

EVOLUTION OF THE LEAN ENTERPRISE SYSTEM: A CRITICAL SYNTHESIS AND AGENDA FOR THE FUTURE⁺

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Abstract: Many aerospace enterprises and other organizations have adopted a variety of management approaches to achieve continuous process improvement, enterprise change and transformation, such as the *lean enterprise system*, total quality management (TQM), theory of constraints (TOC), agile manufacturing, and business process re-engineering (BPR). Among them, the *lean enterprise system*, with its origins in the Toyota Production System (TPS), comes closest to providing a holistic view of enterprises as complex socio-technical systems embodying a mutually supportive set of precepts and practices driving enterprise operations at all levels (i.e., strategic, tactical, operational) and throughout the enterprise value stream encompassing both upstream supplier networks and downstream customer-focused activities. Lean enterprise principles and practices have evolved over many decades through a process of experimentation, learning and adaptation. A distinction is made between the *basic lean enterprise system (BLES)*, capturing salient developments over the period between the late 1940s and mid-1990s, and the *contemporary lean enterprise system (CLES)*, capturing major conceptual and implementation-related extensions of the basic model since the mid-1990s. The *lean enterprise system*, as a viable framework for explaining the structure and dynamics of modern networked enterprises, for managing them, and for improving their performance through either continuous process improvement or planned systemic change and transformation, remains a work-in-progress.

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1 INTRODUCTION

The *lean enterprise system* has been characterized as a new and fundamentally different way of thinking about and managing modern industrial enterprises. Its origins can be traced to the development of the Japanese auto industry management principles and practices over the decades since the late 1940s, based primarily on the evolution of the Toyota production system. Main elements of Toyota's production system, which were deliberately not codified until the 1970s to protect its competitive advantage enjoyed through *just-in-time production (JIT)*, evolved over time through a process of experimentation, learning and adaptation. Principal early attention in the West focused on Toyota's manufacturing and related operations over the period from the late 1970s to the mid-1990s. Since Toyota has served as the role model for *lean production* (Womack & Jones 1996:150), it is also known as the *Toyota Production System (TPS)*, *kanban* or *just-in-time (JIT) production system*.

A defining feature of the Toyota Production System has been the application of the *just-in-time production (JIT)* concept to manufacturing operations. The *just-in-time (JIT)* concept has been credited by Ohno (1988:75,78) to Kiichiro Toyoda, the first president of the Toyota Motor Company and the son of Sakichi Toyoda, the company's founder. In a *just-in-time (JIT) system*, a particular downstream production station *pulls* the right number of needed parts from the immediately preceding or earlier upstream station. A coupled idea is that of the *kanban* or *pull-system*, inspired by Ohno's observation of U.S. supermarkets (Ohno 1988:26-27), which worked on the principle that shelves would be regularly restocked as the customer purchased (*pulled*) needed products at the time and in the quantities needed. The *just-in-time (JIT) system* is enabled by the use of *kanban* cards, serving as a pull-replenishment mechanism sending orders to the earlier upstream station.¹ Thus, every step in the production process is linked and synchronized as a *continuous flow* process (Ohno 1988:5). The *continuous flow* production process is managed through a build-to-order approach utilizing *workload leveling* or *leveled production (heijunka)*, using *takt time*, to balance the workflow along the production line and hence to achieve *stability*. Thus, the *kanban* system and *takt time* together represent a unique horizontal coordination mechanism throughout the enterprise, extending out to the multi-tiered supplier network.

The term *lean production* was first introduced by Krafcik (1988), a researcher associated with the International Motor Vehicle Program (IMVP) at Massachusetts Institute of Technology, to underscore the point that *lean* uses less of everything compared with mass production. Even before the discovery of basic Japanese production methods that later became known as *lean production*, however, their main elements were already known to close observers of Japanese management practices (Sugimori *et al.* 1977; Ohno 1988; Monden 1993; Imai 1986; Shingo 1989). *Lean production* concepts were defined, articulated, and brought to the attention of a wider audience by Womack, Jones & Roos (1990) in their landmark book, *The Machine That Changed the World*, based on the first five years of research conducted under the auspices of IMVP.

An international benchmarking survey conducted by the MIT IMVP researchers in the late 1980s revealed that Japanese auto producers required roughly one-half the effort required to assemble

¹ Critics of *kanban*, as a pull-scheduling system, have pointed out that, even though it may be well suited to a high-volume, repetitive, manufacturing environment, it is not the only way of production scheduling, particularly in cases of demand variability (Hines, Holwe & Rich 2004:1000). Also, for several reasons, the application of lean production methods by Japanese companies, including the *kanban* system, has faced certain limits (Cusumano 1994).

cars compared with their European and American counterparts and the quality of the Japanese-made cars was, on average, 50 percent better than those made by American-owned plants in the United States and about 47 percent better than those produced by European-owned plants in Europe (Womack, Jones & Roos 1990:89). These were significant differences that could not be dismissed or explained away by attributing them to special Japanese social and cultural characteristics. Moreover, Japanese transplant auto production plants in the United States outperformed their domestic counterparts. The Toyota-General Motors joint venture, the New United Motor Manufacturing, Inc. (NUMMI) plant in California, based on the lean production system and employing pretty much the same workforce as before when it was a lagging General Motors plant, made a remarkable transformation in a short period of time, reaching the productivity levels of Toyota's own plants in Japan. These results formed the basis for designating the observed production system at Toyota and other Japanese auto makers as the *lean production system*, also often described as *lean thinking*, which has been defined as “a way to do more and more with less and less – less human effort, less equipment, less time, and less space – while coming closer and closer to providing customers with exactly what they want” (Womack & Jones 1996:15).

Gradually, the scope of the *lean production system* has been expanded from an almost exclusive focus on manufacturing operations to encompass the entire enterprise, from elimination of waste to creation of value, from enriching the enterprise's shareholders to delivering value to its multiple stakeholders, from seeking greater operational efficiency to achieving greater enterprise flexibility and responsiveness, from focusing largely on the core enterprise to embracing the end-to-end networked enterprise defining the core enterprise's *total capability space*, and from continuous process improvement to creation of network-level dynamic organizational capabilities. Accordingly, in this article, the term *lean enterprise system* is used to characterize the evolving scope and content of lean principles and practices.

Lean enterprise concepts began to attract widespread attention in the West in late 1980s and early 1990s at a time of historic change, particularly in the aerospace industry. The end of the Cold War and the intensifying international competition in commercial aerospace ushered a radically new market environment representing a paradigm shift from *performance* to *affordability*. In response to the new affordability imperative, the industry went through a prolonged period of consolidation, realignment and streamlining of existing operations, involving cycles of mergers and acquisitions. Although necessary, this was hardly sufficient. To achieve substantially greater efficiency improvements by focusing on process management many firms in the industry began to adopt *lean enterprise principles and methods* – then known under various names like *just-in-time (JIT) manufacturing*, *lean manufacturing* or the *Toyota Production System (TPS)*. More broadly, the dissolution of the dominant mass production paradigm catalyzed a major shift in management philosophy and practice concentrating on process management and continuous improvement.

A number of other process improvement approaches, as well, gained increasing popularity – principally *total quality management (TQM)*, *six sigma*, *theory of constraints (TOC)*, *agile manufacturing*, and *business process reengineering (BPR)* -- to boost operational efficiency, ensure greater customer satisfaction, and achieve enterprise transformation as a matter of long-term survival.² These approaches were advanced as unique and universally applicable best

² This list of process improvement approaches omits the various enterprise performance *assessment* frameworks -- such as the Capability Maturity Model Integration (CMMI) system developed by the Software Engineering Institute at Carnegie Mellon University, the ISO 9000 standards related to the implementation of quality systems as well as the ISO 14000 series of standards related to the

solutions to address the prevailing enterprise performance problems impeding their ability to achieve greater efficiency and effectiveness (e.g., waste, poor quality, process variation, lack of responsiveness). Among them, the *lean enterprise system* comes closest to providing a holistic view of enterprises embodying a tightly-knit set of highly complementary precepts and practices driving their central value-creating operations – product development, manufacturing, supply chain management – while optimizing the capabilities and utilization of all people and nurturing a culture of continuous organizational learning.

In recent years, lean enterprise principles and *six sigma* concepts have been merged in practice into a unified implementation approach, generally known as *lean six sigma* or as *lean six sigma (LSS) continuous process improvement (CPI)* toolset customized to address particular needs. Many aerospace companies have adopted various combinations of these and other methods, often under different titles (e.g., Lockheed Martin's LM21 lean transformation initiative, Boeing's Lean+ initiative, Raytheon's Six Sigma™ Process, Pratt & Whitney's Achieving Competitive Excellence (ACE) operating system). The main motivation has been to leverage the respective strengths of lean concepts (i.e., elimination of waste, speed of process flow), *six sigma* methods (i.e., virtually perfect quality) and related initiatives to help accelerate enterprise improvement and transformation efforts. Even though initially positioned as competing approaches to accomplish the same end results and choosing one meant the exclusion of others, in fact they each offer key features that can be combined to minimize their respective weaknesses and maximize the synergy among them.

This chapter focuses on the evolution of the *lean enterprise system*, by tracing its development since the late 1940s to the present. The goal of the chapter is to provide a unified contemporary review, interpretation and synthesis of the *lean enterprise system*, to highlight its evolving conceptual properties as well as to help managers make informed decisions in their enterprise change and transformation efforts. To understand the evolving nature of lean ideas, a distinction is made between the *basic lean enterprise system (BLES)* and the *contemporary lean enterprise system (CLES)*. The *basic lean enterprise system (BLES)* captures the development of lean enterprise principles and practices over roughly the period from the late 1940s to the mid-1990s. The dominant ideas took shape during the postwar decades and were documented mostly in the 1970s through the mid-1990s. The *contemporary lean enterprise system (CLES)* captures key conceptual and implementation-related expansions of the basic model since the mid-1990s. Core lean enterprise ideas have been significantly expanded conceptually in light of contemporary theory and reality, with a heavy concentration on the transformation of the aerospace industry since the early 1990s, mostly through research conducted under the auspices of the Lean Advancement Initiative at Massachusetts Institute of Technology (MIT).³ The contemporary system embodies and builds upon the central features of the basic system.

implementation of environmental management systems, and the Malcolm Baldrige National Quality Award criteria for manufacturing excellence. These frameworks or methods are typically used to gauge compliance with defined practices or standards of performance, progress towards pre-defined levels of capability achievement, or levels of excellence. They do not represent planned enterprise performance improvement models or frameworks, even though it might be argued that the implementation of the defined practices and metrics at various maturity levels could well propel an enterprise to a higher maturity level, marking a higher level of performance.

³ The program was launched in 1993 as the Lean Aircraft Initiative (LAI), a consortium of government agencies led by the U.S. Air Force, major defense aircraft companies, national labor organizations, and Massachusetts Institute of Technology. The central purpose of LAI was to help achieve greater

Building on this chapter, the next, companion, chapter is devoted to an integrated discussion of the *lean enterprise system*, *total quality management (TQM)*, and *six sigma*, which together share a common historical heritage, embrace critical common elements, and represent mutually supportive approaches. The broader goal is to help evolve an integrated management system that brings together the highly complementary elements of the various methods to maximize their combined strength and help managers improve their chances of success in planning and implementing enterprise change and transformation.

Following this introductory section, the next two sections provide an overview of the evolution of the *lean enterprise system* by focusing, respectively, on the *basic lean enterprise system (BLES)* and the *contemporary lean enterprise system (CLES)*. A summary comparative review of the key features of the two lean enterprise systems is then presented. Finally, a number of concluding observations are offered to summarize main findings, highlight major conceptual issues that remain to be addressed, underscore a number of implementation-related lessons learned, and outline future perspectives.

Throughout the chapter, the terms *organization* and *enterprise* are used interchangeably, with a clear preference for the latter to highlight emerging organizational forms (e.g., network organization, virtual corporation, boundaryless company) at multiple scales of complexity (e.g., program enterprise, company division, multidivisional corporation, government agency -- with their associated networks of supporting organizations) and embracing a spectrum of organizational configurations ranging from vertically-integrated firms to relatively flat organizational networks.⁴

For rough comparability between the two sections below focusing on the *basic enterprise system (BLES)* and the *contemporary lean enterprise system (CLES)*, the discussion is organized around a number of discrete dimensions to draw attention to their main characteristics: **goal** (main purpose, objective, expected outcome sought through the adoption of lean principles and methods); **background** (origins, defining features); **core concepts** (main organizing ideas, underlying mental model, cause-effect relationships, posited internal and external enterprise context driving

affordability in the development, production, and lifecycle operations and sustainment of defense systems. The program was renamed Lean Aerospace Initiative in 1996, with the addition of both the defense and commercial space sector, and the commercial aircraft industry, into the program. The program's scope was further expanded in 2007, when it was renamed Lean Advancement Initiative to broaden its research and implementation thrust to encompass both aerospace and non-aerospace organizations. The program's main objectives are to: (a) enable enterprises to create value for their multiple stakeholders effectively, efficiently and reliably in a complex and rapidly changing environment; (b) enable focused and accelerated transformation of complex enterprises through the collaborative engagement of all stakeholders in industry, government and academia; and, (c) understand, develop, and institutionalize research-driven principles, processes, behaviors and tools. For more information, refer to the LAI website <http://web.mit.edu/lean>.

⁴ In aerospace, for example, large system-integrators or prime contractors are typically supported by complex multi-tiered supplier networks, where as much as 60%-80% of the total cost of aerospace systems consists of the materials and parts, components, and subsystems provided by the suppliers. Many of the first-tier suppliers or subcontractors are large companies (e.g., Rockwell-Collins, Honeywell, Raytheon, Northrop Grumman) with multiple products, simultaneously engaged in networked relationships with multiple system-integrators or prime contractors (e.g., Boeing, Airbus, Lockheed Martin). The idea of complex large-scale networked organizations is thus beginning to displace the traditional emphasis on individual organizations as the basic unit of analysis.

required change); **focus** (scale, scope and content of targeted change); and **implementation** (change strategy and practices; process and execution of planned change; tools and methods; role of leadership and workers; timing, sequence, pace and type of expected change). Since a substantial volume of literature already exists on various aspects of the *lean enterprise system*, the discussion presented below is highly compressed, favoring selectivity over comprehensiveness. In particular, the discussion below builds on and extends a review of the evolution of the *lean enterprise system* given in Murman *et al.* (2002:87-116).

2 BASIC LEAN ENTERPRISE SYSTEM (BLES)

2.1 Goal

According to Taiichi Ohno, who is recognized as the main architect of the Toyota Production System (Monden 1993:53; Fujimoto 1999:26), the most important objective of the Toyota Production System (TPS), as an enterprise, is to increase production efficiency by “consistently and thoroughly eliminating waste” (Ohno 1988:xiii). According to Monden (1993:1), the ultimate goal was profit, to be achieved primarily through cost reduction or improving productivity by eliminating waste.

2.2 Background

The *basic lean enterprise system (BLES)* embodies the central attributes of the Toyota Production System (TPS), as it has been documented in the literature (e.g., Ohno 1988; Monden 1993; Shingo 1989; Womack, Jones & Roos 1990; Womack & Jones 1996; Liker 2004). The roots of key ideas inherent in the basic system can be traced to the most inauspicious circumstances in which Japan found itself following World War II: a small and fragmented domestic market, small and depleted workforce, scarce natural resources, and little investment capital. The Fordist moving assembly-line mass production system represented the most efficient prevailing way of producing cars through the achievement of significant scale economies. This was made possible by high-volume, large-lot production of standardized parts through dedicated production processes and highly specialized tasks. However, under the prevailing circumstances, “mass production could never work in Japan” (Womack, Jones & Roos 1990:49) and, besides, Japan’s fledgling auto industry had to find some way of withstanding the Western mass production giants poised to enter the Japanese market. The challenge was how to design a new production system that could simultaneously provide a greater variety of low-cost and high-quality products to meet diverse and varying customer needs in a highly fragmented domestic market in an environment of intense domestic competition, where such a new production system would be both *more efficient* and *more flexible* than the prevalent *mass production system*. The *lean production system* emerged in this most inhospitable environment as a coherent competitive response to mass production.

2.3 Core concepts

The basic lean system is not a list of “good” things to do, a toolset, a set of implementation techniques, or some multi-step implementation process. It is driven not by theory-based deductive thinking or postulates extracted from textbooks but rather by a process of experimentation, learning and adaptation. Lean principles emerged through practice and were later discovered, codified and extended by scholars and others. The uniqueness of the *basic lean enterprise system (BLES)* derives not from any of its individual elements but rather from having all the elements working together as a system (Liker 2004:xv).

Mirroring Toyota's experience, the *basic lean enterprise system (BLES)* reflects a management philosophy that values stability and constancy of purpose focusing on long-term rather than short-term results, delivering value to the customer, enhancing the capabilities of all people, elimination of waste, continuous improvement, and establishing long-term collaborative relationships based on mutual trust and commitment. Workers are treated not as a cost factor to be cut but as the main source of ideas for eliminating waste and achieving continuous improvement. Profit is seen not as unit cost plus profit but as the selling price, largely defined by the market, *minus* unit cost, which is under the enterprise's control.

As a production system, the basic lean model represents an interconnected set of highly complementary, mutually-positively-reinforcing organizing principles working together as a system. These interrelated core principles encompass the following:

Customer focus. The starting point is focusing on the customer, to produce the product the customer wants at the right price, at the right time, and to deliver the quality valued by the customer. Customer needs and expectations act as a *pull* on all enterprise activities, representing the "true north," providing orientation for the entire enterprise.

Elimination of waste. In order to make products that the customer values, all forms of waste (*muda*) must be eliminated.⁵ Ohno (1988:95) saw "complete elimination of waste" as the basis of the Toyota Production System. *Elimination of waste* not only reduces cost but also shortens cycle time (e.g., production, product development), in particular the order-to-cash cycle time – the elapsed time from the moment the customer places an order to the point when the company collects the cash (Ohno 1988:ix). It is far more important to remove non-value adding activities, which saves time, than to speed up the production process by driving it faster.

Continuous flow. Continuous flow entails ensuring that only the right parts reach the assembly line at the right time they are needed and only in the amount needed, with no defects. This means, in the limit, *single-piece flow* (i.e., make one and move one) or stockless production virtually eliminating inventories of raw materials, work-in-process inventories or finished products, with minimal travel or movement between operations. Creating *continuous flow* requires, before anything else, careful sequencing of all essential work steps and work standardization (Ohno 1988:130). It also involves the application of a number of methods of workplace organization.⁶ The primary challenge is to discard the batch-and-queue mentality and install a single-piece flow system. Flow is best achieved by discarding traditional functional organizations and by replacing them with integrated product teams organized along the value stream.

⁵ Chief sources of waste include overproduction, defects, waiting, underutilization of the capabilities of workers, transportation, inventory, motion, and excess processing. Each activity, action or step in the production process, either directly contributing to it or enabling it, is classified into one of the following categories: (a) it unambiguously creates value; (b) it creates no value but it is unavoidable given the current capabilities within the company; and (c) it creates no value and can be eliminated immediately. Actions in categories (a) and (b) are analyzed further through the use of value engineering, in an effort to improve the action as much as possible, eliminating unnecessary expenditures of resources. See Ohno (1988:57-58).

⁶ These include visual controls (e.g., *andon* lights, *kanban* cards; color-coded delineation of tools and work spaces), 5S (i.e., sort, straighten, shine, standardize, sustain), cellular manufacturing, and point-of-use storage (POUS), involving direct delivery of materials and parts to specific work stations where they are used.

Perfect quality. *Striving for perfect first-time quality* is absolutely essential for the realization of continuous flow. This means materials and information *flow* from one station to the next, but defects *do not flow by design*, since defects represent rework, a major source of waste. Besides enabling continuous flow, of course, striving for perfect quality is inextricably linked to achieving absolute safety. Toyota's basic rule, in fact, has been safety first, followed by quality. *Continuous flow* would be virtually impossible without *striving for perfect first-time quality*, which permeates all activities throughout the enterprise and embraces all phases of the product life cycle from product development to production, sales and customer support services. This is enabled through the use of many of the methods associated with total quality management (TQM).⁷

Flexibility and responsiveness. Achieving flexibility and responsiveness strongly complements the other principles and amplifies their cumulative impact in terms of both greater efficiency and effectiveness. This is made possible through three important, closely related, innovations: small lot production, radically reducing setup times, and developing a multi-skilled workforce through intensive training and education, where a given worker could perform multiple tasks. Dramatically reducing the set-up time, from many hours to minutes, accomplished by Shingo, the creator of the "single minute change of dies" (SMED), was a significant competitive step forward for Toyota (Shingo 1989).

Collaborative relationships. In the lean enterprise, traditional arm's length, adversarial, short-term, transaction-based relationships are replaced by collaborative relationships, both internally and externally. Internally, the role of managers is to coach workers, help them solve problems, and nurture group and organizational learning in a teamwork environment. Externally, the principal or central firm (assembler) has collaborative relationships with its suppliers, based on mutual trust and reciprocal obligations, involving joint determination of prices, continuous cost reduction, information sharing, and joint problem solving. The multi-tiered supplier network essentially represents an extension of the core (assembler) enterprise, where assembler and its suppliers typically work together under a long-term cooperative agreement over the life of the product. Suppliers are selected on the basis of past relationships and a proven record of performance rather than on the basis of competitive bids. The relationships, involving not adversarial bargaining but synergistic problem solving, are managed in an environment of transparency and established ground rules promoting fair play and avoiding opportunistic behavior.

A relatively small number of first-tier suppliers are given greater responsibility and are integrated early into the design process. While dual sourcing is often practiced to stimulate competition among suppliers, close relationships are maintained with individual suppliers. Selected first-tier suppliers are further given the responsibility for managing their own lower-tier suppliers, acting on behalf of the assembler, through a *clustered control* structure, employing fair play and

⁷ For example, quality is designed into the product at the very outset rather than "inspected in" later in the process. Other well-known methods include *poka-yoke* (error-proofing), quality circles, team-based problem solving, quality-at-the-source, root cause analysis (e.g., 5whys), preventive maintenance, and employee suggestion systems. The production line is stopped to fix problems at the source when and where they occur. In addition, a sophisticated strategy of automation is employed to maximize the capabilities of both workers and machines to achieve "automatic control of defects," which is known as *autonomation* (*jidoka*) or *automation with a human touch*. The main idea is to have machines that can prevent defective parts from being produced. The origin of the idea is traced to Sakichi Toyoda, the founder of Toyota, who earlier had invented an auto-activated weaving machine where the "loom stopped instantly if any one of the warp or weft threads broke" (Ohno 1988:6)

mutually-beneficial relationships. Important practices include the use of target prices, performance monitoring, competition, asset-specific investments, cross-equity ownership, mutual dependence, and pursuing differentiated strategies for suppliers occupying different niches. Suppliers deliver components directly to the assembly line, just-in-time -- through small, frequent deliveries so that there is continuous flow of parts -- with no prior incoming inspection. The assembler and its suppliers work together to trace a defective part to its ultimate source, in the rare event that such problems arise. Supplier associations provide an on-going institutional mechanism for information sharing and technology transfer, for instance involving statistical process control (SPC) and quality assurance (Smitka 1991:17-22;135-174; Nishiguchi 1994:6-7); Womack, Jones & Roos 1990:60; Murman *et al.* 2002:104).

Continuous improvement. Continuous improvement (*kaizen*) means on-going incremental improvement based on knowledge. It involves process-oriented thinking and problem solving through teamwork, employing a wide array of practices, methods and tools (e.g., quality at the source, quality circles, 5whys, total productive maintenance, suggestion system). An important enabler is the Deming Cycle or Plan-Do-Check-Act (PDCA) cycle. Also a key enabler is having a multi-skilled workforce, giving workers many educational opportunities, and teamwork. Continuous improvement serves as the mechanism that ties together all of the lean enterprise principles and fundamentally represents a complex evolutionary process of learning-by-doing and organizational capability building.

Continuous improvement reflects a basic Toyota tenet that serious learning results from action in the *gemba*, or the real place where the work gets done and customer-satisfying value is created, resulting in the product or service that enables the company to survive and prosper. Existing engineering, process and work standards are strictly maintained, while at the same time they are improved on an on-going basis through *kaizen* to reduce cost, improve quality, and increase customer satisfaction by pursuing an incremental, gradual, improvement process. *Kaizen* involves everyone, managers and workers alike. Learning is synonymous with doing. Accordingly, in striving to build a learning organization, management empowers workers “to learn by practicing and doing, being physically involved, using hands as well as their brains” (Imai 1997: 89). The learning experiences in the *gemba*, leading to continuous improvement, reflect an appreciation of fundamental human values. Improvement is not a top-down dictum but a way of life, a source of pride in one’s work, a means of personal fulfillment and growth. In the *gemba*, improvement is both top-down and bottom-up, where the management’s role is “to help *gemba* do a better job by reducing constraints as much as possible” (Imai 1997:13-15).

These principles, and the clusters of activities and practices they embrace, create significant complementarities at the strategic, tactical and operational levels. This means that if the performance levels for a specific set of activities are improved incrementally by employing a given principle, then the performance levels associated with all other activities driven by the application of other principles will also rise incrementally. In other words, both direct (first-order) and indirect (second-order) interaction effects will be positive. As a result, if the marginal costs associated with some activities fall as a result of the realized positive direct and indirect effects, then it will be optimal for the enterprise to pursue all of the principles and associated activities together (Milgrom & Roberts 1990).

2.4 Focus

The *basic lean enterprise system (BLES)* has focused primarily on factory floor operations and only gradually expanded its scope to encompass the supplier network. The center of attention has been the development, management and continuous improvement of a customer-focused, pull-based, small-lot production system designed to provide a variety of low-cost and high-quality

products to meet diverse customer needs. A high level of efficiency is achieved at both a high-volume and low-volume production rate. The factory workflow process is designed to ensure continuous flow pulled by customer demand and enabled by *just-in-time (JIT)* production, which, in turn, is made possible by creating virtually defect free products and processes, with respect for people squarely at the center of the entire system. Relentless pursuit of continuous improvement places central emphasis on elimination of waste, by making optimal use of the capabilities of people, which ensures not only greater efficiency but also delivery of superior products to the customer.

The enterprise, as a *manufacturing system*, encompasses production, product development, and procurement or managing supplier networks (Fujimoto 1999:321), with central emphasis on the design and management of the enterprise's manufacturing-related operations. Womack & Jones (1994:93) envision a *lean enterprise* as "a group of individuals, functions, and legally separate but operationally synchronized companies," where "[T]he notion of the value stream defines the lean enterprise." An enterprise's *value stream* is defined, for each specific product the enterprise produces, as the chain of processes, activities and webs of companies involved in creating and delivering value to the enterprise's customers. In its most expansive form, the *value stream* covers the "entire set of activities entailed in creating and producing a specific product, from concept through detailed design to actual availability, from the initial sale through order entry and production scheduling to delivery, and from raw materials produced far away and out of sight right into the hands of the customer," where the organizational mechanism for making all this happen is called the *lean enterprise* (Womack & Jones 1996:20-21).

2.5 Implementation

The basic system has been reformulated, streamlined and popularized by Womack & Jones (1996) in a way that is easy to understand and implement across many industries, stressing the "how-to" aspects of working towards creating lean enterprises. Value stream mapping is used to identify all the specific activities occurring along a value stream for a product or family of products to develop a visual understanding of the flow of materials and information along the value stream (Womack & Jones 1996: 37-38, 311).

This reformulation defines a five-step process for converting *muda* (waste) into value:

(a) *Value*: The first step is to *specify value* as defined by the end customer. *Value* is defined in terms of the specific products and services having specific capabilities offered at specific prices to specific customers.

(b) *Value stream*: Mapping the value stream for each product provides a basis for performing an in-depth analysis of each of the individual activities in the value stream in order to identify and eliminate all non-value adding activities.

(c) *Flow*: Once the non-value-adding or wasteful activities along the value stream have been eliminated to the maximum extent possible, the next step is to make the remaining, value-creating steps "flow" continuously.

(d) *Pull*: Conceptually, the customer "pulls" the product from the enterprise rather than the enterprise pushing the product onto the customer. This "pulling" action triggers a cascade of production actions throughout the upstream supplier network.

(e) *Perfection*: Companies that have implemented lean principles and practices find that there is no end to the process of reducing waste and continually improving the product and service

delivered to the customer. Consequently, the pursuit of perfection entails a continuous process of improvement.

In this reformulation, a critical point is the crystallization of the focus on customer-pulled *value*, or the delivery of a product or service that is valued by the customer, to signal a shift away from the pursuit of cost reduction through elimination of waste as the central objective. Thus, the goal of the enterprise is defined not as the *absence of waste*, but as the delivery of customer-perceived *value*. What, then, is the relationship between customer-perceived *value* and *cost*? The answer provided by Womack & Jones (1996:35-36) is that customer-perceived *value* is delivered at *muda*-free unit cost, which exactly corresponds to *target cost* driving production operations.

However, the precise meaning of *muda*-free unit cost or *target cost* remains obscure in light of standard microeconomic theory of firm behavior under alternative conditions of market structure. Also, *muda*-free unit cost or *target cost*, defining the (minimum) unit cost at which customer-perceived *value* is delivered, means that the customer is the ultimate arbiter of what constitutes *muda* and what does not (Hines, Holwe & Rich 2004:997). The conceptual basis of such an idea is questionable.⁸

The work of Womack & Jones (1996), in addition to its contribution to a wider dissemination of lean ideas, has also elevated the concept of the *value stream* into the lean lexicon – a borrowing and broadening of the idea of the *value chain* introduced earlier in the literature.

3 CONTEMPORARY LEAN ENTERPRISE SYSTEM (CLES)

3.1 Goal

The basic goal of the enterprise, as conceived by *contemporary lean enterprise system (CLES)*, is the creation of value for multiple enterprise stakeholders. This is generally seen to underwrite an enterprise's overall success. Traditional measures of enterprise success (e.g., larger market share, lower costs, improved customer satisfaction, increased profitability, higher return to shareholders) are generally seen to reflect various, more specific, aspects or dimensions of the value creation concept.

3.2 Background

The basic *lean enterprise system (BLES)* has been extended substantially since the mid-1990s beyond its auto industry heritage, in part through research conducted under the auspices of the Lean Advancement Initiative (LAI) at MIT. Murman *et al.* (2002) provide a detailed discussion of salient recent conceptual and implementation-related developments, including an updated review and discussion of lean enterprise principles, by drawing on the MIT-LAI research. As part of its overall research agenda since 1993, the Lean Advancement Initiative has developed a family of frameworks, methods and tools for the deployment of lean principles at the enterprise

⁸ The notion of *muda*-free unit cost or *target cost*, which would have to be set by the producer ahead of time, would seem to argue that customer's preferences are already known with certainty and that improving cost, quality and delivery would deliver greater value to the customer. At least implicitly, it does not allow for a tradeoff between potential alternative bundles of utility (e.g., new product attributes, brand name, environmentally-friendly attributes) the customer may value and the incremental (marginal) costs of providing to the customer products or services embodying such alternative bundles of utility. More seriously, it would seem to argue that the firm should not invest in exploring the development of new technologies, products and services in the future, since this would deliver no value to today's customer.

level, as summarized by Nightingale (2009). The emerging high-resolution picture of the *lean enterprise*, while still drawing upon Toyota's evolving experience, incorporates new insights and perspectives grounded in a wider contemporary understanding of the structure and dynamics of complex large-scale networked enterprises, such as those in the aerospace industry.

3.3 Core concepts

The *contemporary lean enterprise system (CLES)* takes a holistic view of the end-to-end *networked enterprise* as a complex system, encompassing all enterprise functions and operations – core values, business system, strategy, capabilities, operations – and focusing on enterprise architecture, design and transformation. Lean thinking is defined as “the dynamic knowledge-driven and customer-focused process by which all people in a defined enterprise continuously eliminate waste with the goal of creating value” (Murman *et al.* 2002:90). This is in sharp contrast with the earlier view that the lean enterprise is focused exclusively on the customer and is primarily concerned with the elimination of waste.

There have taken place three major developments that define the basic contours of the *contemporary lean enterprise system (CLES)*, which together represent a distinct further evolution of lean concepts beyond the *basic lean enterprise system (BLES)*: (1) a conceptual reorientation and broadening of the goal of the traditional lean system, placing central emphasis on value creation for multiple enterprise stakeholders; (2) a fundamental reinterpretation of the major thrust of basic lean system, stressing the critical importance of developing an evolutionary learning capability towards the creation of dynamic long-term network-level organizational capabilities as the major source of sustained competitive advantage; and (3) important further interrelated refinements and elaborations of key aspects of the basic lean system, concentrating primarily on integrated product development, manufacturing and supply chain management, which reinforce and strengthen the previous two major developments.

These three developments represent highly complementary extensions of the conceptual scope of *basic lean enterprise system (BLES)*. The first defines the evolving vision and nature of the lean enterprise as a networked system with multiple stakeholders, while the latter two represent substantive theoretical expansions and refinements of the earlier basic lean model in directions more closely aligned with the growing body of academic literature, which identifies organizational learning and building dynamic organizational capabilities as the key source of competitive advantage.

Value creation for multiple stakeholders. Reflecting both a shift in, and a further refinement of, an enterprise's main goal, a *lean enterprise* has been defined as “an integrated entity that efficiently creates value for its multiple stakeholders by employing lean principles and practices” (Murman *et al.* 2002:144). In this definition, the idea of “elimination of waste to deliver customer-pulled value” is essentially replaced by “elimination of waste towards the objective of delivering value to multiple enterprise stakeholders.” Stakeholders encompass any individuals or groups who can affect, or are affected by, the enterprise's achievement of its objectives. The concepts of *value* and *value creation* are also given particular meaning. *Value* is defined in the context of an exchange between the enterprise and its stakeholders, where *value* means utility or worth accruing to stakeholders as a result of the enterprise's activities in return for the resource contributions they have made. Thus, *value* refers to the “particular worth, utility, benefit, or reward” the stakeholders derive in return for their respective contributions, where the level, nature and dimensions of *value* may change over time as the stakeholders' time horizons, preferences, priorities and willingness to pay evolve over time (Murman *et al.* 2002:178-179).

In order for the enterprise to create and deliver value to all stakeholders, it must not only *do the job right* but also *do the right job* (Murman *et al.* 2002:177). This suggests that *doing the job right* through continuous improvement is necessary but not sufficient. The enterprise must also be able to *do the right job*. The notions of *doing the job right* and *doing the right job* are brought together in a *value creation framework*, which consists of three interrelated components: *value identification*, involving the identification of the stakeholders and their value needs or requirements; *value proposition*, entailing the definition of the terms under which value exchanges among the stakeholders can take place and the structuring of the enterprise's value stream to ensure the realization of the promised value exchanges; and *value delivery*, encompassing the actual performance of all functions and processes throughout the enterprise's value stream in order to convey to all stakeholders the promised benefits in accordance with the value exchanges embodied in the value proposition (Murman *et al.* 2002:183).⁹

New and broader organizing principles are offered to guide the effort of lean enterprises to create value for all of their stakeholders by adopting and implementing the *value creation framework*. These principles are: (a) create lean value by doing the job right and by doing the right job; (b) deliver value only after identifying stakeholder value and constructing robust value propositions; (c) fully realize lean value by adopting an enterprise perspective; (d) address the interdependencies across enterprise levels to increase lean value; and (e) people, not just processes, effectuate lean value (Murman *et al.* 2002:281-289).

Developing evolutionary learning capability towards the creation of dynamic long-term network-level organizational capabilities. *Evolutionary learning capability* is a firm-specific ability to learn through multiple paths, or through any path, such as learning from what is already known, experimentation, finding workable solutions ahead of the competitors, or learning from the experiences of others. It is different from, and broader than, *routinized learning capability*, which enables *organizational learning* or building *manufacturing capability* through regular patterns of learning (e.g., problem-solving routines), learning from repetitive operations (e.g., learning by doing), or deliberate learning (e.g., planned searches for alternative courses of action). Unlike *routinized learning capability*, dealing with repetitive and regular patterns of change within the existing system, *evolutionary learning capability* pertains to shaping “higher order system changes that themselves are rather irregular and infrequent, and are often connected with rare, episodic and unique historical events” (Fujimoto 1999:20).

As documented by Fujimoto (1999), Toyota's evolutionary path has not been paved by perfect foresight, planning and rational action that has deterministically shaped all future outcomes. That is, the process underlying Toyota's rise to competitive prominence has not been driven by rational intention to gain competitive advantage. Instead, the company's growth and change over time has been the result of a combination of both intended and unintended developments flowing from what might have been initially considered as rational decisions. The company's evolution

⁹ Although identified and discussed sequentially, in reality all three phases of the proposed value creation framework are closely coupled and highly interactive. The framework suggests that excessive focus on delivering value to the end user or any other single stakeholder group can result in dysfunctional value streams that tend to ignore other stakeholders. That is, *value creation*, as defined here, differs from the traditional, and narrower, view of the basic lean system concentrating on *delivering value* – economic utility, worth or satisfaction – to the *customer*. Further, exclusive focus on making value delivery efficient spells a trap by inviting ever-increasing attention to elimination of waste, paving the way for an *anorexic* lean enterprise rather than a robust and thriving one. See Murman *et al.* (2002: 177-189).

has involved both successes and mistakes. However, over time, the company has gradually and cumulatively developed a capability for evolutionary learning – a certain kind of ability to evolve dynamic organizational capability -- that has enabled it to cope with a complex historical process that was, before the fact, neither predictable nor controllable.

To ensure long-term success, an enterprise's skill at organizational learning and knowledge creation, leading to the creation of an *evolutionary learning capability*, is far more important than mastering such narrower skills as excellence in manufacturing, closely-knit relationships with suppliers, or similar management practices, where the latter strongly enable the former. A common challenge is how to resolve the apparent paradox between rigid work specifications that are necessary -- especially in aerospace enterprises that must be absolutely fault-intolerant consistent with their safety concerns and must, therefore, exercise tight control on their processes -- and the need for continuous organizational learning. Toyota appears to have resolved this apparent paradox through its institutionalization of the scientific method, driving continuous experimentation and rigorous problem solving (Spear & Bowen 1999).

Other lessons for aerospace enterprises have become available from the experience of Toyota and other Japanese auto companies, such as Honda, which have further developed network-wide knowledge-sharing practices fostering superior inter-organizational learning. Toyota, in particular, has been able to create a highly interconnected learning network with clear rules, in which the participating members openly share knowledge, where free riding by anyone is prevented, and both explicit (codified) and tacit (uncodified) knowledge is efficiently transferred across the network. This experience demonstrates that a network of enterprises working together collaboratively can be more effective than a single firm, or a focal firm with arms length relationships with its suppliers, in creating, transferring and using knowledge. The reason is that there is greater diversity of knowledge that can be tapped within a network than in a given firm or in a focal firm that has adversarial supplier relationships. However, it should also be recognized that while creating such a collaborative supplier network is well-suited for exploiting the existing diversified knowledge across the supplier network, it is much less effective at generating new capabilities since the diversity of knowledge in the network will diminish over time as firms in the network become increasingly alike by adopting existing tacit knowledge from others (Dyer & Nobeoka 2000).

Integration of product development, manufacturing, and supply chain management capabilities. Today, the key practice of concurrent engineering -- the practice of simultaneously designing both the product and the manufacturing process for building it through the adoption of an integrated product and process development (IPPD) process, using integrated product teams (IPTs) – is widely understood and used, particularly in the aerospace industry, since its introduction into the F-22 Raptor program in the early 1990s. The benefits include substantial reductions in cycle time and cost, and improvements in quality. Concurrent engineering entails a cross-functional approach, often involving the participation of suppliers. It is generally implemented through an overlapping process involving simultaneous product and process engineering, deployment of cross-functional teams, early supplier integration into the design process, and delegation of greater responsibility to suppliers in designing and developing new products (Clark & Fujimoto 1991). The aerospace industry has widely embraced these emerging lean enterprise practices. In the F-35 Lightning II Joint Striker Fighter (JSF) acquisition program, in which Lockheed Martin is the prime contractor, the air vehicle IPT has been led by a collocated employee of Northrop Grumman, which, along with BAE Systems, forms the core program team working closely with Lockheed Martin.

An important development beyond concurrent engineering has been the development of design strategies and cross-platform product development approaches. Toyota and other leading companies have made further progress in product development by shifting their thinking from efficient management of single projects to multi-project management involving platform sharing. It has been found that projects employing concurrent technology transfer across different product platforms are, by far, the most efficient, measured in terms of engineering hours required (Cusumano & Nobeoka 1998).¹⁰ The important lesson drawn from this research is that efficient management of a single project at a time is no longer sufficient for companies to ensure their success in an increasingly competitive global market environment. Moving in this direction, aerospace enterprises have increasingly stressed subsystem commonality across multiple platforms.

Finally, important lessons from the auto industry in supply chain design and management have become increasingly recognized by aerospace enterprises, based on earlier findings that delegating greater design responsibility to key suppliers has represented a significant source of the competitive advantage built by the Japanese auto companies. That is, an important lean practice is to integrate key suppliers into the design and development process: they participate early in designing new products, assume significant design responsibility, have strong communication links with their customers, and are involved in joint problem solving tasks (Clark 1989; Clark & Fujimoto 1991). Significant features of closely-knit customer-supplier networks include the formation of long-term supplier partnerships and strategic alliances and often involve collaborative problem solving, information-sharing, cost-sharing, and risk-sharing relationships fostering continuous inter-organizational learning. A key development has been, for a core or focal enterprise, to expand its technology and knowledge base through early supplier integration into the product development process.

In the aerospace context, it is shown that having database commonality across the supplier network in the defense aerospace industry helps to control cost overruns in defense acquisition programs (Hoult 1997). Related research demonstrates that early supplier integration into design and development in defense aerospace is a key enabler of *architectural innovation* in new product development (Bozdogan, *et al.*, 1998), where *architectural innovation* is defined as a major modification of how components in a product or system are linked together by proactively leveraging and integrating the existing technology base of the supplier network (key suppliers, tooling suppliers, subtiers) early in the product development process. The results, based on case studies, indicate that *architectural innovation* can yield significant benefits in terms of lower cost, shorter cycle time and higher quality, made possible through early supplier integration into design.

¹⁰ These efficiency gains stem from being able to reuse technology from a base project in another project, sharing tasks across different projects, and being able to make mutual adjustments in performing the design tasks on different projects. Also, using concurrent engineering enables firms to avoid wasted or redundant work across multiple platforms. Part of the explanation for the superiority of concurrent engineering across overlapping projects is the ability to coordinate projects and to make design adjustments as the projects move along, thus avoiding costly subsequent rework. Further, it is found that concurrent technology transfer enables firms to improve their overall market performance, by quickly diffusing new technologies across multiple product platforms. Moreover, concurrent technology transfer, through the overlapping and coordination of tasks across multiple platforms, enables the sharing of key components and helps differentiate end products. See Cusumano & Nobeoka (1998).

These findings are broadly consistent with, and supportive of, a growing body of academic literature in recent years stressing the importance of evolving collaborative inter-organizational knowledge-sharing relationships and learning networks to evolve network-level strategic capabilities in an environment where competition between individual firms is being increasingly replaced by competition between networks and where suppliers are increasingly emerging as important sources of technological innovation.

These recent research-based findings suggest that the *basic lean enterprise system (BLES)*, as well as the *contemporary lean enterprise system (CLES)*, contain elements of a “virtuous circle” not only for achieving short-term efficiency gains but also for creating long-term dynamic network-level organizational capabilities.

3.4 Focus

The emerging focus on value creation for multiple stakeholders has served as a compass for guiding future directions of change in enterprises. Also, the earlier stress on continuous process improvement has given way to a new emphasis on enterprise transformation or, more accurately, on transforming enterprise business processes, while retaining the earlier concentration on operations. Thus, there seems a mismatch between salient intellectual developments, underscoring the importance of developing network-level dynamic capabilities, and the continuing emphasis on enterprise operations focused on achieving greater efficiency and effectiveness.

Meanwhile, total enterprise boundaries have remained somewhat ambiguous. As a reminder, it may be useful to make a distinction between a *core* enterprise and an *extended* enterprise. A *core* enterprise refers to a *focal, central* or *nodal* enterprise, such as a system-integrator or prime contractor (e.g., Toyota, Boeing). It has also been used to refer to a tightly coupled entity, such as an integrated core team of companies working together on a major defense acquisition program, consisting of the *focal* enterprise and its work-sharing partners and major subcontractors. An *extended* enterprise encompasses the network of organizations that are clustered around the focal or core enterprise -- spanning from lower-tier suppliers to end-use customers -- that are involved in the design, development, manufacturing, and lifecycle sustainment of a product or system and that are less tightly integrated with the core entity.¹¹ The construct of a *networked enterprise* has been introduced more recently to provide a more unified definition of an enterprise consisting of a network of interdependent organizations linked to the *core enterprise* through tightly coupled or loosely coupled relationships. The concept of *networked enterprise* defines, in effect, the core enterprise’s *capability space*. An important benefit of the *networked enterprise* concept is that it lends itself to a more precise definition using network theory principles.

¹¹ The concept of an *extended enterprise*, as defined, is basically the same as the notion of the *enterprise value stream* articulated earlier by Womack & Jones (1996:20-21). A more “bounded” interpretation is provided by Dyer (2000:vii,8), where an *extended enterprise* refers to a set of firms within a value chain or production network that have established collaborative relationships, enabling them to work together as an integrated team to produce a finished product (e.g., an automobile). Murman *et al.* (2002:159-162) further define enterprises at multiple levels. Examples include a *program enterprise* (e.g., F-35 Lightning II Joint Strike Fighter), a *multi-program enterprise* (e.g., Lockheed Martin Aeronautics Co., BAE Systems), or a *national and international enterprise* (e.g., European Aeronautic Defence and Space Company – EADS). These definitions reflect the prevalent vantage point, where enterprises are viewed through the lens of the core, focal or central organization.

Despite the rhetoric of value creation for multiple stakeholders and taking a holistic view of enterprises, the concept of the end-to-end networked enterprise has been reduced, for all practical purposes, to one of value exchanges among many enterprise stakeholders.

3.5 Implementation

The implementation of the *contemporary lean enterprise system (CLES)* principles and practices requires a comprehensive approach to improving the performance and capabilities of networked enterprises. An integrated set of implementation frameworks, roadmaps, methods and tools that have been developed by the Lean Advancement Initiative at MIT (Nightingale 2009) have been offered for achieving systemic enterprise change to effect major operational improvements.¹²

4 SUMMARY COMPARISON OF THE BASIC AND CONTEMPORARY LEAN ENTERPRISE SYSTEMS

Table 1 provides a summary comparative overview of the two lean enterprise systems capturing essential outlines of lean enterprise ideas as they have evolved prior to the mid-1990s as well as over the period since the mid-1990s through further research and refinement reflecting contemporary developments. Major differences between the basic system and the contemporary system can be seen by examining the goal, defining features, core concepts, focus, implementation strategy, and mode of change shown in the table. The exclusive customer-centric orientation of the earlier system has evolved to embrace a multiple stakeholders view of the enterprise, but still retaining a distinct focus on customers. This has led to an emphasis on constructing robust value propositions and defining stakeholder value exchanges to help guide enterprise strategies and operations.

Elimination of waste has been replaced with creation of value for multiple enterprise stakeholders. The primary emphasis on efficiency has given way to effectiveness before efficiency. Virtually total concern with operations and core workflow processes (e.g., product development, manufacturing, supply chain management) has been broadened to encompass all enterprise functions and processes, even though actual applications of the system have continued to emphasize process improvements. The value stream perspective dominating the earlier system

¹² In summary, the proposed LAI enterprise transformation framework consists of four main elements: (a) seven principles of enterprise thinking, as well as a set of overarching concepts related to enterprise architecture and architecting to define future-state enterprises; (b) the *Enterprise Transformation Roadmap* tool; (c) the *Enterprise Strategic Analysis for Transformation (ESAT)* tool; and (d) the *Lean Enterprise Self Assessment Tool (LESAT)*. The seven principles, advanced as organizing ideas guiding the transformation process, include the following: (1) adopt a holistic approach to enterprise transformation; (2) identify relevant stakeholders and determine their value propositions; (3) focus on enterprise effectiveness before efficiency; (4) address internal and external enterprise interdependencies; (5) ensure stability and flow within and across the enterprise; (6) cultivate leadership to support and drive enterprise behaviors; and (7) emphasize organizational learning. The *Enterprise Transformation Roadmap* tool maps out a structured, closed-feedback-looped, step-wise process consisting of three main decision-action cycles driving both short-term and long-term transformation efforts: a front-end *strategic cycle*, a *planning cycle*, and an *execution cycle*. The *planning cycle* is implemented by using the ESAT tool; it is employed to develop an understanding of the current state of the enterprise, envision and design the future-state enterprise attributes, align the required enterprise infrastructure, and create the transformation plan. The LESAT tool, which is a capability maturity self-assessment framework, is employed to gauge the enterprise's progress over time. See Nightingale (2009).

has been extended to take a holistic view of the entire networked enterprise, even though here, as well, actual applications of the underlying system concepts have fallen far short of such a vision.

Also, continuous improvement, the centerpiece of the earlier system, has been conceptually expanded to emphasize continuous organizational learning and knowledge sharing. The source of sustained competitive advantage is no longer found in achieving greater efficiency through process improvements but in creating dynamic network-level capabilities. The intervention strategy has been broadened from a focal-enterprise-centric approach focused on operational improvements to a structured intervention approach to achieving change guided by the creation of robust value propositions and definition of value exchanges among multiple enterprises. The aim, at least in theory, is to link together the focal enterprise and the rest of the networked enterprise to ensure a collaborative win-win change and development process spanning the enterprise network. The desired effect is to move away from the lack of any semblance of power equivalence between the focal enterprise and its supplier network, in which the focal firm has traditionally exercised top-down control of its supporting network, to an enterprise system where all participating organizations in the entire network can come together in mutual respect premised on a robust value creation framework shared by everyone. Again, actual applications of the contemporary lean system have lagged behind these conceptual developments.

5 CONCLUDING OBSERVATIONS

The *lean enterprise system*, known earlier principally as *just-in-time (JIT) production*, *kanban*, *lean manufacturing* or the *Toyota Production System (TPS)*, was originally developed at Toyota in the late 1940s and early 1950s, became fully developed over the postwar decades both at Toyota and other Japanese auto companies, came to be recognized in the West as a new and fundamentally different production system in the 1980s, and has since been adopted by numerous firms in many industries, and by other organizations, to improve performance through continuous process improvement as well as through wide-scale planned enterprise change. Its scope and content have been expanded significantly since the mid-1990s, reflecting new research and learning as its adoption has spread outside the auto industry, particularly into the aerospace industry to transform aerospace enterprise operations following the fall of the Berlin Wall in 1989.

The *lean enterprise system*, in its contemporary formulation, provides a holistic view of enterprises embodying a tightly-knit set of complementary precepts and practices driving its central value-creating operations – product development, manufacturing, supply chain management – while optimizing the capabilities and utilization of all people and nurturing a culture of continuous organizational learning. Such a holistic conceptual orientation is the result of many decades of experience, experimentation and learning at Toyota, which has served as a concrete real-world setting. The *lean enterprise system* embraces the organization and management of all enterprise operations at the strategic, tactical, operational levels. It conceptualizes the total end-to-end enterprise as an *extended enterprise*, an interdependent system encompassing the entire enterprise value stream encompassing both upstream supplier networks and downstream customer-focused activities. It thus takes a network-centric view of the total enterprise, organized around the “core” enterprise (e.g., system integrator, prime contractor, lead agency), supported by a closely-knit-together web of organizations, technologies, and processes branching out and encompassing a multi-tiered supplier network akin to an industrial ecology.

An important recent advancement in lean enterprise thinking has been a move away from a primary emphasis on elimination of waste to creation of value for multiple enterprise stakeholders. This has led to an emphasis on constructing robust value propositions and defining stakeholder value exchanges to help guide the enterprise’s strategies and operations. Also, a

significant shift has taken place from a central focus on pursuing continuous improvement of enterprise operations to enterprise transformation, with emphasis on the creation of dynamic long-term network-level organizational capabilities. The latter has been enabled by the development of integrated product development, manufacturing and supply chain management capabilities. The growing importance of building collaborative supplier networks, involving extensive knowledge-sharing and inter-organizational learning, reflects the recognition that competition between individual firms is being increasingly replaced by competition between networks, where suppliers are increasingly emerging as important sources of technological innovation.

Two sets of concluding observations are briefly offered below, the first touching on conceptual and practical issues and the second offering future perspectives.

5.1 Conceptual and practical issues

In general, the *lean enterprise system*, in terms of its earlier, formative, evolution, represents a practice-based, rather than a theory-grounded, enterprise management system. That is, its formative development has been basically *atheoretical* (i.e., lacking a firm theoretical foundation), as well as *acontextual* (i.e., lacking a formal conceptual articulation of the specific external environmental contingency conditions under which it is most effective or where it may be found largely ineffective). A number of main concepts or propositions, such as the construct of the *value stream* and the notion of a *stakeholder-centric* enterprise, remain ambiguous or incomplete. While the *value stream* concept has been useful for identifying and eliminating waste at the level of individual products, it is unwieldy at the level of complex large-scale enterprises with multiple products, each involving hundreds if not thousands of suppliers across the globe. Also, it is often employed as if the organizations along a given value stream behave like iron filings around a magnet – as a mechanical, control-oriented approach, defying real-life complexities. Similarly, the *stakeholder-centric enterprise* concept is framed in a rather simplistic manner, ignoring conflicts among stakeholders in terms of their value expectations or time preferences. Theoretical issues pertaining to aggregation of individual utility functions to derive group or social welfare functions, already addressed in the economics literature over many decades, has received scant attention. Also, despite some efforts to provide insights into the dynamics of network-level organizational learning and creation of dynamic capabilities, almost exclusive emphasis has continued to be placed on enterprise operations and process improvement. This has left an important void in terms of developing an improved understanding of the dynamics of technological innovation in lean enterprises to ensure sustained long-term competitive advantage.

Further, the *lean enterprise system* neglects contingency conditions by assuming a relatively stable or fixed external environment that is predictable and controllable, which essentially defines the boundary conditions within which it is most effective. A related issue concerns the general neglect of demand variability, although it could be argued that demand-leveling is a useful way of cushioning or protecting the system, based on a sound rationale, against external perturbations such as spikes in demand. In any event, as a general matter, lack of an explicit account of contingency conditions raises a basic question about the viability of the *lean enterprise system* under market conditions characterized by high-velocity change, hyperturbulence and uncertainty. An inherent risk is that of conceptualizing modern enterprises essentially as if they were *closed-systems*, something abandoned in the literature in the 1960s, forcing simple, linear, predictable and controllable cause-effect relationships.

Moreover, whether the *lean enterprise system* basically represents an approach for achieving continuous process improvement or strategic enterprise change and transformation through

planned intervention remains an open question, where the theoretical evidence seems to favor the former rather than the latter. Meanwhile, the concept of *transformation* remains conceptually ambiguous, even in the face of the fact it has been the subject of considerable theoretical attention in the organization science literature.

Other aspects or dimensions of the *lean enterprise system* have also come under some criticism. For example, Hines, Holwe & Rich (2004:998-1000) draw attention, among others, to its “lack of human integration” (e.g., exploitative and high pressure working conditions on the shop floor), “limited applicability outside high-volume repetitive manufacturing environments,” “fuzzy boundaries,” and “lack of strategic perspective.” Going forward, these issues invite greater cognizance of human dimensions of lean implementation, potential limits of lean practices, and the importance of taking a strategic holistic perspective to avoid getting trapped in narrow tactical or operational thinking. Application of lean concepts in the aerospace industry, involving the design and building of extremely low-volume systems as well as low-volume high-mix production, does not support the notion that the usefulness of the *lean enterprise system* is limited only to high-volume repetitive manufacturing environments. The lack of a holistic strategic perspective has severely limited lean implementation in the aerospace industry (see, for example, Crute, Ward, Brown & Graves 2003). The point about the “fuzzy boundaries” has been an on-going issue, largely as a function of the evolving nature of lean enterprise thinking, and requires greater attention to core issues of theory construction and relevance.

“How to become more like Toyota” by learning from Toyota, and from other organizations emulating Toyota, has dominated the research agenda, at the cost of evolving testable propositions, a prerequisite for construction of sound theory. Also, abstracting over many decades from the successful experience of Toyota serving as an exemplar company, despite its benefits, may not have been an unmixed blessing. Seeking implicit or explicit validation by reference to Toyota may have created a tendency to idealize observed practices and overlook certain pitfalls, blind spots or shortcomings, rather than reviewing them critically from a larger theoretical perspective.

Further, two main issues pertaining to the implementation of the *lean enterprise system* should be noted. The *first* involves the tension between *incremental change*, driving continuous improvement, and *enterprise transformation*, which involves radical, discontinuous or revolutionary change. The basic question is whether *incremental change* is capable of delivering *enterprise transformation*. The theoretical evidence on this question seems to be essentially negative, since continuous improvement, through incremental change, represents a *convergent process*, where incremental change only further refines and reinforces the existing system or paradigm. In contrast, transformation, through radical or disruptive change, represents a *divergent process*, a sharp break with the past.

Viewing lean enterprise concepts as a tight constellation of mutually supportive and reinforcing principles and practices (i.e., as an integral, indecomposable system) suggests that, to derive the full benefits of lean ideas, individual enterprise elements cannot be improved piecemeal or changed selectively in isolation from the others. Moreover, the adoption of lean enterprise principles, starting from an initial state of a traditional mass production or batch-and-queue type operational system, requires *radical* or *deep* change in the first instance, sweeping the entire enterprise, not *incremental* change, where continuous improvement through incremental change should come after, not before, such radical change. These observations run contrary to the common approach of selectively grafting lean principles and practices into an enterprise’s existing culture, structure and management system through a series of incremental change initiatives, while basically ignoring other lean enterprise principles, in the misplaced hope that this will enable enterprise transformation.

The *second* issue entails whether the dominant *planned change approach* – which represents a top-down, lockstep, linear, sequential, programmatic, control-oriented process – is the appropriate or effective approach to change management and, perhaps more importantly, whether it, in fact, represents the right lessons learned from the evolution of lean enterprise principles and practices. On both accounts, the answer seems negative. The *planned change* model, employed to implement the *lean enterprise system* to achieve large-scale enterprise change and transformation, has come under increasing criticism over the past twenty years for its fundamental flaws in addressing the considerable complexity of organizational change processes and time-dynamics beyond certain threshold complexity levels. Enterprises, as complex systems, exhibit nonlinear interactions, multilevel nested complexity, and strong emergent properties, where the behavior or outcome at a higher level cannot be predicted with confidence by observing detailed structure and behavior at a lower level, nor can the multi-level reverberations of top-down actions can be fully anticipated, directed or controlled.

The implementation of lean enterprise concepts and practices, often bundled together with *six sigma* methods and elements of other approaches, has generally been targeted at achieving continuous improvement at the tactical and operational levels, revealing a serious gap at the strategic level. As a result, there have been numerous individual cases of tangible and even significant operational improvements achieved in both industry and government organizations. These gains have been reflected in terms of lower costs, shorter lead times, higher quality, and increased customer satisfaction. However, the realized benefits have been visible mostly in the form of “islands of success,” (Murman *et al.* 2002:114-116), usually confined to particular programs, processes or functions, and have been rather short lived. Also, the implementation efforts have seemed to favor control of existing processes rather than further experimentation, learning, and innovation, leading to new processes and products.

These implementation-related issues require a fundamental re-evaluation of current *planned change* approaches and force to center stage a fresh re-examination of Toyota’s evolution over time through experimentation, learning and adaptation. Ohno, the father of lean production, did not create a perfectly rational and complete production system after a long day’s reflection. The *lean enterprise system* has evolved and matured over many decades, involving quite a few setbacks. However, this evolutionary real-world experience seems to have been “packaged” or reduced, by both academic researchers and practitioners, without a cogent rationale, into a deterministic and largely mechanical prescriptive formula for achieving change using a top-down, structured, control-oriented implementation approach. The efforts focused on “becoming more like Toyota” seem to have extracted the wrong lessons from Toyota’s own history. A correct reading of the past, already well documented, suggests that today’s *planned change* initiatives to turn existing enterprises into lean enterprises by engineering large-scale enterprise transformation, if they wish to achieve more than marginal benefits, should take cognizance of the limits of deterministic thinking and action. They should allow for ample room for emergent change to take hold and flourish, as a way of addressing the complex dynamics of enterprise change.

Important recent conceptual progress has been made in terms of moving away from an almost exclusive emphasis on largely descriptive “how-to” practices to embrace a broader set of precepts more closely in tune with contemporary mainstream organization theory, particularly in terms of developing the organizational capacity for learning and creation of dynamic network-level capabilities. At its current level of conceptual development, the capacity of the *lean enterprise system* -- as a viable framework for explaining the structure and dynamics of modern networked enterprises, for managing complex enterprises, and for improving their performance either

through continuous process improvement or through wide-scale planned change and transformation -- remains a work-in-progress.

5.2 Future perspectives

The *lean enterprise system* has been widely adopted by aerospace enterprises and other organizations since the early 1990s to achieve significant efficiency gains in operational performance. Both the new affordability imperative in aerospace and, more broadly, a major shift in management philosophy and practice following the dissolution of the dominant mass production system, forced a central emphasis on process management and continuous improvement. The ground has shifted since then, however, and enterprises no longer compete based on process management and continuous improvement. They must instead create dynamic long-term capabilities, establish inter-organizational networks fostering learning, knowledge-creation and innovation, and evolve adaptive and reconfigurable network architectures to thrive under varying external environmental conditions characterized by increasing complexity, high-velocity change and uncertainty. Accordingly, there is an opportunity to build upon and expand the integrated review and synthesis of the *lean enterprise system* presented in this chapter by pursuing a robust research agenda in the future designed to help strengthen its conceptual properties and practical usefulness. An important starting point is to address the types of issues highlighted above and, more generally, to integrate lean enterprise principles and practices more closely with the evolving mainstream organization theory and practice.

Table 1: Summary comparative overview of the key dimensions of the *basic lean enterprise system (BLES)* and the *contemporary lean enterprise system (CLES)*

Lean System Key Characteristics	Basic Lean Enterprise System (BLES)	Contemporary Lean Enterprise System (CLES)
History	Since late 1940s; documented mostly in late-1970s to mid-1990s period	Since the mid-1990s
Goal	<ul style="list-style-type: none"> • Deliver value to customers • Increase production efficiency and profitability 	<ul style="list-style-type: none"> • Create and deliver value to multiple enterprise stakeholders • Build dynamic network-wide capabilities for sustained competitive advantage
Core Principles	<ul style="list-style-type: none"> • Ensure long-term thinking, stability and constancy of purpose • Focus on the customer to deliver customer-pulled value • Take an end-to-end value stream view of the enterprise • Eliminate waste • Create just-in-time (JIT) production system • Strive for perfect quality • Achieve stability and continuous flow • Pursue continuous improvement • Enhance the capabilities of all people • Establish long-term relationships based on mutual trust and commitment 	<ul style="list-style-type: none"> • Adopt a holistic view of the end-to-end networked enterprise • Cultivate leadership stressing long-term thinking, stability and constancy of purpose • Construct robust value propositions and define value exchanges among stakeholders • Eliminate waste with the goal of delivering customer-pulled value to multiple enterprise stakeholders • Ensure synchronized flow throughout the networked enterprise • Foster a culture of continuous improvement and learning towards the creation of long-term dynamic network-wide capabilities • Develop collaborative relationships and mutually beneficial governance mechanisms • Evolve an efficient, flexible and adaptive networked enterprise
Focus	<ul style="list-style-type: none"> • Core enterprise operations & workflow processes • End-to-end value stream of the core enterprise • Collaborative relationships throughout the value stream 	<ul style="list-style-type: none"> • Entire <i>enterprise value stream</i> (core enterprise, upstream supplier networks, downstream activities linking core enterprise to end-use customers) • Enterprise operations at all scales (strategic, tactical, operational) • Leadership processes, core business processes (product development, production, sustainment, supply chain management), and supporting infrastructure processes (e.g., human resources, customer services, information systems, contracting) • Value exchanges among all enterprise stakeholders • Managing both internal and external interdependencies
Implementation	<ul style="list-style-type: none"> • <i>Value</i> -- specify value as defined by the end customer • <i>Value stream</i> -- identify the value stream to eliminate all non-value-adding activities • <i>Flow</i> -- make the value adding steps for the specific products flow continuously • <i>Pull</i> -- let the customers pull value from the enterprise • <i>Perfection</i> – pursue perfection through continuous improvement. Source: Womack & Jones (1996) 	<ul style="list-style-type: none"> • Pursue enterprise transformation by adopting a holistic enterprise perspective, lean enterprise principles, conceptual frameworks, methods and tools • Plan and implement enterprise transformation by pursuing a structured process containing, for example, the following major building-block steps: <ul style="list-style-type: none"> ⇒ Initiate strategic preparedness and learning cycle (e.g., define strategic imperatives, engage leadership in transformation); ⇒ Develop enterprise transformation plan (e.g., define enterprise, understand current state, create future state vision, develop strategic & detailed implementation plan); ⇒ Create required infrastructure systems & capabilities (e.g., enabling policies, metrics, information systems, incentive mechanisms, training of change agents) ⇒ Execute transformation plan (e.g., identify, prioritize, initiate & coordinate high-potential projects) ⇒ Monitor progress, take corrective action and institutionalize systemic change process.
Mode of Change	<ul style="list-style-type: none"> • Continuous incremental change 	<ul style="list-style-type: none"> • Systemic evolutionary change

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