

*Massachusetts Institute of Technology  
Engineering Systems Division*

**Working Paper Series**

**ESD-WP-2003-01.14-*ESD Internal Symposium***

---

**LEAN ENTERPRISES – A SYSTEMS  
PERSPECTIVE**

---

**Deborah J. Nightingale**

**MAY 29-30, 2002**

# LEAN ENTERPRISES – A SYSTEMS PERSPECTIVE

Deborah J. Nightingale

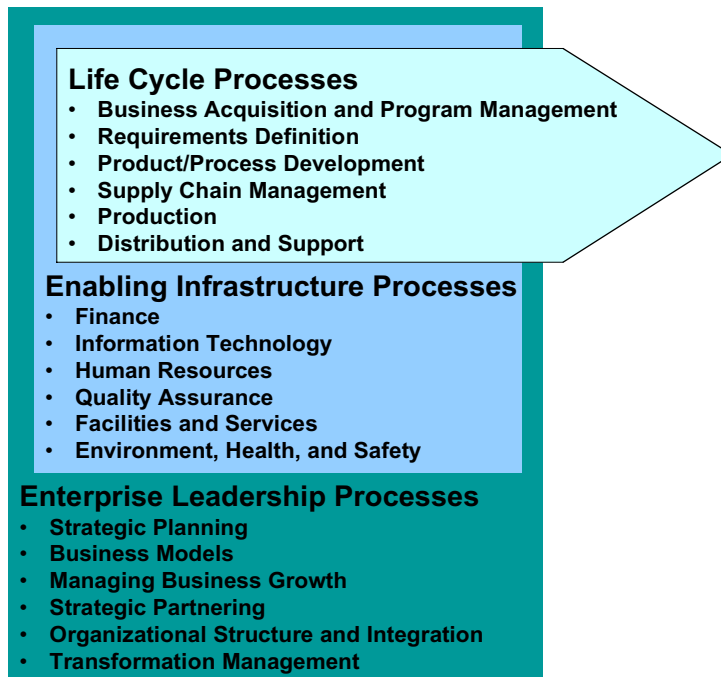
## INTRODUCTION

Becoming a “Lean Enterprise” is increasingly being recognized as an important strategy in achieving critical strategic goals such as responsiveness, cycle time and cost across all phases of the product life cycle. The concept of a lean enterprise is not new. Many books address lean enterprise topics.<sup>1</sup> For example, *The Machine That Changed the World*<sup>2</sup>, the book that introduced lean terminology, has a chapter on “Managing Lean Enterprises”. Despite having much written on this subject, lean enterprises are only starting to emerge in practice. Why has it taken so long to transform organizations to lean enterprises? Lean enterprises are complex, highly integrated systems comprised of processes, products, organizations, and information, with multifaceted interdependencies and interrelationships across their boundaries. Understanding, engineering, and managing these complex social, technical, and infrastructure processes are critical to becoming a lean enterprise.

What then are the attributes of a lean enterprise? Are there key fundamental principles employed to achieve a lean enterprise? What are the key concepts, architecture and interrelationships that comprise the enterprise “system”? What is involved in “engineering” a lean enterprise? This paper will address these questions along with the critical issues involved in modeling, analyzing and understanding the intricacies of complex enterprise systems. First let’s turn to the generic architecture of an enterprise.

## ENTERPRISE ARCHITECTURE

What are the enterprise processes in a corporation, business unit, or government agency that need to be transformed in order for it to be a lean enterprise? A generic lean enterprise architecture is used as the organizing framework, as shown in Figure 1. The architecture is organized into three basic groups, each consisting of a number of enterprise level processes. The interrelationships and interdependencies of all of these processes must be understood and addressed in order to achieve a lean enterprise.



**Figure 1. Generic Lean Enterprise Process Architecture**

Life Cycle Processes: These processes define the product life cycle, from initial conception through design, development, production and operational support. These are the value stream activities that contribute directly to the creation of products, systems, or services delivered to the enterprise’s customers. These processes reflect the lean view of an overall product lifecycle within which functions serve, as opposed to the more traditional paradigm that allows each function to sub-optimize around its own operations.

Enabling Infrastructure Processes: These support the execution of Enterprise Leadership and Life Cycle processes. The enabling processes provide supporting services to other organizational units whom they serve as internal customers. Since they enable rather than directly result in enterprise success, they can be easily overlooked. In a lean enterprise, though, they are reoriented to support the ‘Life Cycle Processes’.

Enterprise Leadership Processes: These processes are developed and maintained by leadership to guide the activities of the enterprise. They cut across all of the entities that make up the enterprise. Enterprise leadership provides the direction and resources to break down barriers among and within Life Cycle Processes in order to create increased value to customers and stakeholders. They also provide the leadership to apply the Enabling Processes to improve responsiveness to the rest of the enterprise.

Enterprises are comprised of processes, people/organizations, information, and enabling technologies. To create value efficiently, these various elements of an enterprise must be appropriately linked and integrated. All portions of the organization (including life cycle as well as enabling processes such as Finance, IT, and HR) must operate in fundamentally different ways in the lean environment than they did under the mass paradigm.

## **LEAN ENTERPRISE DEFINED**

Before we can speak to enterprise constructs, we must address the concepts of “lean”. Lean has historically been focused on the elimination of waste – waste in production, waste in infrastructure, waste in materials and inventory, etc. Research has shown that the elimination of waste outside the creation of value is at a minimum sub optimal. Accordingly, the Lean Aerospace Initiative (LAI) in *Lean Enterprise Value* has developed a new definition of becoming lean:

*Becoming lean is a process of eliminating waste with the goal of creating value.*<sup>3</sup>

This new definition creates a more robust model for improvement, with the emphasis on enhanced product, service and organizational value, not just waste elimination.

Now let’s turn to “enterprise”. Note that the concept of ‘enterprise’, much like ‘system’, is contextual in nature. For example, an avionics system could be viewed as a major system in its own right, as one subsystem in an overall aerospace system, or as comprising a number of smaller subsystems. This conceptual distinction has very practical implications. Just as a particular system and its associated interfaces and attributes must be carefully defined before the tools and methods of system engineering or system analysis are applied, one must be equally clear with the nature of the enterprise. There can be enterprises embedded within larger enterprises, each operating at different levels. For example, an individual program, such as the Boeing 777, can be thought of as an entire enterprise. A corporation or government agency can also be thought of as an enterprise. Even the entire US aerospace industry can be treated as an integrated set of activities with the properties of an enterprise.

In this context, a lean enterprise can be defined (in its most generic sense) as:

*A lean enterprise is an integrated entity that efficiently creates value for its multiple stakeholders by employing lean principles and practices*<sup>3</sup>.

Lean enterprises systematically employ lean thinking and as such are dynamic, knowledge-driven and customer focused. As a result, they are responsive to change. A lean enterprise is continuously evolving with its environment, seeking improvement and perfection. The full benefits of lean can be realized only by re-thinking the entire enterprise: its structure, policies, procedures, processes, management practices, reward systems, and external relationships with customers and suppliers. Now lets turn to each of the elements of the lean enterprise definition.

**Attributes of a lean enterprise** What then are the *principles and practices* that characterize *lean enterprises*? The Lean Enterprise Model (LEM)<sup>4</sup> was developed by LAI based on automotive and aerospace research, coupled with experience with a broad range of improvement initiatives. The LEM is a synthesis of principles and practices, a hypothetical model of a generic lean enterprise.

The model's principles, which include *waste minimization, responsiveness to change, right thing at the right place, right time, and in the right quantity, effective relationships within the value stream, continuous improvement, and quality from the beginning*, state the high-level enterprise goals through the implementation of lean practices. These are the *core principles of a lean enterprise*. Two principles flow from the origins of lean. *Waste minimization* captures the ultimate goal of a lean organization to eliminate non-value-added activities and thereby reduces the time and resources needed to produce a product or service that delivers value to the customer. *Responsiveness to change* captures the need for agility to respond to market opportunities (or, in the case of national defense, to changing threats) in order to produce the product or service when it is needed.

Four additional lean principles round out the model. *Right thing at the right place, right time, and in the right quantity* reflects the goal of every enterprise function performing as needed to meet customer demands. *Effective relationships within the value stream* recognizes that people and organizations function efficiently when there is mutual trust and respect, sharing of information, and open and honest communication between employees, customers, suppliers, and partners throughout the entire value chain. *Continuous improvement* embodies the pursuit of perfection that is fundamental to lean thinking. *Quality from the beginning* recognizes the critical role of building in quality from the very outset, balancing the need to meet schedules and the expectation of continuous improvement.

It's important to note here that lean is not so much about the *individual* principles and practices, but their *effective integration and application* to meet the pull of customer demand, whether it be an external or an internal customer. As elementary as these principles may sound, their embodiment and application throughout the enterprise is far from simple. Table 1 lists a dozen 'Overarching Practices' that support the principles just discussed. Half of the practices are "human oriented", involving people and organization issues, and half are "process-oriented", applying to a broad range of enterprise processes. The practices are interdependent, and each must be adopted to some degree. For example, it takes a seamless flow of information across multiple parts of the organization to implement integrated product and process development. Similarly, flow cannot be optimized without maintaining stability.

**Table 1. Overarching Practices of a Lean Enterprise**

<b>Human-Oriented Practices</b>
<ul style="list-style-type: none"> <li>• Promote Lean Leadership at all Levels <i>Align and involve all stakeholders to achieve the enterprise's lean vision.</i></li> </ul>
<ul style="list-style-type: none"> <li>• Relationships Based on Mutual Trust and Commitment <i>Establish stable and on-going relationships within the extended enterprise encompassing both customers and suppliers.</i></li> </ul>
<ul style="list-style-type: none"> <li>• Make Decisions at Lowest Possible Level <i>Design the organizational structure and management systems to accelerate and enhance decision making at the point of knowledge, application and need.</i></li> </ul>
<ul style="list-style-type: none"> <li>• Optimize Capability and Utilization of People <i>Ensure that properly trained people are available when needed.</i></li> </ul>
<ul style="list-style-type: none"> <li>• Continuous Focus on the Customer <i>Proactively understand and respond to the needs of the internal and external customers.</i></li> </ul>
<ul style="list-style-type: none"> <li>• Nurture a learning environment <i>Provide for development and growth of both organizations' and individuals' support of attaining lean enterprise goals.</i></li> </ul>
<b>Process-Oriented Practices</b>
<ul style="list-style-type: none"> <li>• Identify and Optimize Enterprise Flow <i>Optimize the flow of products and services either affecting or within the process from concept design through point of use.</i></li> </ul>
<ul style="list-style-type: none"> <li>• Assure Seamless Information Flow <i>Provide processes for seamless and timely transfer of and access to pertinent information.</i></li> </ul>
<ul style="list-style-type: none"> <li>• Implement Integrated product and Process Development (IPPD) <i>Create products through an integrated team effort of people and organizations that knowledgeable of and responsible for all phases of the product's life cycle from concept definition through development, production, deployment, operations and support.</i></li> </ul>
<ul style="list-style-type: none"> <li>• Ensure process capability and maturation <i>Establish and maintain processes capable of consistently designing and producing the key characteristics of the product or service.</i></li> </ul>
<p>Maintain Challenges of Existing Processes <i>Ensure a culture and systems that use quantitative measurement and analysis to improve processes continuously.</i></p>
<ul style="list-style-type: none"> <li>• Maintain Stability in Changing Environment <i>Establish strategies to maintain program stability in a changing customer-driven environment.</i></li> </ul>

**Integrated Entities** The next element in the definition refers to *integrated entities*. The general definition of an ‘enterprise’ in the business literature roughly corresponds to what most people think of as a ‘corporation’. But, many high-tech industries such as aerospace, electronics and automotive are complex fields involving a multitude of interconnected industry, government, educational, and nonprofit research organizations that collectively create some of the world’s most sophisticated products and systems. Thus, any simple definition of an entity is bound to lead to an overly simplistic analysis of a lean enterprise.

Three distinct levels of enterprises have been identified based upon the level of entity being considered: *program* enterprises, *multi-program* enterprises, and *national and international* enterprises<sup>3</sup>. They are frequently highly interconnected and interdependent.

**Program Enterprises** The most elemental unit of business activity is the program, a collection of activities that produce a particular product, system, or service that is delivered to the customer and generates revenue. In some industries they may be more commonly referred to as “product” enterprises. Programs usually encompass the full range of Life Cycle Processes listed in Figure 1, and a distinguishing characteristic of program enterprises is that they have accountability for cost, schedule, and performance of the product, system, or service.

In aerospace, programs number in the hundreds, and vary in size from many billions of dollars, such as the F-22, Delta IV launch vehicle or C-130J airlifter, to hundreds of millions of dollars, such as the JDAM, to those of a few million dollars. Similarly, in the automotive industry a program enterprise could include a major brand name product such as Saturn, Taurus or Jeep. The largest programs represent quite substantial enterprises, spanning many locations and a wide range of integrated activity. Most programs feature one core value stream, with ‘Value’ being delivered to the end user or consumer.

**Multi-Program Enterprises** Business organizations and government agencies responsible for executing multiple programs are *multi-program* enterprises. Such enterprises provide the leadership and enabling infrastructure necessary for program execution (Figure 1).

Multi-program enterprises typically contain several program enterprises, with multiple value streams. Recall that ‘enterprise’ is contextual. In its simplest form, a business enterprise could consist of a single division or business unit of a firm. The unit might produce an entire product, portions of a product, or contribute to multiple products. For example, Ford could be considered a business enterprise comprised of numerous product lines. On the other hand, one could also consider the “light truck” division of Ford an enterprise in its own right. A distinguishing characteristic of business enterprises is that they have profit/loss accountability.

A government enterprise in the aerospace context is similar to a business enterprise in that it deals with aerospace products, systems or services, that it is comprised of multiple sub-units, and that it can be part of larger government enterprises. A distinguishing characteristic of multi-program government enterprises is that they have budget authority to purchase products, systems or services.

**National and International Enterprises** While the concept of enterprise has not typically extended beyond the multi-program level, it is increasingly apparent that enterprises face many challenges on their journey to lean that extend beyond traditional enterprise boundaries. In this context, the collection of *all* entities that contribute to the creation and use of products, systems, or services comprises a *national* or an *international* enterprise. This would include not only the products or service providers but also their customers, suppliers, end users, government regulators, etc.

For example, the US Aerospace Enterprise includes all *customers* (airlines, air freight carriers, military and civilian government agencies, general aviation, satellite service providers), government *end users* (warfighting commands and civil space users), *manufacturers* (prime contractors, multiple tiers of domestic and foreign suppliers), *infrastructure* (airports, military bases, maintenance depots, air traffic management), and *related entities* (universities, professional groups, labor unions, laboratories and support organizations).

The US Aerospace Enterprise, with its international customers and suppliers, is one national enterprise within the larger International Aerospace Enterprise. A growing number of aerospace companies are becoming global. Military systems are sold to many countries, sometimes resulting in portions of the system being manufactured or assembled outside of the United States through offset agreements. The newest tactical aircraft, the Joint Strike Fighter, is being funded and developed jointly by the United States and the United Kingdom, and has several other international participants. The International Space Station would not be possible without the participation of many nations and companies.

**Core and Extended Enterprises** For each of these three enterprise levels, a distinction exists between what is termed the *core* and *extended* enterprise. The core enterprise consists of entities tightly integrated through direct or partnering relationships. Less tightly coupled customers, suppliers, and government agencies encompass the extended enterprise - all the entities along an organization's value chain, from its customer's customers to its supplier's suppliers, that are involved with the design, development, manufacture, certification, distribution, and support of a product or family of products. In this definition, products include all of the goods and services that satisfy the customer's, and ultimately the end user's, needs.

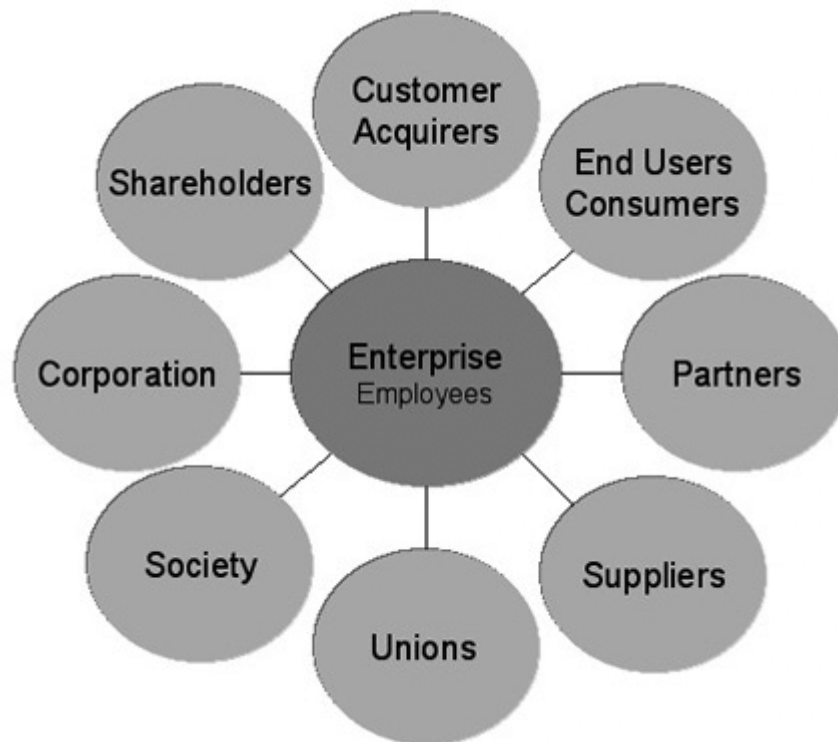
The extended enterprise is the larger base for a given core enterprise. One might call the extended enterprise the 'enterprise of enterprises' supporting the 'system of systems' in delivering value to stakeholders.

The core or extended enterprises must adopt lean principles and practices at all three enterprise levels (program, multi-program, national/international). However, one of the key challenges is to determine the appropriate lean practices and implementation strategies for the different enterprise levels. The interconnectedness and interdependence of most complex enterprises suggests that a piecemeal approach can only lead to "islands of success"<sup>5</sup>.



For a program value stream to be lean, all critical elements of the value chain must become lean - both those upstream and downstream from the core enterprise. For example, it is key that the suppliers supporting the enterprise also be lean. Similarly, there is increasing evidence that the customer must also operate using lean practices in contracting, requirements definition, information sharing, etc. in order for the supplying enterprise to be lean. This includes both government and prime contractor customers.

**Enterprise Stakeholders** In any complex enterprise there are multiple *stakeholders* (Figure 2). Freeman defines a stakeholder as ‘*any group or individual who can affect or is affected by the achievements of the organization’s objective*’.<sup>6</sup> Dunn and Burton suggest that stakeholders generally include stockholders, employees of all types, suppliers, customers, governments, competitors, and activist groups, and notes that sometimes the ‘general public’ is included.<sup>7</sup> Kochan and Rubinstein<sup>8</sup> contend that all stakeholders should be categorized by the role they play in the enterprise and list three criteria to identify the *saliency* of potential stakeholders: (1) the extent to which they contribute valuable resources to the enterprise; (2) the extent to which they put these resources at risk and would realize costs were the enterprise to fail or their relationship with the enterprise terminate; and (3) the power they have over the enterprise. Stakeholders meeting all three criteria are *definitive*; others are *latent*.



**Figure 2. Enterprise Stakeholders**

While lean principles were initially focused heavily on the customer, more recent enterprise research has revealed that the critical success factor for today's enterprises is to *balance* the needs of *all* stakeholders. Even with a broader focus at the enterprise level, the *customer* can be a unifying force. The customer provides the ultimate means (revenue) for satisfying all the individual stakeholders.

*Shareholders* provide capital and expect a positive return on their investment, enabled by ongoing innovation, growth, and profitability by the enterprise.

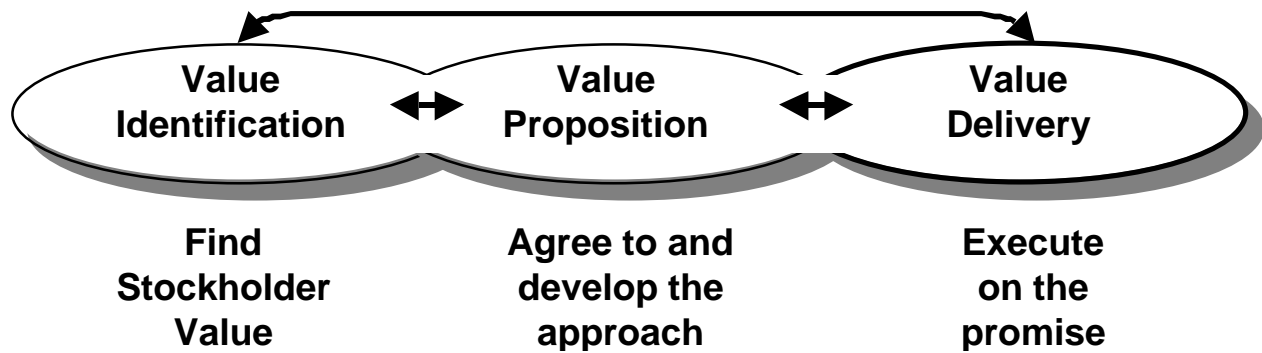
*Employees* – including all levels of management and the workforce are another group of stakeholders, contributing effort and knowledge within the enterprise. This is the center of value creation, which these stakeholders provide in return for fair compensation, personal growth, pride, and various other tangible and intangible factors. A union, yet another critical stakeholder, may represent some employees.

*Business partners* provide risk-sharing capital, intellectual property, and contribute to the enterprise's products or services in return for a sustained portion of the value created by the enterprise. *Suppliers* provide subassemblies, components, or services, and are concerned with mutually beneficial relationships. The number of suppliers and partners are many and varied, numbering in the thousands for large enterprises.

Finally, *society* is an important stakeholder with an interest that the enterprise maintains the environment, provide job opportunities, support the tax base, and serve as a positive force in the community, the country, and even the global economy.

Although customer satisfaction is necessary, it alone is insufficient to guarantee long-term success of the enterprise. The roles of these multiple stakeholders who interact with, contribute to, and derive value from the enterprise must be considered. This leads to new challenges and complexity for enterprise leadership. Attempts must be made to examine and satisfy as many individual preferences as possible, with the understanding that these individuals or groups have particular relationships with the enterprise and with each other. The number of stakeholders can be very large and, with each new stakeholder involved in the enterprise, the complexity of creating enterprise value will most likely increase.

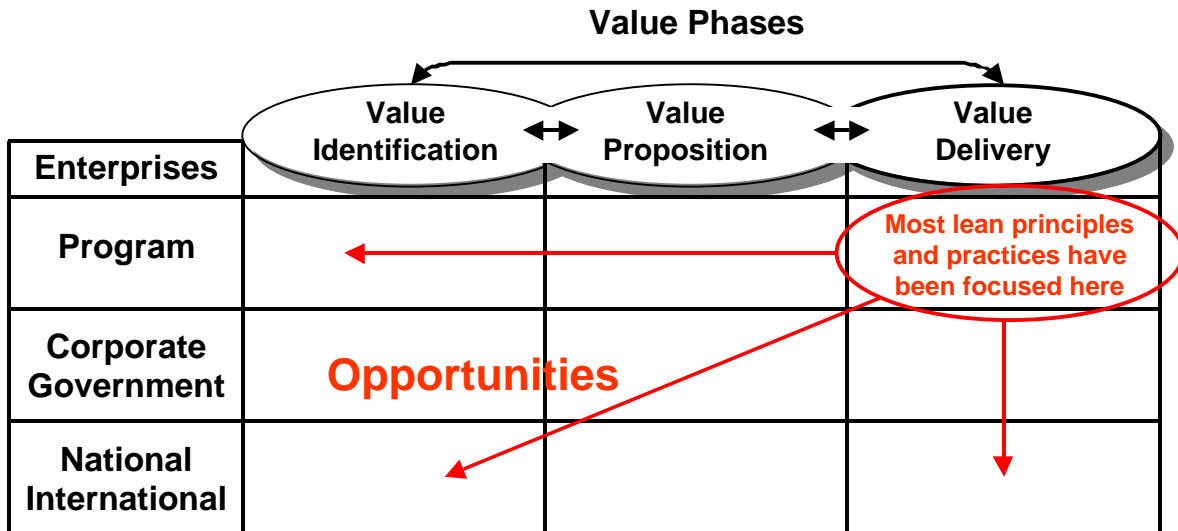
**Value Creation** The last element of the lean enterprise definition is *value creation*. Traditionally lean has focused on the elimination of waste. We now understand that it is imperative that enterprises not only improve efficiencies but that they also create value for all stakeholders. The challenge is how to identify and balance stakeholder needs. In *Lean Enterprise Value*<sup>3</sup> a three-phased framework for value creation has been identified (Figure 3).



**Figure 3. Value Creation Framework**

The first phase involves *identifying* the enterprise stakeholders and their value needs or requirements. After the stakeholders are identified comes a first attempt to understand what part of the project or process adds value for them and what kinds of exchanges are required to provide that value. It's now necessary to construct a *value proposition*. In this second phase is where the needs of key stakeholders come together. During this phase the enterprise structures different explicit or implicit “value exchanges” with each of the stakeholders. Stakeholders need to be able to see both how their value needs are being met and how they contribute value to the enterprise. The third phase of the framework, *value delivery*, is where value is delivered both to the various stakeholders who participate in the enterprise and to the end user when the product or service is received. This is the phase most familiar in the context of lean principles and practices.

These three steps, while conceptually distinct, are iterative in nature as illustrated in Figure 3. They are highly interconnected and must be revisited at different phases of a product life cycle. Additionally, iteration must take place among levels of the program enterprise as well as between the program enterprise and the multi-program and national enterprises. The challenge is to extend the traditional focus of lean principles out from only the value delivery phase of program enterprises to the full range of value creation phases and enterprise levels (Figure 4).



**Figure 4. Opportunities for Extension of Enterprise Value Creation**

Many issues can be identified in looking at the enterprise system from a value perspective. While much research and development remains to fully understand these complexities, what have emerged are some key principles for addressing enterprise value. The next section details these value principles.

### LEAN ENTERPRISE VALUE PRINCIPLES

In the course of many years of research and implementation of lean principles across many different levels of enterprises LAI has identified five principles that have emerged for creating enterprise value<sup>9</sup>.

#### ***1. Create lean value by doing the right job and doing the job right***

This is a phrase first employed by Drucker to indicate that efficiency without effectiveness is totally inadequate. So too in a lean enterprise that is focused on delivering value as well as waste, it not enough to just eliminate the waste without determining the strategic value proposition. For example, one could produce a low cost product, but without it being the “right” product, all efforts are wasted. This principle is often even more apparent in enabling infrastructure processes, such as Human Resources or IT. For instance, the HR dept. could process new employee requisitions in significantly less time, but unless they are hiring the kinds of flexible skills required for a lean enterprise, these waste reduction efforts are without value.

## ***2. Deliver value only after identifying stakeholder value and constructing robust value propositions***

Rather than the single-dimensional thrust of traditional lean thinking, the multi-dimensional attributes of numerous enterprise stakeholders must be considered. This entails balancing the needs and contribution of differing participants.

## ***3. Fully realize lean value only by adopting an enterprise perspective***

Numerous case studies of lean implementations have surfaced the problems of sub-optimizing, or producing islands of success. While we have much data on the benefits of lean in production, product development, and supply chain management as individual entities, we are only beginning to understand the tremendous value of taking an integrated enterprise perspective.

## ***4. Address interdependencies across enterprise levels to increase lean value***

It is critical to understand the interrelationships within and across all enterprise levels. This includes addressing the relationships between the life cycle, enabling and leadership enterprise processes. It also includes addressing the information, organization and strategic interdependencies across enterprises.

## ***5. People, not processes, effectuate lean value***

‘The hard stuff is the soft stuff’<sup>10</sup>

The technical issues of implementing lean are easy relative to the organizational and cultural ones in transforming an entire enterprise. It is becoming ever more clear that the most difficult challenge in achieving a lean enterprise is the involvement and motivation of the organization towards a common vision.

Now let us address system issues in this value-based comprehensive definition of a lean enterprise.

## **ENTERPRISE SYSTEM ISSUES**

There are a number of significant issues in the enterprise system that require further study, analysis and research. Some general categories include: *standardization, integration, leadership and “enterprise engineering”*.

The challenges being faced include identifying the appropriate levels of standardization, integration, and collaboration across enterprises. How do we design, analyze, and research these crosscutting issues? Tom Peters<sup>11</sup> introduced the term “loose-tight” in his analysis of excellent organizations. What processes, information, products, and organizations need to be “tightly” integrated/standardized vs. those that should be more “loosely” controlled or decentralized? Are new models of leadership required to achieve lean enterprises? Can enterprises be “engineered” much the same as products are engineered?

**Standardization** is rapidly becoming a key enterprise strategy for becoming lean. Standardization is occurring across products, processes, technology, and information management.

*Product* standardization has long been deemed effective to reduce total life cycle costs. This is certainly the case within a large multi-program company and has now emerged in the recent Joint Strike Fighter (JSF), which serves four separate applications, with major system commonality across them.

At the multi-program enterprise level, corporate wide *process* councils have emerged in most of the large aerospace companies. These councils bring together groups across the enterprise involved in executing the same processes (for example, program management, product development, and supply chain management). The councils develop standard processes across the company, building upon the best practices that exist within the various organizational units or from outside the company.

At the national enterprise level, the DoD instituted the Single Process Initiative (SPI) as part of the acquisition reform efforts of the 1990s. Prior to SPI, different DoD organizations had different process requirements for their contractors. A given contractor with multiple DoD customers would have to maintain multiple process standards that could be audited for compliance, an expensive and wasteful approach. Under SPI, a contractor facility was able to adopt a single process standard, which each DoD agency accepted.

Additionally, many large companies are standardizing their *information and knowledge* management systems. For example, they are reviewing the numerous IT systems that have emerged as a result of mergers and acquisitions and determining which systems can be employed in common.

**Integration** To create value efficiently, various elements of any enterprise - processes, information, organizations, and enabling infrastructure - need to be appropriately linked and integrated. There is a great tendency for organizations to function as a group of ‘silos’, with each sub-unit (for example, procurement or engineering) acting independently of the other sub-units. Often, sub-unit performance excels, but the enterprise as a whole fails to achieve its full potential. It is important to understand what elements require full *integration* vs. *interfacing* and/or effective communication flow.

Integrated Product and Process Development (IPPD) is an example at the program enterprise level that has made a revolutionary impact on the cycle time and quality of new product introduction. IPPD includes the use of Integrated Product Teams, comprising all key stakeholders, which address organization integration. IPPD also includes the use of CAD/CAM systems to provide a single, integrated digital definition of the product being developed, as well as integrated information systems.

Integrating information, organizations, and processes across multi-program and global enterprises presents further challenges.

**Leadership** Transforming an entire enterprise to lean has revealed new challenges in the role of leadership in effecting a change of this magnitude. Issues such as multi-program process standardization, global seamless information flow, and enterprise-level optimization across multiple stakeholder objectives are critical strategic factors. Tonaszuck<sup>12</sup> documented that leadership commitment and alignment is imperative to becoming a lean enterprise. Most critical are the overall enterprise leaders, who drive lean practices and principles from the top of the organization.

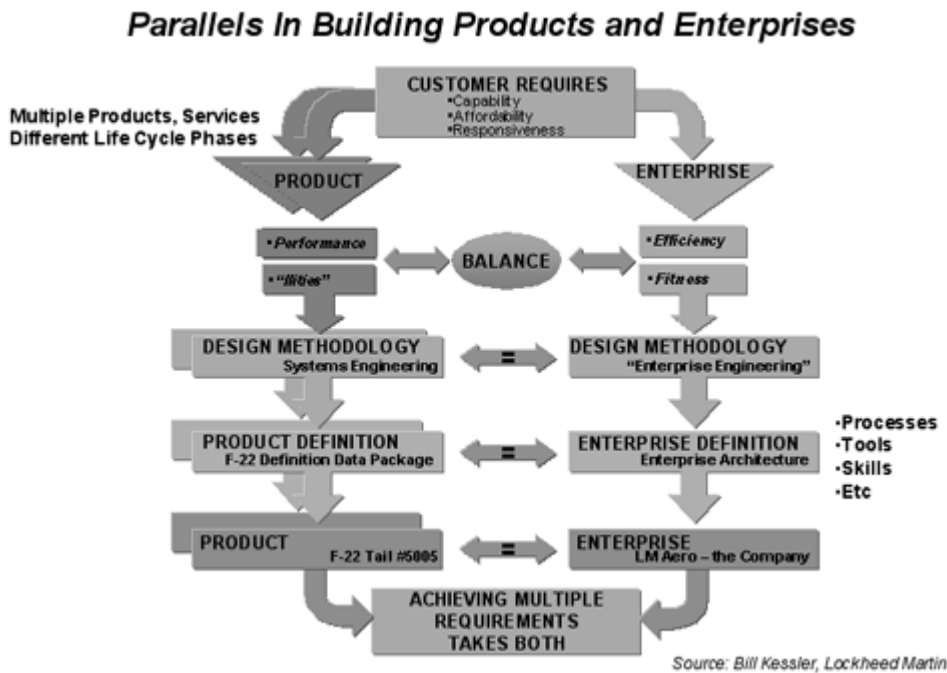
Enterprise change management and assessment methodologies have been developed by LAI to assist leaders in lean transformation. The Enterprise Transition to Lean Roadmap<sup>13</sup> was developed based on lean principles combined with change management research as a framework for translating an enterprise vision into a transformation plan aligned with enterprise goals and objectives. The framework portrays the overall “flow” of action steps necessary to initiate, sustain, and continuously refine an enterprise transformation based upon lean principles and practices. The Roadmap was developed from an enterprise perspective, with particular attention paid to strategic issues, internal and external relations with all key stakeholders, and structural issues that must be addressed during a significant change initiative.

The Lean Enterprise Self Assessment Tool (LESAT)<sup>14,15</sup> is a capability maturity model that assesses both the “leanness” of an organization and its readiness to change. LESAT is designed for use in self-assessment by the leadership of an enterprise and for continual improvement in the capability of the enterprise to meet its lean objectives. The focus of LESAT is at the enterprise level and is meant to highlight the key integrative practices at the uppermost level of an enterprise. A set of lean practices is identified for each of these three sections of the Enterprise Architecture (Figure 1). A total of 54 lean practices are included in the LESAT maturity matrices representing some of the more important behaviors that lean organizations should exhibit. Research is underway to understand the interrelationships of these leadership, life cycle, and enabling practices and their impact on enterprise performance.

**Enterprises as Engineered Systems** Enterprises must be viewed holistically, with the above issues addressed as a complex integrated system. Enterprises do *not* lend themselves to the traditional decomposition approach to complex systems. Just as product development cannot be effectively accomplished without the extensive involvement of

other life cycle processes such as manufacturing, supply chain, and the customer, so too must all three sections of the enterprise architecture be included in enterprise transformation and analysis. Leadership and Enabling processes, in particular organizational and information infrastructure issues, must all be considered in parallel and in an integrated fashion – thus adding to the complexity of the enterprise as an engineered system.

Lean enterprises must be both “engineered” and “architected”. New methodologies, analysis approaches, and research on these complex system interrelationships are required. Dr. Bill Kessler, VP Advanced Enterprise Initiatives for Lockheed Martin Aeronautics, suggests that there are parallels in building products and in building enterprises<sup>16</sup> (Figure 5). In the terminology of the three levels of the enterprise contained herein, he compares and contrasts the “program” enterprise and its traditional product performance and “ilities” focus vs. the integrated enterprise focus. He employs the terms “enterprise engineering” and “enterprise architecture” as enterprise level analogies to the traditional systems engineering and product definition steps in a program environment.



**Figure 5. Products and Enterprises Parallels**



The critical issue is to create the understanding, methodology, and interfaces to achieve balance across the multiple programs, stakeholders, and requirements of the enterprise. For success in achieving customer capability, affordability and responsiveness it is imperative to consider a total enterprise perspective.

In conclusion, enterprises, much like products, must be engineered as complex integrated systems consisting of people, technologies, processes and information components. These must be considered in concert with each other and across various local and global enterprise levels.

## REFERENCES

- 
- <sup>1</sup> See, for example: D. Dimancescu, P. Hines, and N. Rich, *The Lean Enterprise – Designing and Managing Strategic Processes for Customer-Winning Performance*, (New York: AMACOM, 1997), J.P. Womack, ‘The Lean Difference: Building a High Performance Enterprise’, *Prism* (First Quarter 1992), 103-111; J.P. Womack and D.T. Jones, ‘From Lean Production to the Lean Enterprise’, *Harvard Business Review* (March-April 1994), 93-103; T. Fujimoto (1999); J.H. Dyer, *Collaborative Advantage: Winning through Extended Enterprise Supplier Networks* (New York: Oxford University Press, 2000); Jeffrey H. Dyer and Kentaro Nobeoka, B.A. Henderson and J.L. Larco, *Lean Transformation – How to change your business into a lean enterprise*, (Richmond, VA: Oakley Press, 1999), ‘Creating and Managing a High-Performance Knowledge-Sharing Network: The Toyota Case’, *Strategic Management Journal* 21 (2000), 345-67.
- <sup>2</sup> J.P. Womack, D.T. Jones, and D. Roos, *Machine That Changed the World: The Story of Lean Production*, (New York, Rawson Associates, 1990), pp. 192-222
- <sup>3</sup> E.M. Murman et al, “*Lean Enterprise Value*”, (New York: Palgrave, 2002)
- <sup>4</sup> S.I. Weiss, E.M. Murman, and D. Roos, ‘The Air Force and Industry Think Lean’, *Aerospace America* (May 1996), 32-8.
- <sup>5</sup> E.M. Murman et al, “*Lean Enterprise Value*”, Chapter 5, (New York: Palgrave, 2002)
- <sup>6</sup> R. E. Freeman, *Strategic Management: A Stakeholder Perspective*. (Boston: Pittman, 1984).
- <sup>7</sup> C.P. Dunn and B.K. Burton, ‘Stakeholder Interests and Community Groups: A New View’, Proceedings of the International Association for Business and Society Annual Meetings (1996).
- <sup>8</sup> T.A. Kochan and S.A. Rubinstein, ‘Toward a Stakeholder Theory of the Firm: The Saturn Partnership’, *Organization Science*, 11:4 (July-Aug 2000), 367-386.
- <sup>9</sup> E.M. Murman et al, “*Lean Enterprise Value*”, Chapter 1, (New York: Palgrave, 2002)
- <sup>10</sup> C. Cool, *Journey to a Lean Enterprise*, Oct 31, 2001, MIT ESD61J presentation
- <sup>11</sup> T.J. Peters and R. H. Waterman Jr., *In Search of Excellence-Lessons from America’s Best-Run Companies*, Harper & Row, 1982.

---

<sup>12</sup> D.M. Tonaszuck, *The Impact of Leadership on Systematic Organizational Change*, MIT SM Thesis, 2000

<sup>13</sup> MIT (2000). *Transitioning to a Lean Enterprise: A Guide for Leaders – Volume I: Executive Overview*. Cambridge, MA: Lean Aerospace Initiative, MIT.

<sup>14</sup> MIT (2001). *Lean Enterprise Self-Assessment Tool – Version 1.0*. Cambridge, MA: Lean Aerospace Initiative, MIT.

<sup>15</sup> D.J. Nightingale and J.H. Mize, *Development of a Lean Enterprise Transformation Maturity Model*, Journal of Information Knowledge Systems Management IKSM, accepted for publication in November 2002.

<sup>16</sup> W. Kessler, *From Lean Production to Lean Enterprises...A Key to Operating Performance*, October 24, 2001, MIT ESD61J presentation.