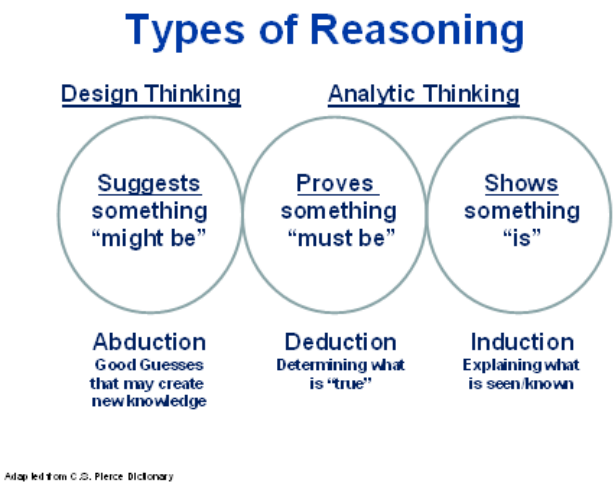

Figure 5. Types of Reasoning in Design and Scientific Argumentation

Thus, abduction "is a technique used to narrow down the number of alternatives by picking out one or a few hypotheses from a much larger number. . . and comes into play. . . with a phenomenon that has not yet been explained" (p. 8) and provides the insight to make a logical leap (Pierce, 1965) to a new understanding. This sets the stage for the type of possibility thinking (Schuller, 1967) that is critical to innovation. Design methods thus provide a solution to one of the thorniest leadership questions of the innovation movement: *How to do innovation?*

IV. Customer Focus

Many readers will already be familiar with the Simon Sinek concept of the "Golden Circle." His famous TED Talk on the topic has over 18 million views on YouTube as of this writing. As Sinek (2009) explains, when doing something new that is intended either to be used by or that affects others, especially if we expect them to buy it, the starting point must be "why".

From a Design Thinking perspective, innovation endeavors begin with more than just detailed customer knowledge; a level of insight often referred to as customer empathy is also required. In this mindset, employees are challenged to:

- Start by developing deep understanding of the customer, their feelings about the context within which they operate, and their key business challenges and opportunities.
- Use that empathy to envision a better world on their behalf.
- Set discrete goals that will give life to that vision.
- Then innovate to make it so.

Thus, useful innovation starts with customer empathy and a vision derived from that empathy. By developing detailed customer knowledge, we understand *the why* that motivates a particular customer, and this gets to the heart of anticipating their needs. Starting with *why* leads to discovery of *the what.* This approach of targeted innovation is counterintuitive. Asked to describe a process for innovating, many people start by talking about ideas. Companies and organizations striving for innovation often sponsor Idea Fairs. Such exercises are wasteful and perhaps even destructive to the organization's ability to achieve their innovation goals. What should come first is getting to the right articulation of a customer value-creation challenge. Getting this right is the secret sauce to outperforming the competition and is foundational to the creation of a culture of innovation. To remain an industry leader, Boeing will have to continue aggressively applying Lean methods and tools while exploring next generation ideas and methods for innovation. Design Thinking offers a range of powerful and standardized tools that guide the user toward development of a deep understanding of *the why*. Further, it facilitates a smooth process for evaluating iterations in thinking, building, and learning to identify *what and how*. This is an innovation paradigm.

Ultimately, the task is not simply designing something and making it work well at the least cost. Rather, it is to design the right something and communicate the connection between that thing and the target customers' or users' activities or feelings. Numerous psychologists have studied why focus groups do not really represent consumers. One noted researcher in this space is Philip Hodgson (2004). He observes, "It is not the voice of the consumer that matters. What matters is the mind of the consumer. The big mistake is in believing that what the mind thinks, the voice speaks" (p. 1). Sinek relates this dichotomy to the distribution of various functions in the brain. Perceptions dealing with feelings and comfort are in the more primitive areas of the brain, sometimes referred to as the limbic system. Higher powers of reasoning and language are controlled in various regions of the cerebral cortex. Marketing, selling, and design are psychological processes and inherently qualitative activities that should be understood as such by those engaged in innovation activities. The most powerful messages engage both the old brain (the limbic system) and the higher order cerebral cortex.

Discovering customer needs takes time and requires intentional activities like observing and conversing with them, forming relationships, and gaining insights into the rough spots in their daily lives. In the language of Lean, this process of discovery is called "going to the Gemba." Conversation will provide clues, but direct behavioral observation is significantly more informative. Instructions on

how to recognize and uncover opportunities (what it is exactly we are to observe) and how we should go about performing these observations in a disciplined manner is under-documented in Lean literature. This information is required in order to produce repeatable results. This is just one example of how the strengths and weaknesses of Lean and Design Thinking synergize.

V. Lean by Design: A Game Changer

In the traditional practice of Lean as institutionalized at Toyota (Morgan and Liker 2006), seven types of waste or *muda* are identified. These are typically classified as overproduction; inventory, waiting, motion, transportation, rework, and over processing. In the very first chapter of the book, *Lean Thinking*, Womack and Jones (1996) identify an eighth waste type: goods and services that do not meet the needs of the customer. When that which is produced is a poor fit or unsuitable as measured against what the customer values, it is usually because the producer has disregarded or is totally unaware of the value opportunity. If the value is misunderstood, then the metrics by which the right values are judged are not being used. The producers are measuring success or failure by one set of metrics while customers or would-be customers are measuring something different.

Much of Lean literature is focused on manufacturing. The idea of going to the place of work or the Gemba is equated with spending time with the customer in their work environment. Further, in Lean literature the word *Gemba* has taken on the transcendent meaning of "the place where the truth is found." Lean literature is filled with anecdotes about people going to the Gemba and the discoveries they make there. Observations made in the Gemba and conversations had with the people found therein are cited in virtually every book ever written on the subject of Lean. The Lean toolkit contains several powerful tools such as value stream mapping which can be applied to what is learned in the *Gemba*. However, what tools could the practitioner use while in the Gemba to help make the right observations and have the right conversations? This is especially important if one is uncertain about what actions would make a valued contribution. What if the *Gemba* is not in a factory setting but instead in an office or place in the virtual world?

Today's business environment is about *more for less*. The expectation is that businesses must provide more valuable products and services at lower costs. The idea of "better, faster, safer, cheaper" has dominated business thinking since the early Lean movements of the seventies and eighties. Through Lean, Boeing has achieved success by maintaining its competitive advantage with continuous incremental improvements to its products and services. It is understood that Lean practice does, in fact, deliver on the promise of *more for less*. It is also known (through simple observation) that over the past decade innovation is now driving new emerging markets, as well as effecting existing markets. Today customers equate value with products and services that are not just simply better, but innovatively better – the market is calling for *game changers*. Further, the expectation is that those innovations should resonate with why a company is delivering them in the first place. The *why* must map to a shared belief between both the supplier and the customer that the service or product truly has additional value. The writing on the wall suggests *innovative* is the new *better*, with *faster, safer and cheaper* simply expected. Competitive companies are driven to innovate faster with lower cost than their competitors. Additionally the reasons for doing so must directly relate to the customer's needs and values.

This emergent paradigm is not just about the ability to innovate faster, but to be able to do it over and over again; quickly, reliably and with high quality. Of course, customers still expect businesses to provide continuous improvements to existing products and services. Customers reward the speed of development for innovative new solutions only when the solution resonates with their perceptions of value. Orders for Boeing's new airplanes and the reception of Tesla's electric car in the market place validate this assumption. In today's markets, it is not enough to have new and innovative designs. Nor is it enough to produce existing products efficiently and cost effectively passing that savings on to the customer. To differentiate itself, Boeing must do it all. Further, it must be done in a manner that continues to escalate the emergence of a culture of innovation, so innovative behaviors become second nature that is the way things are done around here.

Throughout this paper, the practice of Design Thinking is explored with a focus on how it can directly guide the process of innovation. Design Thinking can be taught and mentored, and is a repeatable process. How do we take advantage of this? How can we be innovative and lean simultaneously? This synergy can be realized through the blending of Design Thinking and Lean practice at the very onset of product development - more specifically, with the direct and intentional application of design principles and practice to Lean. In fact, Lean already has a practice that approaches that ideal -- The Production Preparation Process or 3P.

Introduced in the US in the mid-1980s by Chihiro Nakao (a contemporary of Taiichi Ohno), 3P has been used with remarkable success across diverse industries in processes that start out lean because they were designed that way. Typically viewed as one of the more powerful and transformative of the Lean methods, 3P focuses on eliminating waste through product and process designs that require the least time, material, and capital resources to produce (McDonnell & Locher, 2012). Lean 3P is an event-driven practice (Coletta, 2012) that combines the design of a product simultaneously with the development of the operational value-chain (Porter, 1985) that will produce it. Designing the value-chain at the onset of the innovation process, using proven Lean principles, has benefits. It results in products that are more valuable, require less initial capital investment, and have lower ongoing cost for production.

This facilitates achieving the very essence of the concept of more for less. Instead of just using Lean to fix existing problems in the manufacturing or delivery process, 3P takes Lean upstream for integration into new product design from the start. This is where Lean can have the most influence on both the product and its value-chain. Ultimately, 3P methods represent a dramatic shift from the continuous, incremental improvement of existing processes sought with Kaizen methods alone.

The addition of Design Thinking to Lean methods provides the advantages of deeply understanding human needs and developing alternative designs that create breakthrough value. Combining Design Thinking mindsets and methods with Lean 3P will help avoid the creation of baked-in operational problems. This type of problem could ruin even the most promising of innovations. Boeing employees have learned, from hard-won experience, innovation at the scale of the company's products requires functional groups to work together. Conversely, traditional development approaches often result in a series of successive sub-optimizations and hand-offs. Market pressures can often drive employees to reach a design decision without fully understanding the subsequent impact to the value-chain that produces it or other downstream processes. This diminishes the ultimate value of the innovation. The concept is simple: bring the product and value-chain stakeholders together in a unified design process where products are developed together with the operations that will produce them. This includes product designers and engineers and representatives from Logistics, Operations, Marketing, Research and Development and Manufacturing. All participants should be trained (or mentored) in the *lean by design* practice. This will provide the flexible knowledge base for employees to work toward achieving the best alternative outcomes for each respective area; ultimately bypassing costly post-production changes.

The concept of lean by design proposes lean principles be incorporated into production of a product, service, or system during the design phase rather than after the design is complete (Fig 6). Lean needs to be interwoven into the design process. This will create a synergistic multiplying effect between product and process. This will result in greater quality and higher value for less cost; something sorely needed in today's "more for less" market environment. It is not enough anymore to have just a great design, nor is it enough to commit to continuous improvement of production and delivery through Kaizen. A company must "hit the ground running" with products and services that are already there – already *Lean by Design.*

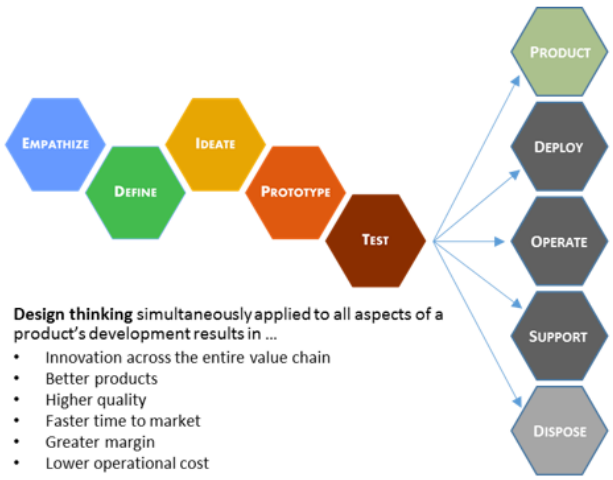

Figure 6. Design Thinking Applied Across the Value Chain

V. Summary and Conclusion

Design Thinking and Lean are far from rival strategies. They are not exclusive to any particular type of industry, product or service. The Legal firm Seyfarth Shaw, for example, is exploring and adopting Design Thinking into their SeyfarthLean® process in an effort to create superior client-centered services that are "Lean by Design" (Poor, 2015). The Architectural firm NBBJ is integrating Lean practices (including 3P) into their Design Services to achieve innovative improvements in physical spaces that are "Lean by Design" (Sausser, Susi, 2015). Design Thinking and Lean are complementary approaches that together drive toward innovative achievements that result in game changing improvements (Grace, 2012). When looked at closely, Lean methodology has always utilized core design principles. The very practice of Kaizen implies the need for constant and continuous design improvements. In many cases, practitioners using a particular Lean method might not even realize they are actually following proven design theory in the procedural form of Lean tools. To be Lean, businesses must be able to design lean processes continuously.

The only way to know if you are solving the "right" problem or delivering the "right" solution is to research the problem space thoroughly and from multiple and diverse perspectives. All good design starts with the why, and that is the core of Design Thinking. Clearly, Design Thinking does not replace Lean methods or Systems Thinking; rather it is complementary and even catalyzing. Most well thought-out technical disciplines overlap and in many cases, different names are created for similar if not identical concepts and tools. Young engineers in particular struggle with questions like "Should they focus on fleshing out a Lean value stream map or a Six Sigma process map?" The outputs of these two approaches often end up looking quite similar with their main differences being in the elements they emphasize. Choosing between tools is more about the customer focus and the accomplishment sought, the unique complex of

problems, and who the members of the team are, as opposed to being internally substantive. Becoming flexible in the use of different tools and methods is quite a useful skill. It helps employees shift points of view and thought processes from one area of emphasis to another. Additionally, it provides the ability to speak to different audiences in languages they understand. It makes our responses to a dynamic environment, well, dynamic.

What we discovered in our first prototyping of the synergies between Lean and Design Thinking is that this blending of the methodologies is the next logical step in our journey to shift mindsets toward a culture of performance and innovation. The fact that Design Thinking fills a gap in Boeing's current Lean+ toolkit only strengthens the rationale for its adoption as a partner in this evolutionary journey. The synthesis of these two powerful methods for leadership and change will propel Boeing to achieve levels of breakthrough in product innovation for which it will be known for the next 100 years – producing products and services that are *Lean by Design*. It will just be *The Boeing Way*.

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