LAI Research Overview

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LAI Vision

US Aerospace enterprises reliably and efficiently creating value and rapidly adapting to change

LAI@MIT – Mission

Provide leadership to evolve and sustain a learning community through knowledge creation, implementation tools, education and outreach, and policy recommendations to enable realization of the LAI vision.

LAI@MIT -- Who are we?

LAI@MIT is a group of professionals from diverse industry, government and academic backgrounds. The group builds upon the traditional strengths of MIT as a scientific, technical, research and educational institution, providing access to and involvement from a broad range of capable faculty, students and research staff. LAI@MIT's efforts and activities focus on creating unique and considerable value for all members and participants through the LAI consortium. To create and deliver desired value for LAI members, four major strategic imperatives guide our efforts:

- Sustain the LAI Consortium
- Expand the Lean Enterprise knowledge base
- Foster a learning community
- Facilitate enterprise transformation within and between industry and government

LAI@MIT-- Strategic Imperatives

1. **Sustain the LAI Consortium as a partnership between industry, government, the workforce, and academia, to address common problems and take collective action.**
   Strategies to accomplish:
   a. Maintain a cadre of capable faculty, students and research staff from diverse industry, government and academic backgrounds that functions in a cross-disciplinary manner to achieve consortium goals
   b. Take a leadership role in the consortium
   c. Maintain active and strong participation in aerospace industry and professional events
   d. Maintain a balance of expectations, resources and influence of all consortium stakeholders and act as the neutral broker in the consortium

e. Achieve recognition throughout the US aerospace community and within LAI itself as the intellectual center of competence for lean enterprise

2. **Expand the lean enterprise knowledge base through knowledge creation**

   Strategies to accomplish:

   a. Continue to evolve a strong, leading-edge research program in support of the LAI vision
   b. Develop an integrated product set to enable lean transformations throughout the US aerospace enterprise
   c. Infuse the knowledge from large scale enterprise transformation efforts into future LAI research and products

3. **Foster a learning community within the total aerospace enterprise**

   Strategies to accomplish:

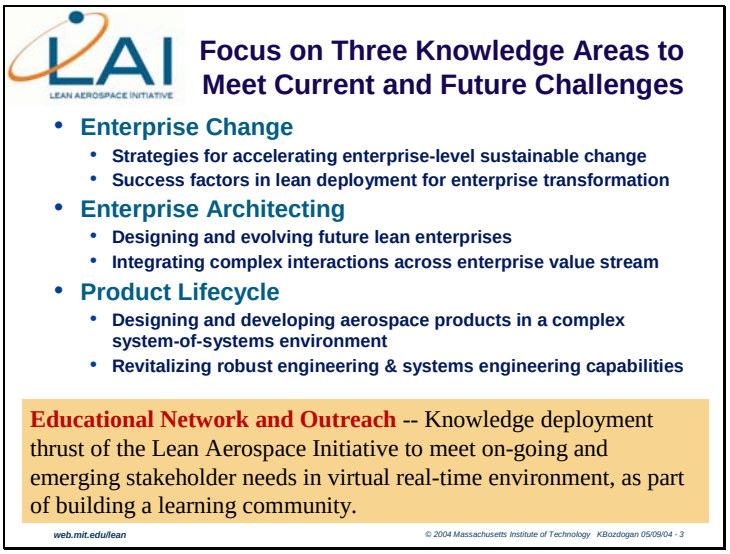
   a. Convene forums to provide the venue for knowledge transfer and stakeholder dialogue
   b. Extend knowledge sharing to non-LAI organizations, relevant associations, and institutions in the aerospace community
   c. Create, deploy and update LAI curriculum and contribute to university, government, and company curricula
   d. Incorporate LAI knowledge into university curriculum at the graduate and undergraduate levels
   e. Foster development of a network of trainers, educators and lean change agents

4. **Facilitate enterprise transformations within and between industry and government.**

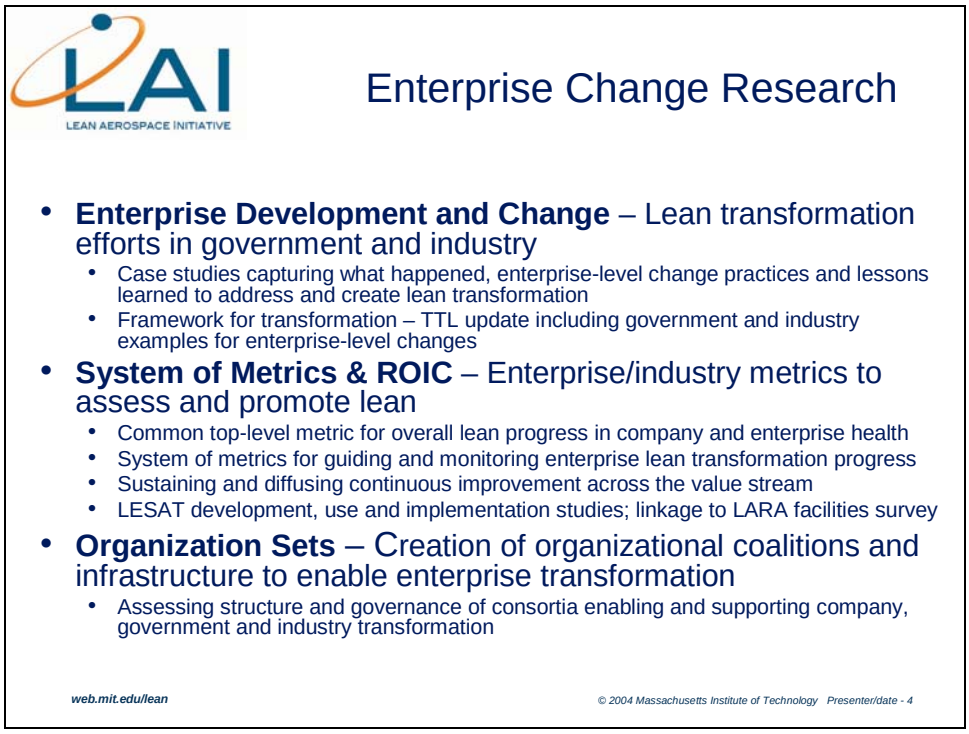
   Strategies to accomplish:

   a. Develop the process to capture and codify experience in large scale enterprise transformation efforts
   b. Transfer knowledge from LAI research into industry and government organizations
   c. Analyze and synthesize implementation observations and lessons learned
   d. Diffuse large-scale enterprise transformation knowledge within and outside the consortium
   e. Assist members of the consortium in the transformation of their organizations, management processes, people and mindsets
   f. Identify policy change opportunities

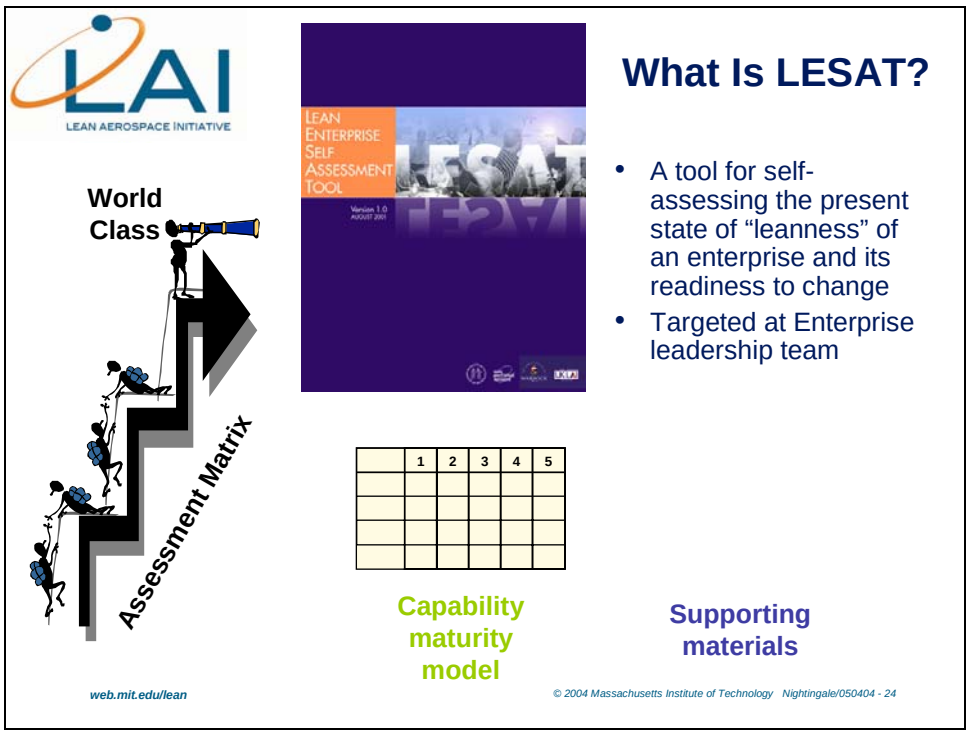
Key Knowledge Areas



Enterprise Change



LESAT



The Lean Enterprise Self Assessment Tool (LESAT) is one of the Lean Aerospace Initiative's tools to assist enterprises in their lean transformation. The LESAT specifically is used to self assess the present state of "leanness" and indicate the readiness of the enterprise for change. It is a tool that is targeted to the enterprise leadership team and emphasizes primarily the interactions between elements of the enterprise rather than the specific actions of organizational elements.

LESAT is organized around the generic process architecture found in most aerospace enterprises. The three LESAT sections are: Lean Transformation/Leadership, or the processes and leadership attributes nurturing the transformation to lean principles and practices; Life Cycle Processes, the processes responsible for the product from conception through post delivery support; and Enabling Infrastructure, the processes that provide and manage the resources enabling enterprise operations.

LESAT includes a total of 54 “lean practices” (each expressed at the enterprise level). For each lean practice, five levels of lean maturity are specified. A company assesses itself on each lean practice by determining the “Current Level” of maturity and by specifying the “Desired Level”. In this manner, significant “gaps” are identified, providing direction for modifications to the company’s enterprise-level lean transformation plan.

Government LESAT

The Government Lean Enterprise Self Assessment Tool (Government LESAT) is one of the Lean Aerospace Initiative’s tools to assist enterprises in their lean transformation. The Government LESAT was derived from the Lean Enterprise Self Assessment Tool (LESAT) for those government organizations that do not specifically produce a concrete product. In application of the LESAT, it was found that the LESAT language did not translate well to this environment; therefore, a modified version of the LESAT was created to address these differences. The Government LESAT specifically is used to self assess the present state of “leanness” and indicate the readiness of the enterprise for change. It is a tool that is targeted to the enterprise leadership team and emphasizes

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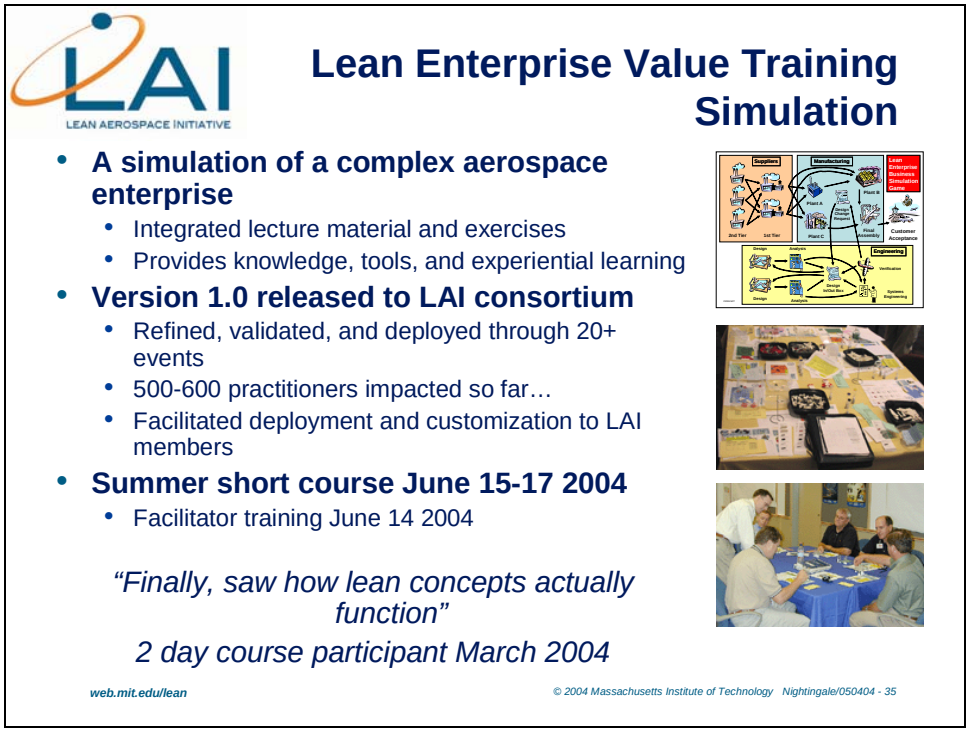
Lean Enterprise Value Training Simulation



The Lean Enterprise Value (LEV) Training Simulation, a.k.a. *the Game*, is a complete, flexible simulation of a complex enterprise, which allows interactive, hands-on lessons in lean improvement. It is based on lessons learned through several years of research by the LAI as synopsized in the book *Lean Enterprise Value* (Murman, et al, 2002.) It is a one-of-a-kind training tool designed to provide a compelling experience of lean tools and principles and integration of the lean enterprise.

The simulation is configurable to teach lean lessons in a few hours or over many days. A baseline enterprise-level course provides a 2-3 day training experience for lean enterprise managers and change agents. The simulation context provided by the game is robust and flexible and can accommodate a wide range of learning objectives. Customized variations can be tailored to meet specific learning objectives or reach specific target audiences, and current users have used the simulation to teach the following skills or lean principles:

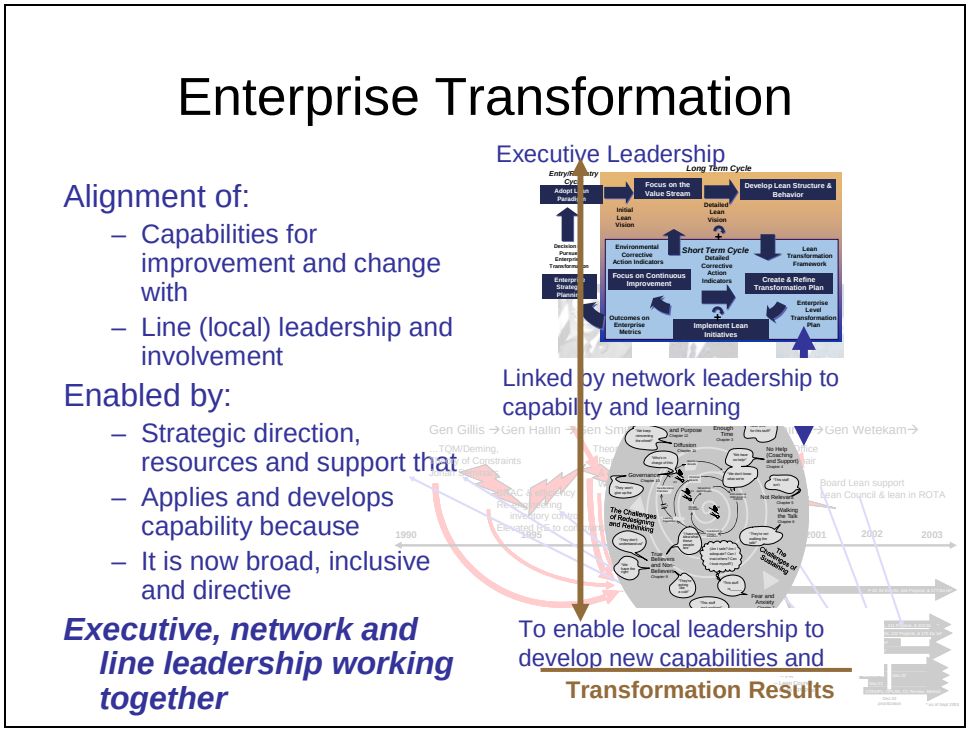
Basic lean operations principles (process and value stream mapping, organization, throughput and inventory management, pull systems, etc.)

- Constraint management
- Lean financial management
- Return on investment in lean improvements
- Product development value stream mapping concepts and skills
- Enterprise value stream mapping
- Enterprise change dynamics and transition planning

The game and associated components have been validated through developmental use at a variety of locations, and they have been organized into the version 1.0 release configuration. Each new implementation potentially creates additional features within the simulation system, which will update the current release configuration and be made available to game adopters.

The game is best used as an integrated component of lean training, customized to meet specific learning objectives, and mentored to assure a good learning experience. The game is currently facilitated by LAI personnel and/or associated facilitators with intimate knowledge of LAI knowledge and products. The preferred mode of deployment is to actively train local facilitators during training offerings so that adopting organizations can ultimately use the game "in-house" at their convenience.

Enterprise Transformation

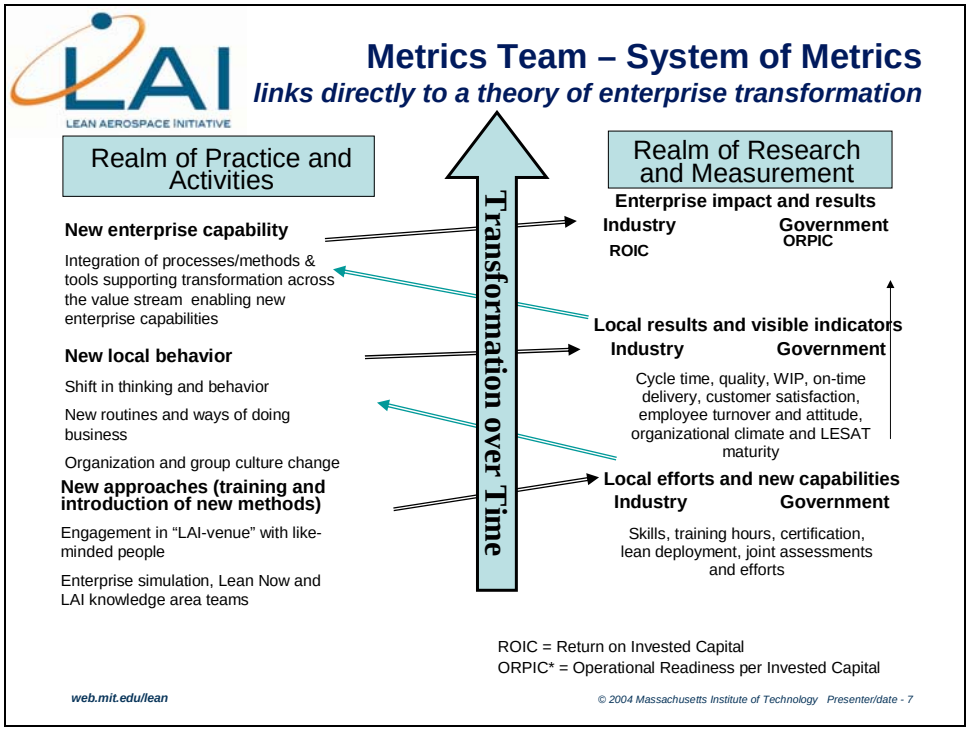


Lean enterprise transformation is a complex systems problem. Lean principles involve technical and analytical approaches to understanding, analyzing and redesigning work, work processes and information and material flow. These lean concepts are put into understood and put into practice by people in their workplace, involving individual, team and organizational changes in behavior, routines, thought and culture. A challenge for lean enterprise transformation is the integration of the technical and behavioral approaches to lean at strategic and operational levels to bring about overall system improvements (from the perspective of all stakeholders, i.e. workers, managers, engineers, suppliers, customers and shareholders). How do organizations accomplish lean transformation? What is the relationship of executive-level strategy and resource allocation approaches and efforts (top-down) with broader workforce development, training and change programs (bottom-up)?

This research involves field work conducted by visiting companies undergoing lean changes, interviewing people at multiple organizational levels and in different functions, collecting corresponding financial, operational and workforce metrics, and writing

descriptive case studies with analytical interpretations. Insights and patterns for factors influencing the speed, progress and effectiveness of enterprise lean transformation approaches are to be developed and tested across subsequent case studies. The case studies are published as LAI working papers, used for teaching and presented at sponsor meetings. Insights and references to case studies will be utilized in revising the Transition to Lean (TTL) document and incorporated into the Lean Enterprise Model (LEM).

Metrics Team

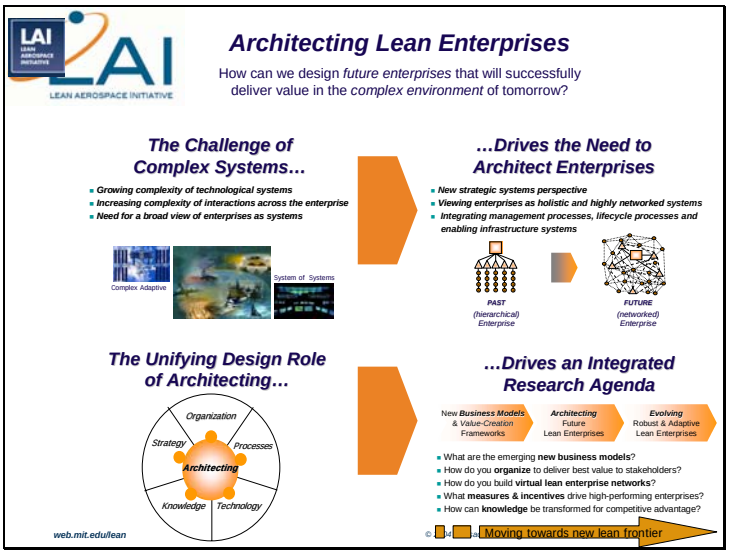


LAI and its members companies are interested in and have discussed the appropriateness of using a single top level metric to reflect the "lean…ness" of a business enterprise. ROIC, or "return on invested capital," has been proposed as this top-level metric for lean in a government/industry enterprise. Any metric, however, can only capture certain information. It is thought that ROIC is more appropriate in enterprises that are mature in the development and use of lean concepts. The progression of efforts and development of capability resulting in lean enterprises is thought to be more appropriately captured by

a system of metrics that link improvement resources and efforts with the development of capabilities, application of those capabilities, and subsequent achievement of intermediate and mature results in attaining what ROIC improvements would certify as "lean…ness."

What metrics are appropriate for describing, guiding and sustaining lean enterprises? Can sufficient data be obtained on the development and achievement of "lean…ness" in government and industry so as to develop a model that can describe and predict the relationship of investments in training and continuous improvement efforts, including lead and lag times, and other factors such as cultural characteristics and leadership approaches in an overall lean enterprise transformation? Can we obtain sufficient data from companies and their facilities to statistically correlate investment in training and lean efforts with the development of capabilities for continuous improvement, realization of those benefits through improvements in intermediate business (such as flow time, process, quality, on-time delivery and cost improvements) and people (such as workforce attitude, motivation, job satisfaction, safety, performance and customer satisfaction improvements) indicators? In examining historical data from various companies and facilities could we find and model progressions in time and effort for achieving top-level (ROIC) lean results, or find factors that explain and predict variance across companies and facilities?

Architecting Enterprises

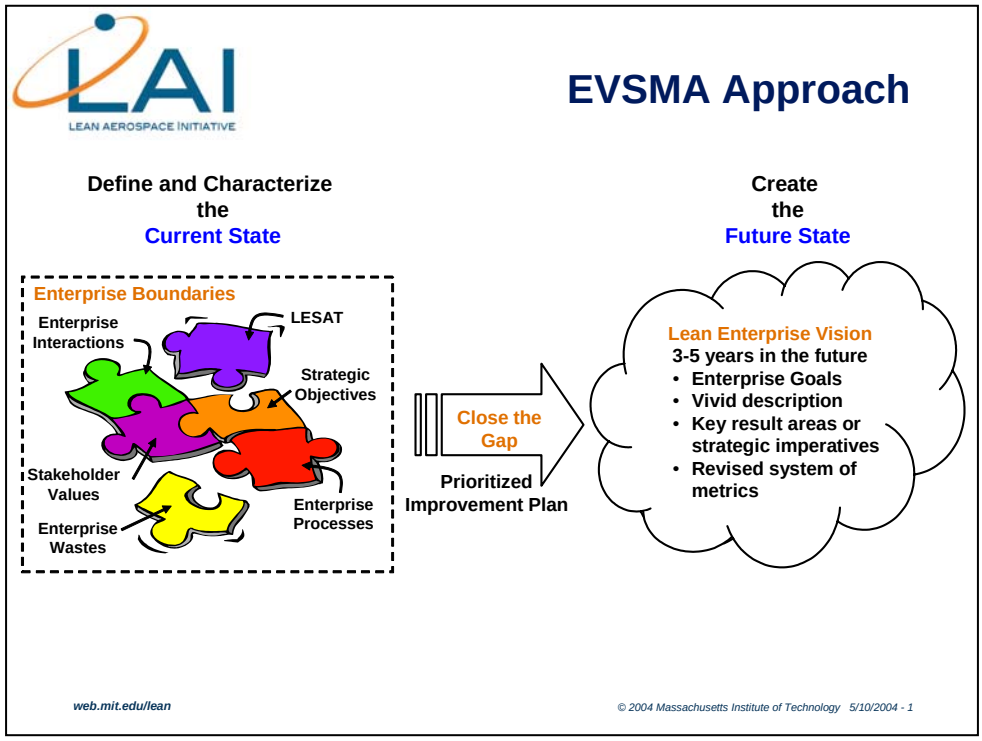


Enterprises are complex, highly integrated systems comprised of processes, organizations, information and supporting technologies, with multifaceted interdependencies and interrelationships across their boundaries. Understanding, engineering, and managing these complex social, technical, and infrastructure dimensions are critical to achieving and sustaining enterprise performance. What then are the key attributes of the successful enterprise, both today and emerging? What are the key concepts, elements, and interrelationships that comprise the enterprise "system"? What is involved in "architecting" and "engineering" an enterprise to achieve desired characteristics in context of environment, business model, and associated product system? These are key questions being explored in LAI research today.

Enterprises have long been studied by management scientists and social scientists; however, this has largely been through taking one single view of the enterprise such as studying the organizational structure or the information architecture. *Enterprise Systems Architecting* is a new strategic approach we are formulating which takes a systems perspective, viewing the entire enterprise as a holistic system encompassing multiple views such as organization view, process view, knowledge view, and enabling information technology view in an integrated framework. The current *Enterprise*

Architecting practice is well established today, but the prevailing view tends to be information technology centric, and it works well for the simpler enterprises trying to align processes and technology with organizational structure. As the enterprise moves from simple organization to a complex networked organization (an extended enterprise), we assert that an enriched view is needed. Further, we believe that this art and science needs to be more highly integrated with strategy and culture, and we require some new lens with which to view the enterprise. With this enriched view, LAI has undertaken a number of research projects that are focused on the various aspects of complex enterprises, with an objective of understanding what approaches can be used and what decisions need to be addressed when enterprises are created or re-architecting to meet new mission and business objectives.

Enterprise Value Stream Mapping and Analysis



The Enterprise Value Stream Mapping and Analysis (EVSMA) methodology serves as an integrated framework for diagnosing and improving overall enterprise performance, by identifying enterprise-level waste and enhancing the value delivery to each enterprise stakeholder. The objective of applying the EVSMA methodology is to optimize the

enterprise value stream as a critical element in formulating the strategic business plan and transforming to a lean enterprise.

The Enterprise Value Stream Mapping and Analysis methodology provides enterprise executives with a management tool that will help them:

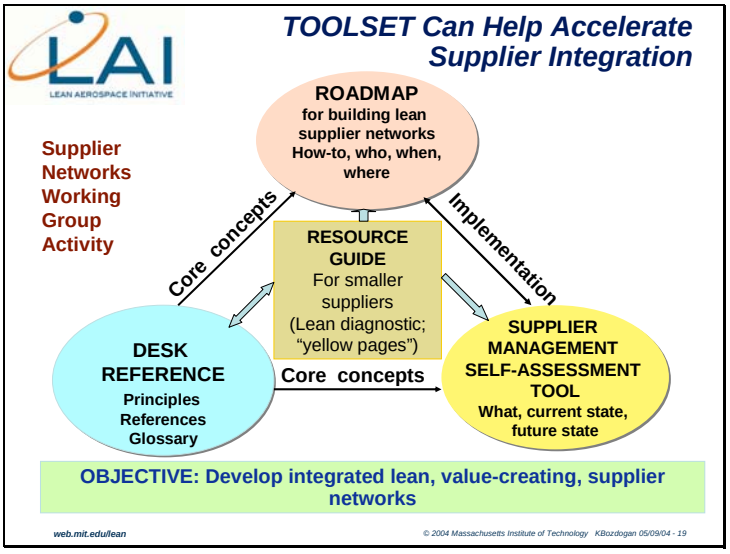
1. Identify barriers to the creation/delivery of value to each stakeholder,
2. Specify a vision of the future lean enterprise,
3. Determine significant gaps between current and future states, and
4. Prioritize opportunities for eliminating waste and increasing value creation/delivery for the maximum benefit of the total enterprise.

The primary benefits and distinguishing features of the EVSMA methodology are that it:

- Focuses at the total enterprise level, on enterprise-wide processes, rather than within individual functions, programs, or tasks
- Provides a cohesive methodology for diagnosing an enterprise in order to expose sources of waste and to identify impediments/barriers to value delivery among functions and processes
- Gives consideration to the needs/values of all stakeholders
- Provides an analysis to connects stakeholder values, strategic objectives, and enterprise processes
- Identifies process interfaces, disconnects and delays

Identifies improvement opportunities that will benefit the entire enterprise

Supplier Networks Working Group



Version 1.0 of the SUPPLIER TOOLSET consists of two integrated modules:

- ROADMAP TOOL
- SUPPLIER MANAGEMENT SELF-ASSESSMENT TOOL

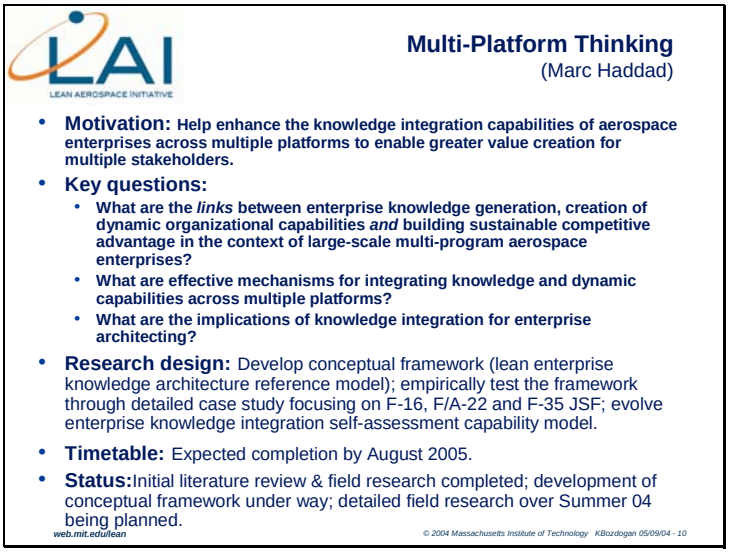
Both the ROADMAP TOOL and the SELF-ASSESSMENT TOOL are integrated and should be used jointly. The ROADMAP TOOL represents a "how-to" implementation guide that lays out a structured process for evolving lean supply chain management capabilities in order to build lean supplier networks. The ROADMAP TOOL is linked to the Transition-to-Lean Roadmap (TTL) at the enterprise level and follows a process architecture similar to that used in the TTL. It defines major building blocks and specific implementation steps. It also identifies key interactions and major feedback loops. In addition, the tool provides implementation aids ("Roadmap Explorations"). For example, for each major building block, it defines inputs, outputs, barriers, enablers, potential metrics and tools and methods. At the same time, it discusses a number of issues and questions that are commonly faced in such an implementation effort (*e.g.*, why, what, who, how, where, when) and identifies potential tensions or conflicts that can be anticipated and proactively addressed. Finally, the ROADMAP TOOL can be used to accelerate on-going lean supply chain transformation efforts. It can also be used by companies just starting their journey to develop lean supplier networks.

The SUPPLIER MANAGEMENT SELF-ASSESSMENT TOOL ("SELF-ASSESSMENT TOOL") represents a framework that companies can utilize to conduct a self-assessment of how much progress they have made in developing lean supply chain management capabilities. In addition, the tool can be used to establish future performance targets and identify further improvement opportunities. This tool differs from the supplier lean assessment tools used by many aerospace companies, which focus on an assessment of the internal lean and six-sigma capabilities of individual supplier companies, such as the extent to which they have implemented basic lean manufacturing practices. Such tools take many forms, ranging from fairly simple diagnostic instruments to fairly detailed assessment tools. They are often used by primes and major suppliers as part of their supplier development process. The SELF-ASSESSMENT TOOL does require such supplier lean assessment steps, but only as part of a much larger and comprehensive framework for designing and managing lean supplier networks.

The SELF-ASSESSMENT TOOL is linked to the Lean Enterprise Self-Assessment Tool (LESAT) and follows a similar approach. It defines eight (8) overaching practices governing lean supply chain management and thirty (30) enabling practices. The tool identifies five capability levels and defines the lean supply chain management attributes for each enabling practice at each one of the five capability levels. The tool provides, for each overarching practice, diagnostic questions, lean indicators and potential metrics. The tool is presented in a user-friendly EXCEL format, which provides an automated self-scoring feature that generates summary charts based on the self-scoring results and future improvement targets.

Enterprise Architecture Research

Multi-Platform Thinking



The literature on knowledge and knowledge management in organizations primarily stresses the importance of knowledge as a strategic resource of the firm. Knowledge in all its forms (both tacit and explicit) is considered "the most powerful engine of production". Organizations have long recognized the need to leverage knowledge in order to sustain competitive advantage in an increasingly global business environment. The acquisition and sustainment of competitive advantage is accomplished by both creating and capturing new knowledge, and by sharing and reusing existing knowledge. Examples of knowledge-based organizational capabilities are "core competencies" (Prahalad and Hamel), "organizational routines" (Nelson and Winter), "combinative capabilities" (Kogut and Zander) and "dynamic capabilities" (Teece et al), all of which are developed by continuously combining skills and technology streams to create new products.

While the literature abounds with frameworks and best practices for creating and deploying knowledge or for developing knowledge-based organizational capabilities, there is a missing link tying knowledge to the actual development of critical product-system capabilities. This link is especially relevant in the context of aerospace multi-

program enterprises, where both product and organizational complexity make knowledge integration both challenging and essential for leveraging economies of scope and sustaining competitive advantage.

The proposed thesis will develop a framework in terms of technology, management and policy choices to effectively integrate knowledge across organizational boundaries, with the goal of enhancing critical system capabilities for complex technological systems such as avionics, particularly the interoperability of avionics systems and the commonality of their subsystem components.

Enterprise Integration Strategies

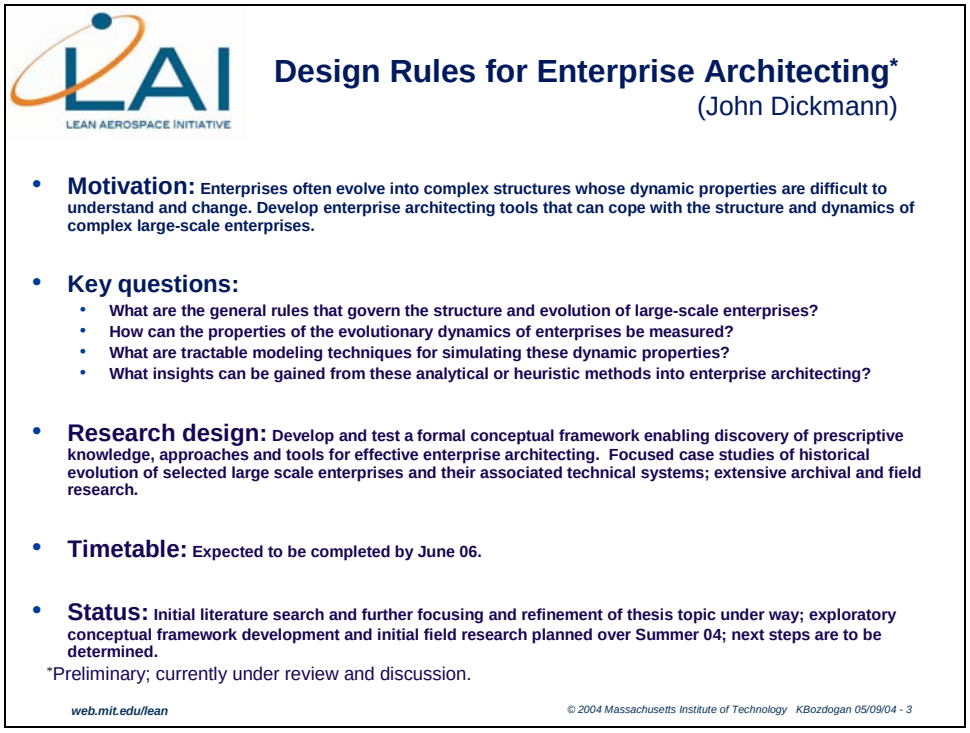
In today's complex system architecture environments such as the aerospace industry, no longer is any single company in command of all of the latest technologies necessary to produce a state-of-the-art product. As the complexity and degree of integration of products increases, so too must the supporting knowledge networks that create them.

Increasingly, it is evident that the firms that best integrate their product with those of others as part of a similarly complex enterprise network are destined to lead in tomorrow's environment. Under these new rules of competition, the question must be

asked: what are the optimal knowledge integration strategies that deliver the most value to customers and stakeholders? The proposed research attempts to answer this question by examining the extent to which firms adopt alternative knowledge integration strategies and regimes across alternative system architectures, such as in a systems-of-systems architecture environment. This research also aims to identify and examine the fundamental issues of knowledge integration across the enterprise value stream from multiple perspectives and search for underlying principles that can help identify whether, to what extent, how, and when enterprises should achieve knowledge integration, as well as how to mitigate the key barriers.

Following initial literature review, a conceptual framework that is expected to yield essential insights into knowledge integration issues across enterprise networks will be developed. This framework will then be empirically examined through a number of focused case studies representing alternative configurations of enterprise networks. The first case study, already underway, will be of the F-35 Joint Strike Fighter program enterprise, coordinated by Lockheed Martin. This key case study will consist of two phases: a broad overview, consisting of interviews with top-level actors in the network, followed by a second phase, consisting of interviews with both foreign and domestic JSF partners and potentially interesting areas within Lockheed Martin.

Design Rules for Enterprise Architecting

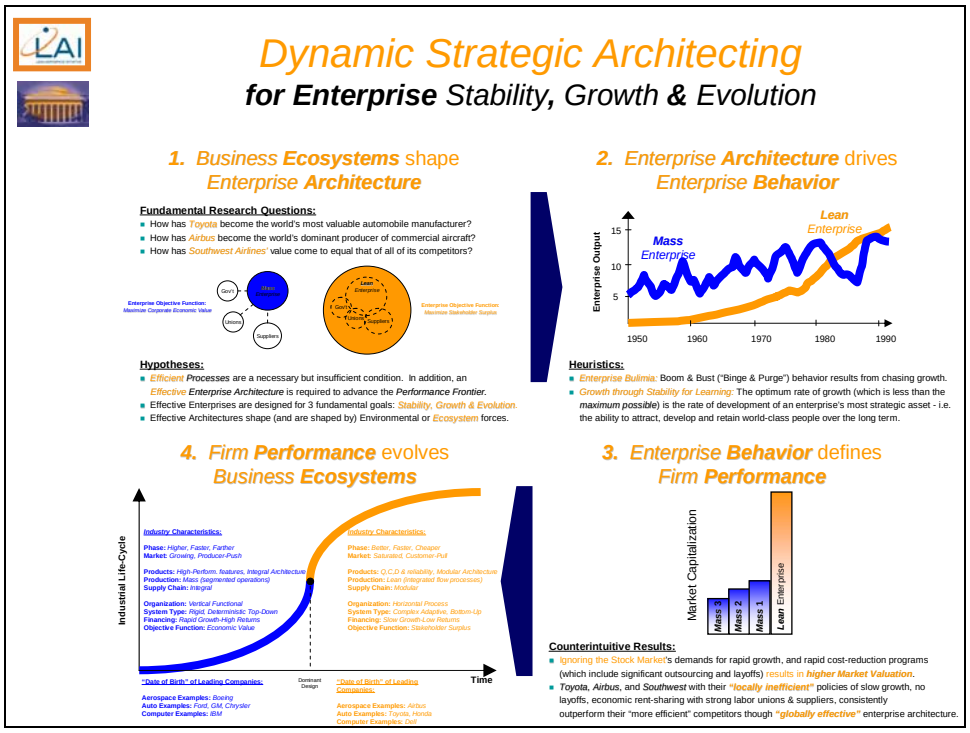


Many enterprise transformation initiatives appear to be 'brute force' efforts that lack staying power. If Lean Thinking is to have a lasting impact, especially on enterprises and processes that have long histories and patterns of behavior and performance, it seems necessary to view them through new lenses. Emerging tools and methods from complex systems research (including high end computational tools) may provide the means for achieving deeper understanding of the structures and evolutionary dynamics of enterprises that give rise to existing patterns. By understanding these dynamics, it might be possible to identify new principles, methods and 'keys' that would allow us to alter the dynamics in such a way that we can 'target' beneficial trajectories.

An analytical framework is currently in development (an initial framework has been notionally developed and tested). Once the framework is more formalized, a set of potentially useful cases will be identified to test applicability of the framework. Requisite course work to support a transition to a more formalized framework, stressing quantitative modeling approaches and methods, will be undertaken concurrently. The development of a more formalized framework will encompass choices from among a

number of alternative quantitative approaches including (1) network/graph theory, (2) heuristic algorithms (e.g., simulated annealing, genetic/evolutionary algorithms), (3) nonlinear dynamical systems theory, (4) Markov decision processes, (5) evolutionary game theory. Both the conceptual framework and its application in selected test cases will stress "stylized" features of enterprises to demonstrate computability and generalizability

Dynamic Strategic Architecting for Enterprise Stability, Growth & Evolution



The research explores the non-linear dynamic causal relationships between an enterprise's environment, its strategic architecture and its performance. The key hypothesis here is that *Stability* is a fundamental attribute of dynamically complex enterprises that enables sustainable *growth*, and ultimately permits evolutionary development.

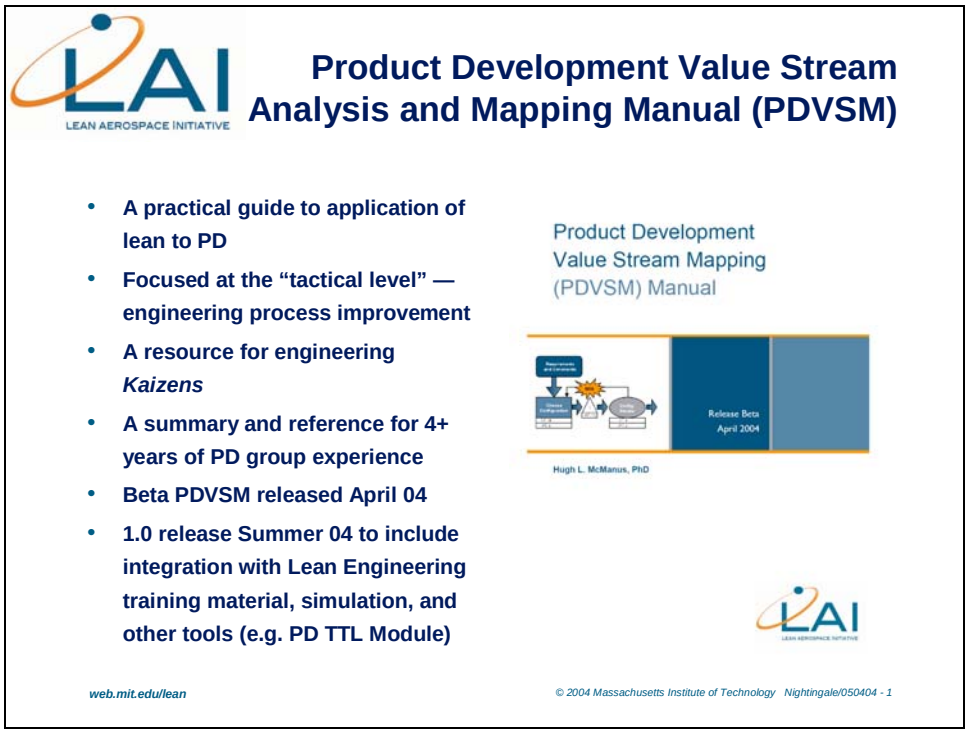
The key points addressed by the thesis are:

- An enterprise's environment (or ecosystem) simultaneously defines and is defined by the enterprise's architecture.
- An enterprise's architecture simultaneously defines and is defined by the enterprise's behavior (or performance).

- An enterprise's performance simultaneously defines and is defined by the enterprise's environment (or ecosystem).

Product Lifecycle

Product Development Value Stream Analysis and Mapping Manual

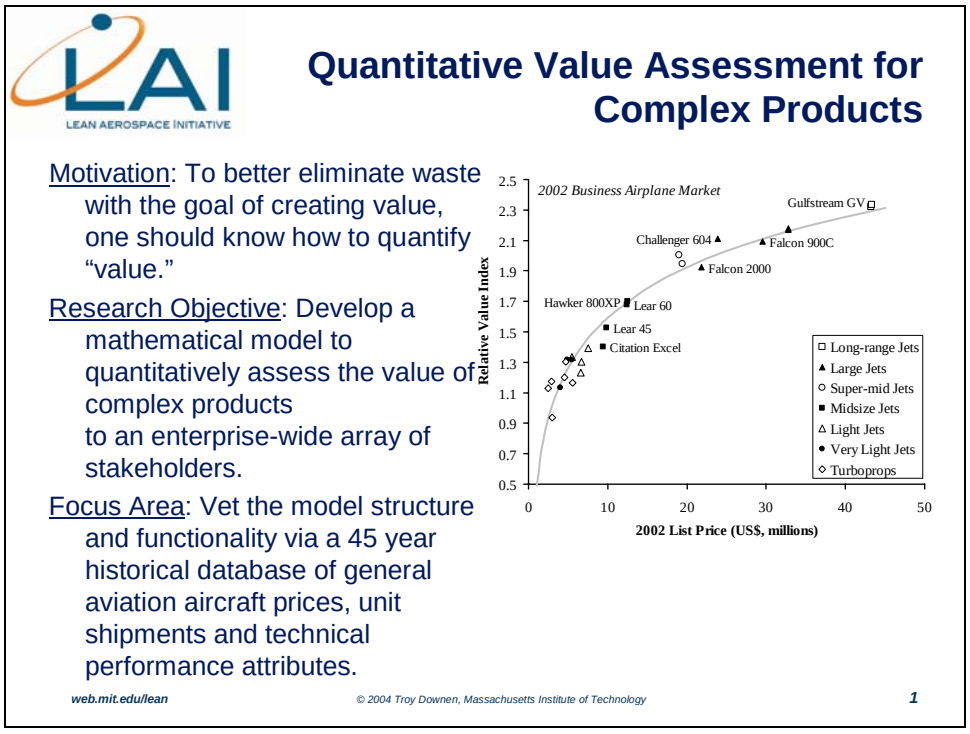


The Product Development Value Stream Mapping (PDVSM) manual is a 110+ page how-to guide for applying lean principles in engineering settings. There are many guides available for applying lean principles in an operations setting. Engineering and product development (PD) is more challenging for the straightforward application of lean principles from operations environments because of its non-routine and iterative nature. Much of product development involves discovery and risk-reduction, which are atypical of the traditional lean manufacturing environment. The PDVSM shows how PD tasks can be characterized and mapped, how waste can be identified, and discusses various strategies for eliminating waste and inefficiencies in PD. The content of the PDVSM draws on extensive research and knowledge from the LAI PD community, as well as the latest in PD thinking from other research at MIT and other universities.

During its development, the PDVSM has been used by LAI members to train engineers and managers in conjunction with PD lean improvement events. It has been used in conjunction with related LAI materials, including the Lean Enterprise Value simulation game and related lecture material. A number of such development efforts have been undertaken to validate and refine the PDVSM material and concept. To date, the results have supported the usefulness and applicability of the PDVSM to aerospace produce development. Demand for the preliminary versions of the document has been strong and there is evidence that LAI members have freely distributed the draft materials within their own organizations. There has also been demand from outside the LAI consortium for the PDVSM, but such requests for the material to date have not been honored.

Other related materials in development include the PD transition to lean (TTL) guide, which identifies steps on the path to lean PD capability. The final 1.0 version of the PDVSM will represent a bundle of materials that can be used separately or together, to introduce lean to the PD environment. This will include the PDVSM, PD TTL, a tailorable module of the LEV game and associated training material, and potentially other items to be defined. Additionally, the PDVSM text will be adapted to accommodate the relatively greater emphasis on training and implementation.

Quantitative Value Assessment for Complex Products

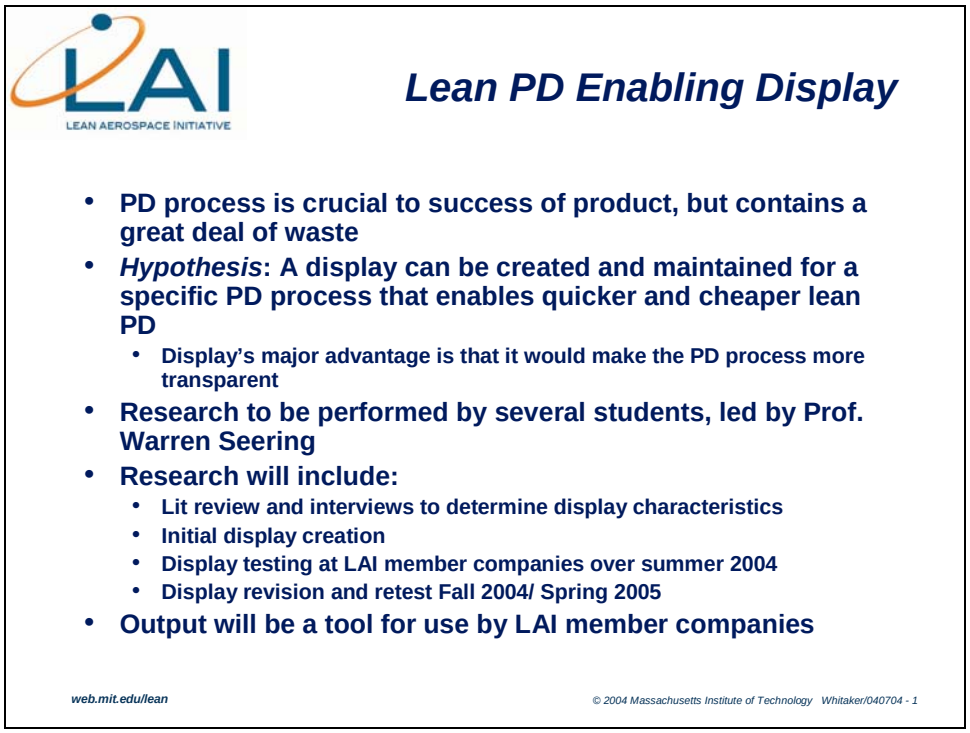


The booming economy of the 1990s spurred an invigorating development period in the business aviation industry in which customers clamored for new high performance products. This development boom underscored to several companies the adverse impacts of pursuing poorly-conceived products. Business aircraft development is a high-risk venture even for the largest of corporations. A new development program for a single turbine-powered aircraft can cost from $500 million to $1 billion and require up to a decade from program launch to first product delivery. The viability, financial and otherwise, of many enterprise participants is highly contingent on getting the right product to market at the right time and on budget.

Business aviation product development lacks a decision aid tool for valuing technologies and products within the context of an historical database of industry developments and which takes a comprehensive approach to customer values. Furthermore, the industry requires a method by which customer values can be evaluated for prioritization in future research and development.

Various aspects of the history of the business aircraft industry have not been evaluated with a quantitative tool to gain insights regarding past and future industry dynamics (e.g. the effects of technology infusion, development and erosion of markets). Finally, there has been much written in the 1990s regarding identifying core competencies in efforts to refine business processes and improve performance. However, no formal frameworks are available within which to identify enterprise competencies or link, for example, these competencies to critical technologies or products offered by the enterprise.

Lean PD Enabling Display



More than 80% of a product's lifecycle costs are determined by the PD process, which often contains iterations and extremely long cycle times. Improving the operation of the PD process has the potential to save LAI member companies billions of dollars per year. It has been suggested that lean principles apply not only to manufacturing but also to PD. This research will determine if some of these principles are transferable from the shop floor to the cubicle. The main principles to be studied include: measure and improve (value stream), make processes transparent, and manage PD risk and uncertainty.

A literature search will be made to determine the correct lean principles to try to employ. Initial display design will be created using information from a case study of current PD processes at a LAI member company as well as discussions with PD practitioners. Subsequent display revision will be conducted after interviews with LAI member company employees who actively participate in the PD process. Ultimately, the display will be tested on a specific product at a LAI member company, and the results of the PD process will be compared to those of other similar projects at that company. Emphasis will be on measuring the length, cost, and quality of results of the PD process. This project will produce a basic display tool that will enable lean PD practices. It will also form the foundation of a possible doctoral dissertation for Ryan Whitaker when he finishes his master's degree in June 2006. The tool is envisioned to fit with the PDVSM and PDTTL in the category of Lifecycle Processes.

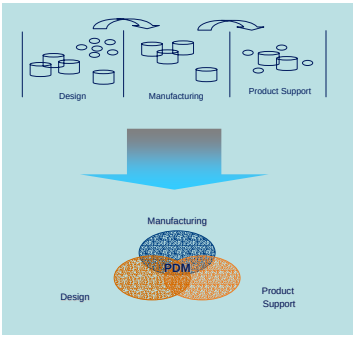
Enabling Product Lifecycle Through PDM

Enabling Product Lifecycle Through PDM

PDM-type applications are greatly impacting the way companies do business throughout their *product lifecycle* – it is not just CAD drawings anymore.

The *implementation* of a PDM entails several tough decisions such as:

1. ***"Which legacy processes and tools do I shutdown and how?"***
2. ***"What PDM tool is compatible with my culture, current investment, and corporate mandates to integrate at Enterprise level (one tool)?"***
3. ***How do I interface between development workflows and program planning?***



A representation of the current state of product data storage and sharing versus the integration that PDM tolls and processes can enable.

Similar needs exist in all phases of a product's lifecycle, from design and manufacturing, through product support and retirement. There currently is *not sufficient information* to make confident choices. Understanding the state of the industry's PDM use and *lessons learned* regarding this IT investment will be useful for future planning and development of PDM configurations.

New product development strategies are relying more on information technology tools due to software advancements in design, analysis and increasing capabilities to support information

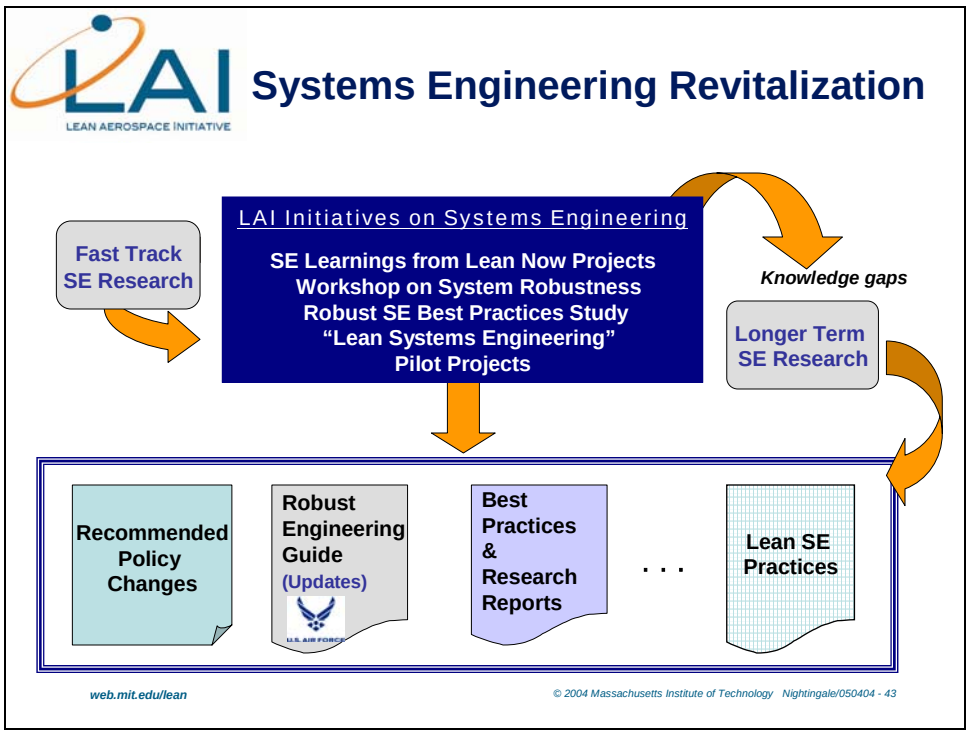
sharing across multiple boundaries. Often, new IT tools are implemented without taking full consideration of the processes that underlie and are affected by them, as well as cultural boundaries that may exist. This can hinder the effectiveness of a new tool because it is either not supported by the processes, or the tool was incorrectly chosen for the processes in place. New tool implementations may therefore cause more perturbations in the product development process than they resolve.

PDM/PLM-type applications are one of these applications greatly impacting the way companies do business throughout the product lifecycle. Similar needs exist in all phases of a product's lifecycle from design, all the way through product support and retirement. Understanding the state of the industry's PDM use and lessons learned regarding this IT investment will be useful for future planning and development of PDM configurations, and possibly other implementations.

A structured interview process will be used to collect data at several company sites and over a range of supported programs at those sites. The structure will be in the form of a maturity matrix and a set of supplemental questions. The data will be used for benchmarking purposes, as well as to identify key areas that are of particular interest. Case studies at select companies will then be used to further explore those key areas.

The benchmarking data regarding the state of PDM implementation and use in the industry, as well as the maturity matrix, will be published. The value derived from consortium experience will include recommendations and best practices for PDM implementations and strategies. Also, LAI data sheets and a thesis will be published.

System Engineering Revitalization



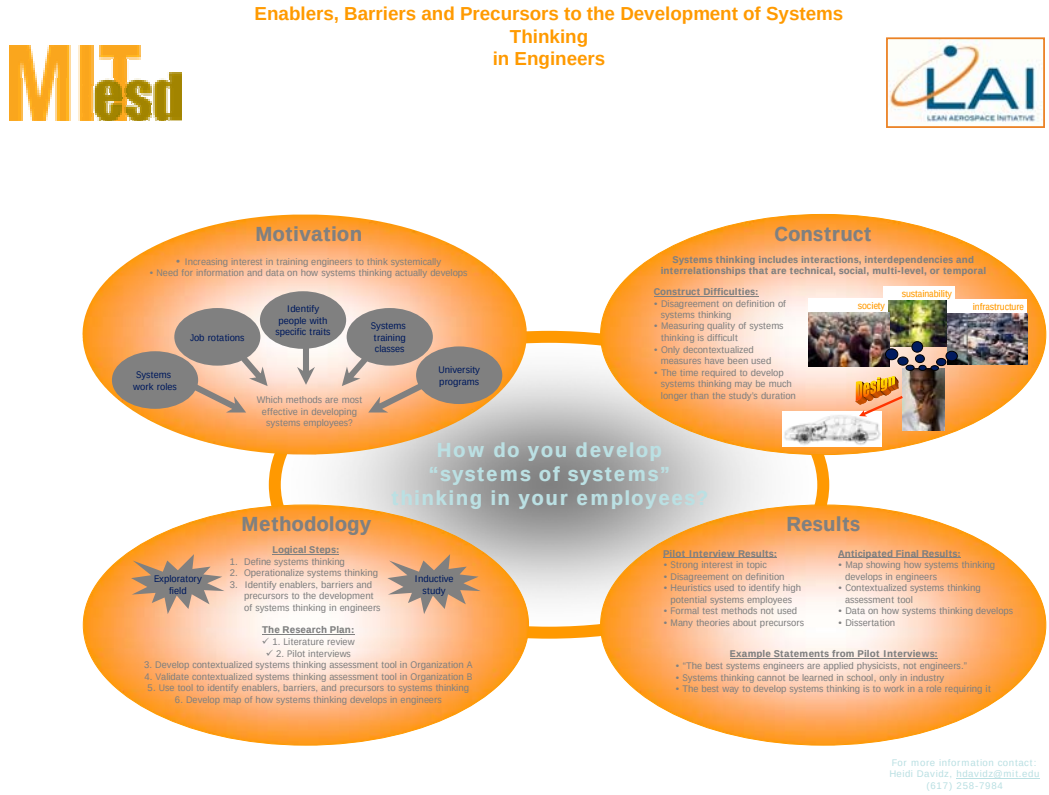
LAI is supporting the Air Force and Department of Defense efforts on Systems Engineering (SE) Revitalization. LAI has initiated fast track research which involves looking for past LAI research findings that can contribute to this effort, along with some near term industry studies. We are also looking at past Lean Now projects, to glean any learnings applicable to SE.

LAI has organized a workshop sponsored by the Air Force for early June on the topic of Systems Engineering for Robustness. This workshop will capture best practices on this topic, and LAI will produce a report as well as inputs for the next update of the AF Guide on Engineering for Robustness. Following the workshop, some additional best practice studies and longer term research will be undertaken by the LAI research group at MIT based on recommendations from the workshop participants.

Additionally, an SE subgroup of the LAI EdNet has been examining the synergies between lean practices and systems engineering practices, with an some initial work

being reported a major systems engineering conference this summer. The group has undertaken a longer term project to produce an LAI product for use by program managers. As these various efforts are conducted, policy and guidance changes will be recommended. The LAI group at MIT expects to have several new graduate students undertaking Masters or Doctoral research in support of systems engineering revitalization goals such as robustness, flexibility and expandability of systems which will be useful to both government and industry stakeholders.

Enables, Barriers and Precursors to the Development of Systems Thinking in Engineers



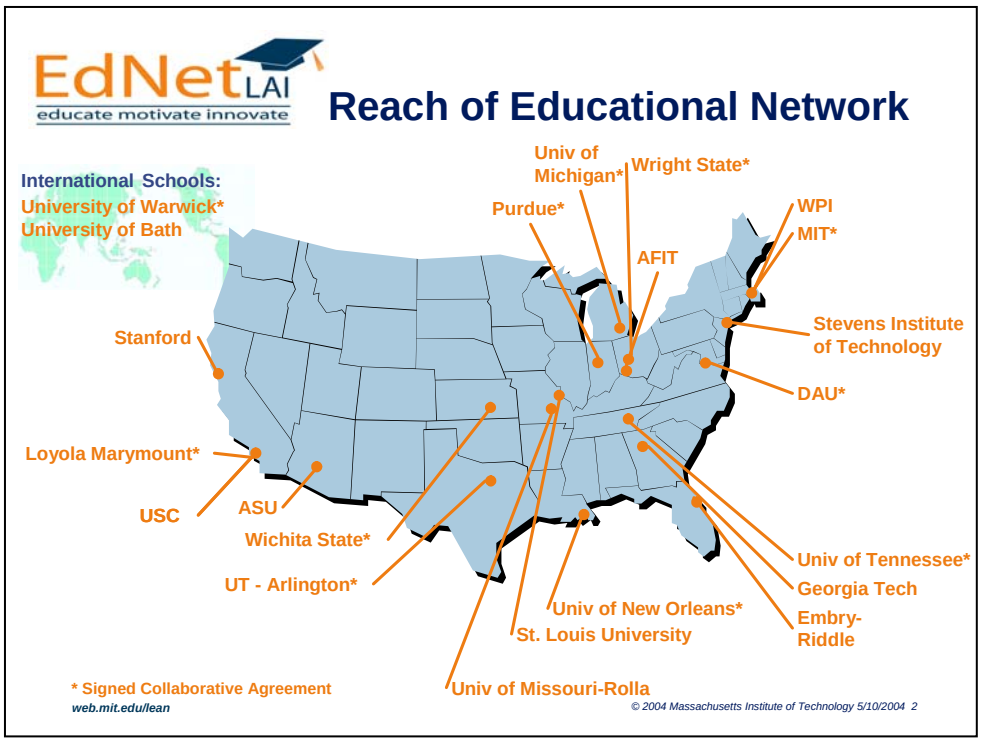
As systems become more complex and as industry roles change, companies are more responsible for systems solutions. However, there is a shortage in systems talent. There are not enough experienced systems engineers within the government and industry to meet current and future program needs. Some systems leaders believe it may take more than twenty years to develop a senior systems engineer. Accelerating this development process is of immediate concern.

By identifying enablers, barriers, and precursors to the development of systems thinking, my research will provide an empirical foundation for more effective and efficient interventions in the systems thinking development process. Currently, many systems training programs are structured using heuristics and isolated experiences. By studying the systems thinking process more methodically and rigorously, my research will

positively impact educational interventions and employee development in systems thinking for engineering professionals across industry, government, and academia.

Currently, there is no common view on the systems engineering education process. My research would also contribute to INCOSE efforts with the Accreditation Board for Engineering and Technology (ABET) to accredit academic programs in Systems Engineering. Since ABET focuses on the characteristics of programs and the products of these programs, my research results on the effective development of systems thinking are directly applicable to the accomplishment of this goal.

Education and Outreach



LAI Educational Network Vision: Active communication and collaboration among member schools supporting the transformation of the greater US aerospace enterprise.

LAI Educational Network Mission: Support continuous learning throughout the US aerospace enterprise by sharing knowledge and curriculum developed by EdNet members.

In order to pursue a substantial curriculum development effort, and to build on the open, inclusive, and learning characteristics of LAI, it is necessary and appropriate to take multiple approaches. One approach is the creation of the LAI Educational Network (LAI EdNet). The LAI EdNet, advances lean thinking through education and advocates enterprise level lean practices. The network also significantly broadens the reach of lean curriculum. It provides an opportunity for other universities to collaborate in the LAI community by providing a forum for communication between schools, as well as

linkages to the stakeholders of LAI. The appropriate structure which satisfies many of the motivating goals is that of a network. A network structure implies flexibility and multi-lateral interaction. This is essential to meeting the goal of creating a maximum leverage but low overhead engagement for all universities involved. The goal of the network is not to develop and deploy curriculum, but simply to facilitate the execution of curriculum development and its deployment in a distributed environment. First and most important, LA EdNet exists to stimulate ad hoc collaboration between network members. There are several opportunities for participation in the LAI EdNet. Meetings of this community are held regularly, hosted by various universities across the country. Additional information on LAI EdNet is available on the LAI Web site (web.mit.edu/lean) under "LAI Communities".

Lean Academy

A compelling need has developed to infuse and integrate "Lean" principles and practices into the content of engineering curricula. On-campus curricula changes are constrained by time limits, faculty capability and multiple stakeholder expectations. A strategy that

can generate near term impact and long-term systemic change is to work with industry through their summer internship and co-op programs. The LAI Lean AcademyTM exploits this opportunity to provide education to both students and instructors on Lean at the point of use where the principles and practices are being applied. The course was piloted in June 2003 with 25 summer interns at Rolls-Royce Indianapolis. A second offering was given January 2004 at Arizona State University to 20 university faculty and industry "students" who join the pilot instructors as instructors for four planned Lean Academies in summer 2004.

The LAI Lean Academy is an opportunity for students to participate in a one-week, intensive, hands-on learning experience that introduces Lean principles in conjunction with an opportunity for "real world" applications, such as an internship or co-op experience. Initially targeted at undergraduate students nearing graduation, Lean Academy is also an excellent opportunity for graduate students or new hires.