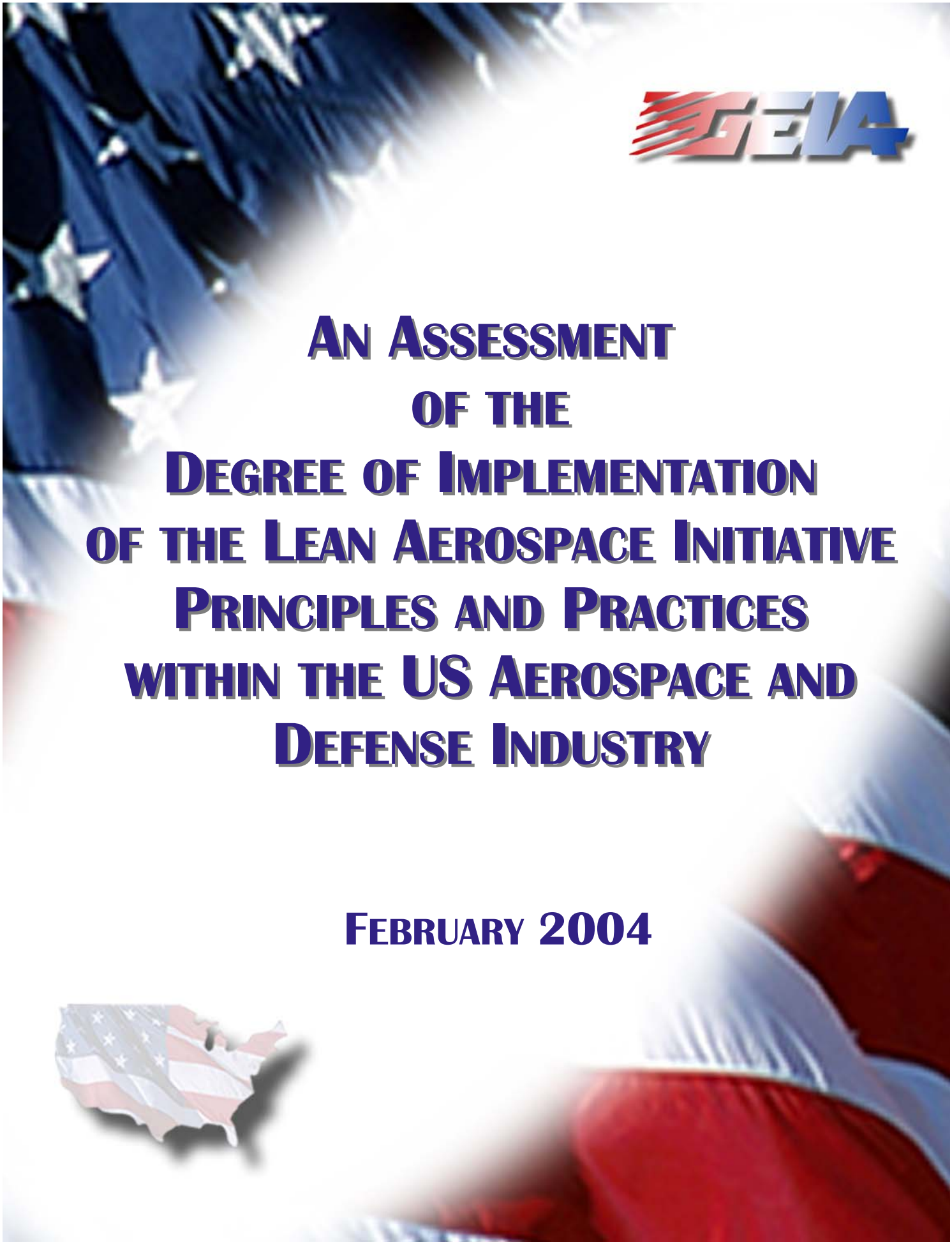


An Assessment of the Degree of Implementation of the Lean Aerospace Initiative Principles and Practices within the US Aerospace and Defense Industry

February 2004

An Assessment of the Degree of Implementation of the Lean Aerospace Initiative Principles and Practices within the US Aerospace and Defense Industry

February 2004

A report prepared by the Industry Association Crosstalk Coalition under the Chairmanship of the GEIA

The Industry Association Crosstalk Coalition

Government Electronics and Information Technology Association (GEIA)	Aerospace Industry Association (AIA)	National Defense Industrial Association (NDIA)

This report was prepared by
Thomas E. Shaw and Alexander Lengyel of the GEIA and Greg Ferre of MIT

Acknowledgements

Appreciation is extended to all companies responding to the Industry Associations team's request for their survey response, site visits and other Lean relevant information. Special appreciation is extended to Mr. Jim Davis of Boeing's Corporate office, the Boeing IDS Lean teams in St. Louis, Philadelphia and Mesa; to Mike Joyce of Lockheed Martin Company Corporate and Mr. John Zedro and his team at Lockheed Martin Commercial Space Satellite Company, the Marotta Scientific Company, Mr. Dan Heinemeier of the GEIA, Mr. William Lewandowski and member companies of the AIA Supplier Management Council, Ruth Franklin of the NDIA and the AFEI, and to all members of the industry association Lean Assessment Team. These include Mr. Alec Lengyel, Ms. Kimberley Eakins Largent, Mr. Walter Berkey, Mr. Dan Silva and Mr. Greg Ferre (MIT Researcher).

Thomas E. Shaw, Chairman
Systems, Standards and Technology Council (SSTC)
Government Electronics and Information Technology Association (GEIA)
A Segment of the Electronic Industries Alliance (EIA)

TABLE OF CONTENTS

An Industry Association Assessment of the Degree Of US Aerospace and Defense Industries Implementation Of the Lean Aerospace Initiative (LAI) Principles and Practices

1. Executive Summary

This report is a formal documentation of the results of an assessment of the degree to which Lean Principles and Practices have been implemented in the US Aerospace and Defense Industry. An Industry Association team prepared it for the DCMA-DCAA-Industry Association "Crosstalk" Coalition in response to a "Crosstalk" meeting action request to the industry associations.

The motivation of this request was provided by the many potential benefits to system/ product quality, affordability and industry responsiveness, which a high degree of industry Lean implementation can produce.

Assessment results

A formal briefing at the April 27, 2002 Crosstalk meeting of initial findings of the assessment process indicated a substantial implementation of enterprise processes by prime contractors (50-60%) but only 10-15% by suppliers and other contributors such as application IT providers.

Overall only 25-35% of enterprise operational processes in the industry at large were Lean. These findings highlighted the supplier network as the Achilles Heel to industry wide benefits. With an industry average of 70% of cost accruing from supplied material, the overall industries Lean implementation score was severely depressed by the low level of Lean implementation by the supplier community.

To address this pressing issue the AIA (Aerospace Industries Association) Member Company CEOs and its Supplier Management Council (SMC) have embarked on an aggressive Lean informational and educational program to promote understanding and Best Practices for Lean implementation and the values to be realized.

Although the overall degree of industry Lean implementation still falls within the earlier reported range approximately a year after the initial report, the momentum generated by Lean Programs has resulted in significant gains from Lean implementations by prime contractors and LAI Coalition members. The impact of AIA SMC initiatives and its Lean emphasis show promise of significant overall industry improvement.

Principal Findings

Important additional findings from this assessment are described in depth in Section 5 of this report; however, several are so pervasive that they are highlighted in this summary with the intent that they be examined by appropriate company and government agency executives and mapped to their internal Lean initiatives.

First, the success of Lean programs in the Aerospace and Defense industry is fundamentally linked to the strategic implementation of two classes of IT business systems such as enterprise resource planning systems (ERP), product data management systems (PDM) and engineering modeling and simulation systems. Best gains are achieved by value stream mapping and implementing operational improvements closely sequenced with the implementation of the enterprise systems.

Most prime contractors have instituted Lean initiatives in their engineering functions with extensive use of modeling and simulation tools and all electronic design and development. Additional Lean gains can be achieved through the minimization of the number of legacy systems interfaced with core business systems; such interfaces cost on average approximately $1,500 annually to maintain and represent complex IT system synchronization and data management issues. A “one bill of material” used by the entire enterprise allows seamless transmission of information between the PDM and the ERP systems and is essential to eliminate waste in transactions and their associated support effort, thereby adhering to the Lean principle of waste minimization. In Engineer to Order organizations producing complex engineered systems and products the “configuration management” effort is a very significant consumer of resources and modern systems significantly ameliorate this problem. Examples of companies successfully employing the above approaches are included in the body of this report.

It was noted that there appear to be two distinctive approaches in major contractor Lean Programs: One is a robust and effective enterprise systems implementation using a single instance integrated system, closely sequenced with a Lean value stream analysis and operational improvements. Lockheed Martin Commercial Space Systems is an excellent example of this approach. The other is a very aggressive Lean Program initiative integrated from Corporate, with management responsibilities clearly assigned throughout the entire organization, and with precise metrics measuring everyone’s Lean progress supported by an IT “best of breed” architecture. Boeing IDS is a prime example of this approach.

Second, several companies are making outstanding progress in embedding, institutionalizing and obtaining value from their Lean initiatives both “above” and “below” the factory floor. This is primarily the case for prime contractors and major suppliers. For example, Boeing IDS companies are obtaining major benefits from a number of innovative approaches; from use of the Balanced Scorecard methodology in their strategic planning to non-linear goal setting and measurement of their program and project teams, and strategic outsourcing practices. Lockheed Martin Commercial Satellite Space Systems, having used Lean principles in the design of its facility and processes, utilizes a fully functional ERP system to execute all operational processes and obtains real time metrics for process status and management actions.

Third, the LAI and its substantial body of resource materials have provided an essential framework and guidance to the industry for a more consistent and effective communication of Lean Principles and Practices.

Fourth and probably most important, successful Lean transformations are best characterized by leadership recognition of the critical role of cultural change and through committed workforce involvement.

Main Drivers for Lean Implementation in the Industry

The three main drivers to broaden the penetration of Lean Best Practices to the industry as a whole are:

- The continuation and expansion of the major contractors Lean Supplier Programs, which highlight contractor expectations for supplier Lean operations and are supported by more education, training and access to other relevant resources.
- The role of enterprise IT systems such as highly integrated ERP products which can capture the results of value stream analysis and sustain these Lean processes through the inherent discipline of the IT software and the associated process metrics.
- Results of the Lean "Implementation journey", as a sustaining force for those who are on the journey and as an example and inspiration for those not yet on the journey and even for those who have not committed to such a journey.

Other important drivers are:

- A consistent, supportive and proactive role of government agencies such as the DCMA and the DoD and the individual programs (and their program managers) that fall within the responsibilities of each and
- The manner in which companies establish and implement human resource recognition and evaluation programs as a key component of their Transformation to Lean Process.
- Exemplary personnel, team and business area goal setting and independent evaluation programs such as developed and administered by the Boeing Company represent an industry leading model. They, like the Rockwell Collins Company, found use of the Balanced Scorecard methodology to be a useful component for structuring strategic Lean implementation programs in consort with the LAI LEM, LESAT and TTL resources and for construction of their human resource development and evaluation processes.

This report provides details of the assessment process and findings. In addition it provides additional insight into the stability and momentum of the industry's Lean implementation initiatives and best practices from selected prime contractor and

supplier site visits and interactions. Specific recommendations for both industry and government are included for further review and assessment. Selected site reports are included in the Appendices of this report as additional reference material to support the findings, conclusions and recommendations of this report.

Primary recommendations

Primary recommendations from this assessment are:

- Industry needs to develop a consistent version of its various interfaces with suppliers and associated template(s) so that all suppliers get to reap the benefits from Lean implementation and eliminate duplication by not implementing Lean differently for each procurement, program, or internal business area.
- Industry must define what it means to their operations and the final product to have a Lean Supply base. This includes reduction in all life cycles of operational elements, process cost reductions, improved quality and value to their customers
- DCMA should review its policies, guidance and support to Transformation to Lean initiatives of the industry to provide consistency and uniformity in its evaluation of company proposed Lean projects, impact on their system descriptions, disclosure information and forward pricing.
- A&D companies should review their use of IT systems so that they embed validated value stream analysis in their IT systems to sustain the gains derived from their Lean Transformation. Implementation of IT systems should follow best practices as described in this report.
- "Crosstalk" association member companies should participate in a collection, synthesis and communication of enterprise Lean Best practices as continuing their focus on the industries "Transformation to Lean".
- Outstanding DCMA/contractor working relationships such as demonstrated by the Rockwell Collins Company should serve as models for mutual Lean performance standards.
- DCMA and government program managers should perform a value stream analysis on their own processes to insure that they are consistent with Lean Best Practices and are in consonance with the contractor and in particular with their suppliers Lean initiatives These value stream analyses should also be used to provide a basis for assessing the value of a Lean supply base to the industry at large and relevant government agencies.
- An evaluation by government of their cost estimation models should also be part of their review of their Lean processes since major reductions in contractor cost as a result of highly successful Lean implementation efforts may penalize these contractors for cost risk and realism. Such new models would provide additional

incentives to contractors and government personnel to enhance their Lean initiatives and maintain the overall momentum of the industry. Additionally, a compilation of Lean Best Practices across the industry would provide a set of Templates useful to the A&D industry and other industry at large.

The Lean paradigm in a $20-50M company is very different than for the (much) larger companies like Boeing or Lockheed Martin that have each implemented their own version of Lean. The DCMA and other governmental organizations should recognize this and work directly with the supply base to integrate their oversight activities with the Lean initiatives of these companies. Even though initiatives like the one described at Marrotta with Aerojet are helpful in demonstrating the value of Lean, many small suppliers are concerned that they do not see Lean practices or principles discussed or enacted in their ongoing relationship with both their customers and the government. Consequently they have a difficult issue motivating their staffs when this does not occur as a routine matter. DCMA personnel already on site can be a constant source of reinforcement of Lean practices and principles and help dispel these suppliers concerns.

2. Background

A significant body of knowledge has been acquired on Lean principles, practices, tools and techniques thanks to the understanding of the Toyota Production System and the publication of its application to the motor vehicle industry in the landmark "The Machine That Changed the World" by Womack et al.

In the early 1990s, the Lean Aircraft Initiative emerged as a consortium of MIT researchers, the USAF, and a coalition of 12 major US Aerospace and Defense firms. Its objective was first to aggregate, analyze, and organize the earlier work on the motor vehicle industry, then adapt the applicable features to the Aerospace and Defense industry. As LAI engaged in research on new processes and methodologies to enhance efficiency and effectiveness within the entire aerospace industry, it appropriately changed its name to Lean Aerospace Initiative.

The purpose of the Lean Aerospace Initiative was to translate these automobile industry findings to the US aerospace industry so the DoD and the Aerospace community could benefit from them. Several important publications have emerged from this decade-long effort, with a focus on gains in product development cycle time, significantly reduced system and product cost, and overall greater affordability with improved quality and customer acceptance. The LAI publications include the Lean Enterprise Model (LEM), the Transition to Lean Roadmap and the Lean Enterprise Self-Assessment Tool (LESAT). More recently LAI has published "Lean Enterprise Values", providing in-depth perspective and guidance on the LAI findings and research to date.

LAI and its consortium members gave momentum for other organizations to work on Lean. Universities such as the University of Tennessee and the University of Dayton created instructional courses and workshops; Deloitte & Touche, McKinsey and Lean Horizons Consulting and the Center for Operational Excellence are a few of several consulting firms to provide specific Lean expertise to individual companies. Subject matter experts from these organizations and others have written and published specific experiences as well as described processes and frameworks for transitioning a company to a Lean state.

However, given the above investment of both money and expertise, the question remained about the real return on investment of such an effort. For several mature Lean programs the data on benefits achieved exists and in some cases periodic goals for further improvement are established. However, there is no consolidated view of how Lean impacts the industry overall. This issue was addressed during a "Crosstalk" meeting with members of the DCMA[1], the EIA/GEIA[2], the AIA[3], and the NDIA[4] during which common issues that affect and influence government/industry working relationships are addressed. The issue was raised while discussing the relationships between Acquisition Excellence and Lean. Although LAI seemed to have brought impressive value to its members, the lack of hard evidence made the case difficult to advocate. Moreover, it became clear that an assessment of the degree of Lean initiative implementation across the industry would be useful to address the issue of Lean impact on affordability and competitiveness and if significant how it could be extended to include the broad scope of industry involved.

Consequently, chaired by the EIA/GEIA, the above noted industry associations organized a multi-association effort to assess the degree of Lean principles and practices implemented and embedded among the diverse entities of the Aerospace and Defense industry. Representatives from the EIA/GEIA, AIA and NDIA associations were assigned to address the formal request of the DCMA and its Director, Brigadier General Edward Harrington. The personnel assigned and there various affiliations are noted in Appendix A.1.

An initial report of the results of this assignment was briefed at the DCMA-DCAA-Industry Association "Crosstalk" meeting of April 27, 2002. This presentation is included in its entirety in Appendix A.3. This briefing recommended that industry compile its results in a formal report to expand upon the results of the April 27th briefing and to include additional insight, perspective, observed Best Practices and recommendations to the industry at large and associated governmental and military service agencies.

This report presents the conclusion of the industry association's assessment efforts and the results of this effort. The subsequent sections of this report address the details of

[1] Defense Contract Management Agency
[2] Electronic Industries Alliance/Government Electronics and Information Technology
[3] Aerospace Industry Association
[4] National Defense Industrial Association

the approach, the methodology and models used in the assessment process. It also highlights the site visits to companies in the course of this effort as well as certain specific best Practices observed during the site visits. Finally the industry team has developed specific recommendations that are viewed to be important in advancing the Lean initiatives in-depth penetration of the US Aerospace and Defense community.

3. Assessment Process

The objective of this assessment was to obtain a comprehensive view of the penetration of Lean Principles and Practices within the aerospace industry throughout its processes. Several issues were addressed, and for each one of them an approach yielding semi-quantitative results was identified.
Specifically, the assessment-raised issues about the depth of information sought, the range of companies surveyed the company evaluation models for their state of Lean used, the interpretation of the subsequent results and their potential generalization. These translated into the following questions:

1) How holistic a view or perspective of the A&D industry companies and their processes were appropriate and necessary to avoid a narrow and insular result (such as a focus on manufacturing only)?

2) What set or classes of companies would comprise a rational research domain?

3) What model of enterprise processes would provide a basis for determining the degree of Lean implementation and its institutionalization?

4) How could the results from individual companies, ranging from Engineer-to-Order to Build-to-Print product companies to supporting service companies, be combined into a useful result?

5) What assessment instruments or techniques would be useful and effective across the number and variety of companies in this complex Aerospace and Defense industry?

Because of practical limitations on the Industry Associations resources to conduct this assessment it was important to utilize already available informational resources coming from LAI and from the Industry Associations. The decisions made and the approaches followed are summarized in the following sections so that the basis for the assessment results, the Best Practices identified and the recommendations made are defined and described.

3.1. Enterprise View and Perspective

The research conducted by the LAI or consulting companies such as Accenture and IBM aimed in part at understanding how to achieve pervasive positive impact on the performances of the A&D industry through Lean. They suggest it requires having all the significant enterprise processes included in a life cycle view of a Transformation to-Lean initiative, from Concept Development to system or product retirement and disposal. Most important to a successful transformation was company executive leadership taking ownership of the Lean Transformation process, focusing on Lean education to all employees and recognizing Lean is a major cultural change requiring a continual emphasis on leadership and education.

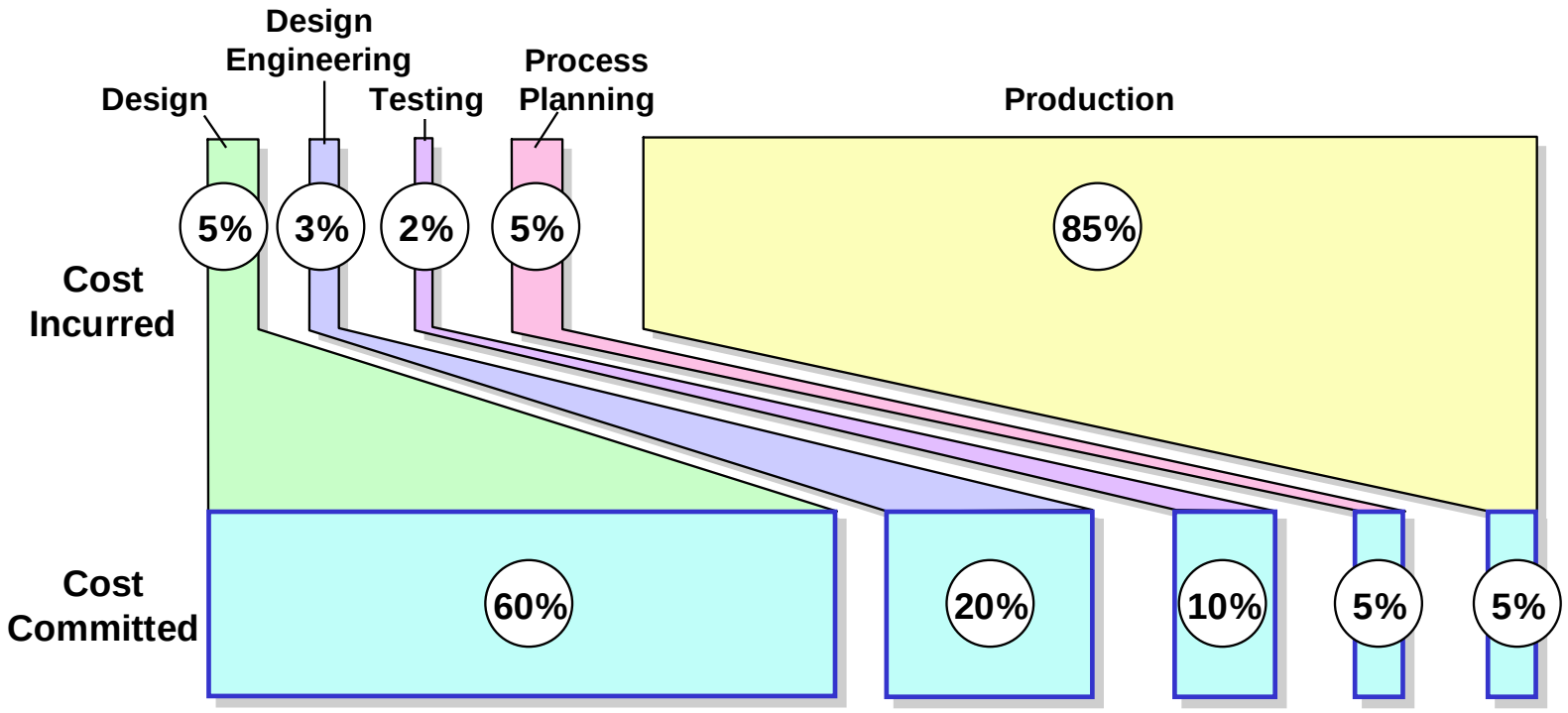
In particular, this research showed that the engineering intensive product development phase which usually accounted for 5-8% of the planned program cost (see Figure 1 on page 13), was responsible for 75-85% of the system or product ultimate attributes[5], while manufacturing only accounted for 15-20%. This meant that the enterprise Lean initiatives needed to include these “front end” or “above the factory floor” activities and identified the Life-Cycle view of enterprise processes as critical to assessing the Lean transformation of the industry.
It has also been observed that well implemented IT systems ranging from design tool sets (CAD, CAM, CAE), and enterprise scope process integration IT systems such as PDM and ERP systems were significant enablers of process effectiveness and efficiency. Examples are included in Sections that follow.

The findings and observations noted above were not sufficient to guide industry to a more strategic view of Lean benefits and their status against a specific Lean maturity model. It was necessary to provide companies with a comprehensive process methodology to assess their enterprise Lean ranking against their Transformation to Lean objectives. This conclusion resulted in the development and field-testing of the Lean Enterprise Self-Assessment Tool (LESAT) and accompanying Facilitator's Guide by LAI. The Enterprise Processes included in LESAT, the extent and scope of the processes and the substantiation required for each process to obtain a meaningful first level assessment of enterprise Lean status were viewed as a solid basis for the assessment itself and to identify the classes of companies to be included.

The industry team decided to use the LAI LESAT Version 1.0 (August 2001) as a baseline resource for the Lean assessment. LESAT also helped in determining the classes of companies to be included in the assessment process as noted above. In particular, the team decided that the Lean contribution of all classes of companies in the industry should be included in order to assess the Lean implementation extent across the entire A&D industry. In that perspective, companies providing specific services such as IT systems providers[6] and electronic design software should be included in the assessment since they contribute significantly to operational performance improvement through their products.

[5] quality, maintainability, technical performance and so on
[6] SAP, Oracle…

Figure 1
Program Costs are Committed Early On



Source: Andersen Consulting

3.2. Classes of Companies in Assessment Domain

The classes of companies selected for assessment based on the rationale described in Section 3.1 are listed below.

- Traditional Engineer-to-Order: Prime Contractors such as Boeing and Lockheed Martin, Raytheon or Northrop Grumman
- Avionics Suppliers such as Rockwell-Collins
- Component and device suppliers such as Harris Corporation and DynaBil
- CAD providers such as Mentor Graphics
- System IT suppliers such as SAP and Oracle
- Consultants specializing in Lean process, ERP or PDM implementations such as Accenture, IBM or Lean Horizons Consulting.

However AIA[7] data indicated that the supply chain contributed an average of 70% of the final product cost. Therefore this assessment gave a special emphasis to the Supply Chain, understanding that restricting a Lean assessment to the major contractors meant dramatically overstating the real status of the industry and understating the improvement efforts that could be attained by the industry as a whole. This report contains recommendations for improving this situation, including strong support of the AIA SMC programs, use of simplified integrated IT systems aimed at the smaller suppliers and support by major contractors and their associates of the tier 2 and tier 3 suppliers in particular in implementing Lean programs.

Given the classes of companies selected for this assessment it was necessary to determine how best to solicit their involvement. A decision was made to utilize two major sources of companies; those comprising the membership of the EIA/GEIA[8] (over 100 member companies) and the Associate Members of the AIA comprising the Supplier Management Council (approximately 180 member companies). The GEIA Company membership provided an excellent match to the class of company decisions reached in 3.1. In general, with few exceptions, the major prime contractors were also members of the AIA and NDIA, the industry Associations comprising the Industry Association component of the Crosstalk coalition.

3.3. Enterprise Lean Assessment Models

The issue of enterprise assessment model was triggered by the existence of discrepancies in terms of Lean implementation and evaluation tools used across in the A&D industry. Five enterprise assessment models were discussed.

Model 1:

[7] Aerospace Industries Association
[8] Government Electronics and Information Technology Association, a Sector of the Electronic Industries Alliance

For enterprises in the Engineer-to-Order of complex systems there are approximately 350 key processes, from concept definition design activities to product delivery, including MRP II transactions, for example. The most complete assessment of the degree of Lean processes implementation would be to examine each one of these 350 processes, determine its contribution to the cost of operations and develop a complex set of algorithms to calculate the ultimate "degree of lean" of a company[9].

For example, while implementing their ERP system, some companies address each process and optimize/simplify it: by doing so, they achieve a reasonable state of Leanness. The discipline of an ERP system (particularly an integrated system) forces the transactions involved to be preformed consistently so the degree of Lean embedded in the process is maintained and institutionalized over time. An illustration of the enterprise processes involved is included in Figures 2 to 4 on pages 16 to 18, "solution maps" (provided courtesy of SAP) of enterprise processes of several departments within an A&D company (engineer, manufacturing, marketing).

[9] assuming that there was consistency in the degree of "Lean" by each individual responsible for each process

Fig 2

Aerospace & Defense - Manufacturing Solution Map

Enterprise Management	Strategic Enterprise Management	Business Analytics	Business Intelligence & Decision Support	Accounting	Employee Relationship Management & Workforce Analytics
Sales & Marketing	Sales	Marketing	Service	Analytics	
Project Manufacture (R&D/MTO/ETO relevant)	Project Definition	Quotation & Contract Costing	Project Data Management	Program Management	Project Planning	Project Execution
Research & Development	Project Set-Up	Design, Concept & Specification	Engineering, Prototyping & Product Development	Hand Over & Contract Verification	
Make to Order	Product Development & Configuration Management	Inquiry & Quotation Processing	Order Entry Processing	Manufacture, Assembly & Shipping	Quality Control
Engineering To Order	Inquiry & Quotation Processing	Concept & Product Development	Project Management	Manufacture, Assembly & Shipping	
After-Market / InService Support	Preparation of InService Support Data	Spare Parts Management	Warranty / Guarantee Processing		
Business Support	Employee Life-Cycle & Transaction Management	Procurement	Financial Supply Chain Management	Fixed Asset Management	

Fig 3

Sales & Marketing

Sales	Marketing	Service	Analytics
Sales Planning & Forecasting (S1, S13)	Marketing Planning (S1, S13)	Service Planning & Forecasting (S1, S13)	Customer Analytics (S13, S1)
Distributed Catalog & Content Management (S1)	Marketing Development Funds (S1, S2)	Help Desk (S1, S13)	Product Analytics (S13, S1)
Organization & Territory Management (S1, S2, S13)	Product Management (S1, S13, S7, S2)	Knowledge Management (S1)	Partner Analytics (S13, S1)
Account & Contact Management (S1)	Collateral Management (S1)	Customer Service & Support (S1, S13, S2)	Marketing Analytics (S13, S1)
Task & Activity Management (S1, S13)	Content Management (S1)	Complaints Management (S1, S13, S2)	Sales Analytics (S13, S1)
Opportunity Management (S1, S13)	Catalog Management (S1)	Installed Base Management (S1)	Service Analytics (S13, S1)
Interactive Selling & Configuration (S1)	Customer Segmentation (S1, S13)	Account Self Service (S1)	Interaction Channel Analytics (S13, S1)
Virtual Showroom (S1)	Personalization (S1)	Request Management (S1)	
Web Auction (S1)	Campaign Management (S1, S2, S13)	Live Customer Assistance (S1)	
Price Management (S1, S2)	Campaign Execution (S1)	Service Order Management (S17, S1, S2)	
Shopping Basket Management (S1)	Lead Management (S1)	Service Contract Management (S1)	
Quotation & Order Management (S17, S1)		Resource Planning & Optimization (S1, S13)	
Distributed Order & Inventory Management (S2, S1)		Service Operations Management (S1, S13, S2)	
Contract Management (S1)		Professional Services (S1, S13, S2)	
Incentive & Commission Management (S31, S1)		Billing & Payment (S2, S13)	
Partner Compensation (S1, S31)			
Multi-tier Sales Tracking & Forecasting (S2, S13)			

SAP Product Available
SAP Product Available with Future Releases
Future Focus

Partner Product Available
Partner Product Available with Future Releases
Collaborative Business Map Available

Sxx, Vxx, Bxx SAP Product & Service
Pxx Partner Product
For more information see: http://www.sap.com

Fig 4

Project Manufacture (R&D/MTO/ETO relevant)

Project Definition	Quotation & Contract Costing	Project Data Management	Program Management	Project Planning	Project Execution
Project Structuring, Planning and Scheduling (S8, S141)	Quotation Costing (S12, S8, P19)	Configuration Management / Engineering Change Management (S8, P31)	Progress Tracking (S8)	Resource & Workforce Planning (S8)	Confirmation (S8)
Project Builder and Project Planning Board (S8)	Preliminary Purchasing (S6)	Document Management (S8, P104)	Cost Control (S12, C13, S8)	Costs (S8)	Project-Oriented Procurement & Production (S6)
Work Breakdown Structure (S8, P253)	Inquiry Intake (S6, S2)	CAD Integration, Virtual Product Development (S8, P103, S126, S133, S128, S130, S127, S132, S131, S129)	Actual Costing (S32)	Budget (S8)	Claim Management (S8)
Project Activity Network (S8)		Collaborative Design and Engineering (S8, S140)	Revenues (S8)	Scheduling Functions (S8)	Project Orientated Material Management (ProMan) (S8)
Material & Resource Planning (S8, S4)			Payments (S8, S11)	Workforce Planning (S8)	Project Information System (S8, S13)
Collaborative Project Management (S141)			Milestone Billing (S12, S8)	Cross Contract Resource Planning (S32)	
			Resource Related Billing (S8, S12)		

SAP Product Available
SAP Product Available with Future Releases
Future Focus

Partner Product Available
Partner Product Available with Future Releases
Collaborative Business Map Available

Sxx, Vxx, Bxx SAP Product & Service
Pxx Partner Product
For more information see: http://www.sap.com

This process description shown in the figures above is to the second level only; there are a significantly expanded number below the second level. However, such a depiction of enterprise processes represents the "ideal" model for a company assessment of its Lean status and is the one featured in the set of models defined for the companies included in the assessment process. However, many companies had not implemented enterprise-wide fully functional ERP systems or had implemented such in only one or more of their company divisions or business areas. Therefore it was necessary to define alternative models that could be used to obtain an enterprise assessment of Lean status. These follow the most desired model noted above.

Model 2:

The next most useful model approached Lean implementation through Life-Cycle analysis. Instead of looking in detail at the 350 processes, the company looks at the cycle times of parts of the entire process. For example, most companies restricted their Lean efforts to manufacturing. Therefore they focused on the manufacturing processes to assess their degree of Lean implementation. In some cases the companies moved from the factory floor to upstream operations including Engineering, thus providing a basis for estimating their degree of enterprise Lean implementation on a broader scale. By using this approach and knowing their cost of major Life-Cycle processes such as Design Engineering or Manufacturing they could provide a reasonable estimate of their Lean implementation status.

Model 3:

The third model listed was one that addressed Lean implementation by enterprise primary functions only, i.e. Engineering, Quality, and Manufacturing.

Model 4:

The fourth model differs from the first three in that it attempts to approximately link the degree of Lean implementation to the degree of Lean education within the staff. Practically, companies determine the percentage of Lean trained[10] staff compared to the total staff, including hourly work force where appropriate.

Model 5:

Lastly, if none of the above applied, management would give their best estimate of where they were in Lean implementation. Or, if they had performed an assessment using the LAI LESAT assessment methodology this was used as a ROM of their status.

Obviously the most desired information would be that from model number one. No company meets the requirements it imposes, although some are getting closer now as a result of their integrated IT systems implementation and associated metrics.

[10] Six Sigma, black belts, Lean Principles and Practices education and training, etc.

Nevertheless, it was recognized that the state of Lean implementation across the industry was highly variable, and that it would be necessary to accept data from all five models in order to compile the results into a meaningful conclusion. In particular, it was anticipated that most of the supplier network would fall into the later model category since it was obvious from interaction with the AIA Supplier Management Council that most suppliers were well behind the prime contractors in their Lean implementation progress and in implementation of enabling technologies such as ERP.

3.4. Integration of Assessment Model Information

Considering the information coming from the models described above and the importance of getting as wide a view as possible of the state of the industry, it was decided that the results from each model would have equal weight. In particular, a few limitations were noted and acknowledged. First, it became obvious that few results would accrue from Model 1 due to the lack of full functionality implementations. Furthermore, in Model 4, the estimates by management would probably overstate Lean status since not all staff members would be equally proficient in their Lean performance.

Given the complexity of the range of companies in the A&D industry, it was felt this equal weight assessment process was the best feasible one, but consequently that the assessment results would have to be viewed as qualitative at best. However, they will give clear guidance to the general state of the industry and point to where further action on the part of industry (and government) is needed.

3.5. Assessment Instruments

The issue of what form the assessment should take addressed several issues:

- the level of resources respondent companies could involve
- the level of knowledge responders had of Lean
- the manner by which results obtained could be verified and validated

It was decided that a two-part process would be most appropriate for the conditions and limitations of the assessment. Part one would be a survey sent to the member companies of the GEIA and the AIA Supplier Management Council. Part two would be selected company follow-up by on site visits to provide more detail to the survey findings. The assessment team felt a field assessment was necessary to get a more comprehensive view of the state of Leanness of a particular company and their views as to the state of the industry.. Such was also needed to capture their existing Lean Best Practices, the barriers to Lean implementation they encountered, and their view of the role of government agencies in fostering Lean initiatives. Finally the field assessment was essential to compile recommended actions that would improve the industries progress towards a broad, comprehensive Transformation-to-Lean values and operations.

The survey instrument itself underwent significant debate and modification. It was simplified as much as possible for ease of response, and yet retain the critical information necessary for the assessment objective. In particular, a specific section was incorporated to address the supply management issues from a supplier perspective. Appendix A.2 contains the original survey questionnaire and instructions for it use.
Later editions contained the same question set to maintain consistency of the database but updated the introduction to reflect status of the assessment. It was important for many companies to maintain response information as company confidential. Hence, this report will not address the specific companies, their reported status or Best Practices they consider proprietary (unless the company explicitly authorized it).

In the development of the survey questionnaire, meetings were held with MIT staff involved with the LAI program, not from the view of involving them in the survey but to get their view as to areas of duplication of their or other surveys or survey complexity that could complicate the response. Discussions were also held with DCMA personnel for the same purpose. But it should be emphasized that this was an Industry Association project and was not a product of either the LAI or DCMA/DCAA. As can be noted from the survey questions considerable background was requested on Lean involvement, key contacts, role of government involvement, barriers to Lean implementation, role of application and system IT products as enablers of Lean implementation, and a five question set on supplier relations and involvement.

As expected a wide variety of responses were obtained and the results summarized in a briefing to DCMA staff and its Director Brigadier General Harrington on April 27, 2002 (Appendix A.3). Since this initial briefing several members of the team followed up the survey results with site visits to companies such as Boeing (several divisions), Lockheed Martin, and Marotta Controls, Inc. The specific purpose was to gain further understanding of their Lean program status, identify Best Practices that would be of value to industry at large and to gather recommendations for further industry and government action. The individual company findings are addressed in Section 4.0, below. The totality of findings and information gained is summarized in Section 5.0

4. Highlights of A&D Companies Lean Programs, Initiatives and Focus

This section underlines the Lean efforts and initiatives the A&D industry underwent and is still dealing with. Particular focus is given to the use of the LAI tools and methodologies and IT systems as key enablers of the Lean efforts. Also underlined are the critical issues of the role of the government and the supply chain in an industry wide Lean Transformation. Finally, the assessment team noticed a number of issues and barriers for future debate and action.

4.1. Role and Utilization of LAI Resources

Several major corporations have crafted a Lean Vision and Strategy comprising a set of operating principles, business objectives, performance standards, reward systems, and human resource education and training. Boeing is one of those: it has identified Lean Excellence as one of its three Corporate Core Competencies. Each Boeing component develops and implements a comprehensive set of Lean objectives with associated metrics and increasingly aggressive goal setting. Personnel are evaluated against those Lean goals.

However, most companies have focused on the applications of Kaizen events and Six Sigma excellence (particularly in manufacturing). Those are easier to define and execute than in the traditional engineering dominated design and development processes of Engineer-to-Order organizations. Most of these companies embarked on these initiatives to enhance their competitive position in the market place and to address issues of system "affordability" identified by the DoD. Generally, the initiatives began before LAI's methodologies and guidance was available in documented form.

Companies with large engineering staff like Lockheed Martin Co. are aggressively shifting emphasis to the processes inherent to the functions of engineering such as design[11], configuration management, failure analysis, and "design to requirements". This step is necessary as approximately 50% of annual revenue accrues from engineering activity[12] with engineering establishing the key attributes of the final system or product. The Lockheed LM21 and Rockwell Collins initiatives are representative of the elimination of waste using a translated manufacturing approach to Lean: value stream mapping, Kaizen events and Six Sigma process excellence objectives. Therefore, most companies were embarking on basic Lean activities while the LAI products such as the LEM, the TTL and LESAT were maturing and undergoing evaluation by the coalition members. But most companies enterprise wide emphasis on Lean became much more formalized in the mid to late 1990's when LAI products such as those noted earlier became available and had the benefit of significant evaluation and testing by the LAI.

Approximately 50% of the respondents modified the LAI products and tailored them to their culture and lexicon. For example, Northrop Grumman Newport News adopted a "Lean Qualification Program". Highly correlated with LESAT, this Lean Qualification Program is a systematic approach to organizing and focusing Lean efforts at five stages of progression along a Lean maturity path. Furthermore it identifies all the key work processes in an area of responsibility and provides the criteria for evaluating their current leanness state.
The area director heads a Lean Guidance Team (LGT) that provides overall objectives budget and structure for Lean projects. Lean Implementation Teams complete a value stream mapping of the process in each work center, with support from their process leader and LGT. They then develop ideas and priorities for improving their process.

[11] shorter cycle time and fewer design errors
[12] for Lockheed Martin Co.

Green Belt Projects use continuous improvement tools to attack variation and waste in specific processes as identified through value stream mapping, FMEA's, Kaizen Blitz, and Lean Events.
Northrop Grumman Newport News also utilizes additional resources from Virginia's A.L. Philpott Manufacturing Extension Partnership, Old Dominion University, University of Michigan, and the Lean Enterprise Institute in developing their Lean programs and projects.

It is clear from the responses obtained that the Lean journey takes different forms depending on the company. Such variation is set by company tradition, the number of existing programs that can be modified to address Lean objectives, the relationships with Universities and of course top management determination to become and maintain competitive leadership in their markets.
In a subsequent section of this report the suppliers' approach to Lean is summarized. In general their approach is guided by issues of limited resources, questions as to motives of prime contractors in "imposing" Lean requirements and their being confronted by a wide variety of such requirements by the different approaches of their customers to supplier relationships

Among this diversity, however, certain Best Practices in the Transformation to Lean were observed or reported. These are summarized in Section 5.

4.1.1. The Rockwell Collins example

From analysis of the survey responses approximately 50% of companies indicated extensive use of LESAT, the TTL Roadmap and their associated guiding instructions. In doing so, they adapted the formal LAI processes to their own company culture and terminology. Like most of the other respondents, Rockwell Collins used a variety of resources to implement and sustain their Lean program. For example, they used the book Lean *Thinking* in which Womack and Jones establish Lean Principles to bring value, conduct value stream analysis, establish flows, enable pull and strive for perfection. The adoption of the ISO 9001 certification is also a means of implementing Lean and continuous improvement. This certification focuses on improvements in customer acceptance, and tracks performance using metrics such as mean time between failures, mean time between unscheduled removals, or warranty returns.
Initially, Rockwell Collins used the TTL roadmap to prepare strategy and education improvements for the enterprise. Rockwell Collins then created their own methodology called the Rockwell Collins Lean Roadmap: this tool expands upon the LAI TTL model using social and technical design elements to create a systems approach.
Nevertheless, Rockwell Collins has made extensive use of LESAT, utilizing it in every department of the company. This tool was useful to evaluate the company's current leanness state. However, Rockwell Collins found LESAT brought its true value when applied to determining gaps between current and future desired state. The LESAT results were also used in the creation of their strategic, financial and annual operating

plans. They also were used to forge Lean action plans. Rockwell Collins will continue to use the LESAT as a strategic tool and has created an "Executive" LESAT to determine immersion and applications in their executive staff. In parallel, Rockwell Collins has had an excellent implementation of enabling IT technology in the form of its ERP implementation.

4.1.2. The Boeing IDS example

Boeing IDS as a whole has successfully used the LAI methodology to provide a framework for its Lean Programs. “LAI provided a means of explaining what we are doing” noted a Lean team member in Boeing’s Philadelphia Rotorcraft Division. Boeing IDS has developed extensive methodologies suitable for their organizations plans to implement the Boeing Corporate Lean Program and is successfully implementing it.
The Boeing IDS approach was also founded on Jim Womack’s “Lean Thinking” book and its Toyota Production System methodologies, LAI research and several DARPA projects. They used the LAI research and the LEM framework as a means of communicating and prioritizing its efforts to eliminate waste in all elements of its processes, with outstanding results. The LAI tools were used as templates and were adapted to the IDS environment.
IDS St Louis developed a Lean philosophy which they integrate as much as possible into their culture. The Lean initiative at IDS relies on the following points:

- Strong, visible leadership of the Boeing Engineering and Manufacturing Councils.
- An aggressive Boeing Corporate Lean Program with significant inter-company communications and cooperation.
- An integrated Lean implementation staff.
- A consistent set of methods and techniques across IDS for implementing Lean and close coordination with BAC.
- Lean Engineering and Manufacturing Assessment processes, which promote aggressive goal setting and both self-assessment and independent assessment mechanisms.
- An extensive Supplier Development program including a Lean Transformation Template bolstered by Boeing’s reputation among suppliers as a Lean Best Practice company.
- Use of AIW (Accelerated Improvement Work Teams) to focus specific resources on a priority need. The AIW derives directly from LEM.
- A Goal setting and measurement process which is the key to Boeing’s sustained Lean performance and progress, and is sustained by use of the Lean Manufacturing Assessment tool (LMA).

Like LESAT, LMA is based on a maximum 5 rating with gradations based upon specific, demonstrable metrics and measures. Management, teams and individual performance are assessed against these criteria. Furthermore, it is a non-linear system with each new year’s levels significantly more challenging than those previous. The Lean leadership at Corporate, IDS and each Division or Business Area provides both

coaching and independent assessment events to insure that the fidelity of the system is maintained. This process has become a part of the Boeing management culture. Substantial effort is allocated to yearly formal manufacturing assessment, applying the LMA criteria to all participants. IDS and BAC treat this review as an assessment process vs. a traditional "IRS" type audit. This approach encourages candor and realism on the part of the participants. BAC has used the LMA process for over five years during which the process has been enhanced, simplified and institutionalized.

In an effort to apply these Lean principles to the entire company rather than only to manufacturing, IDS St Louis is attempting to integrate engineering, manufacturing and supply chain as its primary Lean focus since 80% of its product costs is locked up in this segment. Information is at the core of this initiative, which directly impacts the engineering practices as a result of its IT application program selection, its implementation structure and governance.
The IDS Lean Engineering initiatives comprise 12 Best Practices (somewhat aligned to the LAI LEM Best Practices) representing the core of its engineering “Foundation for Change” with key attributes that include Model Based Definition, Electronic 3D Simulation, Virtual Design Reviews/Collaborative Engineering and sophisticated use of IPT (Integrated Product Teams), among others.
There are nine tenants to Lean Manufacturing. These include Value Stream Mapping, Line Balance, Standardized Work, and Visuals in Place, Pulse and Moving lines, to note several. Investments in facility “choke” points such as complex structure drill and fasten processes are alleviated by capital acquisitions. Flexible tooling is stressed.

Boeing St. Louis has made impressive gains in cycle time, cost and quality of product as a result of employing the Lean actions noted above. For example, the outer wing fabrication on the F-18 has been reduced from 46 to 20 days and is expected to be further reduced to 17 days in 2004 by transition to a pulse line. Their approach is institutionalized and demands improving performance each year. The overlay of Lean staff, Lean Training and on the job Lean education is estimated to amount to 5 percent of work force payroll. This is a significant amount compared to certain professional service and software development companies and is very significant compared to many in discrete development and manufacture of complex products.

4.1.3. The Lockheed Martin Commercial Space Systems example

The LMCSS Business Area is a state of the art space satellite facility and staff, formulated in 1995/1996 as a Greenfield design based on TBM principles similar to those of the Lean Aerospace Initiative. After the initial design of the facility, LMCSS implemented an integrated ERP system, which is now in place providing real time information to all that need it and providing systematic metrics to measure the progress of Lean activities. Design of the manufacturing approach and of the processes used for manufacturing payloads preceded the publication of the LAI methodology. However, as

a member of the LAI consortium, Lockheed Martin had close relationships with LAI. Lockheed Martin Commercial Space Systems extensively used Kaizen events and methods to design the processes and a Master Kaizen was used as a value stream creator.

Current Lean initiatives are an integral part of the LM 21 Lockheed program led by Mike Joyce of Lockheed Martin's corporate office in Bethesda, MD. The Newtown enterprise value stream initially emphasized discipline in marketing, engineering tools in design and Kaizen for processes but has now been modified to shore up Lean Sustainment. It is focused on the objective of Six Sigma in design and manufacture with discipline and Lean captured by an Operational Excellence program. All systems are produced on mixed manufacturing arrangement consisting of 7 product cells with standard manufacturing processes. The only differences are additions of tollgates for government inspection and validation.

Originally designed as a major satellite sub-system (payload) engineer-to-order facility, its performance excellence combined with a market downturn resulted in it being converted to full satellite design, manufacture and operation responsibility as a Company consolidation initiative.

To answer both the challenges set by the market downturn and the quest for leaner/better practices, LMCSS Newtown moved away from a multiple dedicated product cells to a single mixed model line. They implemented standard operations and Mixed Model Manufacturing (M^3).

The search for commonalties led to a new floor layout with only three major common flows: Hermetically Sealed Devices/Microelectronics, Screened Packages Devices/RF Subassembly, and Integration and Test. Common standards allowed the operators to work on all products in a multi-model line. The end results of implementing common processes within common product flows were more flexibility, more time savings, more product efficiency, and less critical skill requirements. They eliminated 45% of the equipment, and had fewer people to manage on the floor. Parallel processing, standardization and discipline were developed to eliminate Work in Process (WIP). The facility, staff, equipment and processes were in place to use Lean principles and create a model of excellence in Lean.

4.2. Role and Utilization of Information Technology Systems

Research by the LAI has shown the increasing and critical role of information technology in enabling Lean. Several companies have used IT systems to embed and solidify the results of their value stream analysis and process simplification, particularly at the enterprise level. In doing so, they achieved and sustained the full value of their Lean initiatives. This results from the repetitive and consistent transaction train IT systems require for any calculation or analysis to proceed. A precept of Lean is continuous improvement from a known baseline: these systems provide that baseline.

Hence, they are safeguards against backing down from the Lean discipline so long as the company management culture insists on their use for all enterprise information.

Furthermore, integration of enterprise processes into one IT system (like an ERP system) insures less information loss or time wasted in the interfacing of such information from several stand-alone systems. For example, Rockwell Collins has implemented the SAP A&D Version 4.6c2 (specifically designed for A and D companies) as its enterprise resource system. In moving to this system several hundred legacy and non-integrated systems have been eliminated. The SAP system ensures consistent data collection, availability, and reporting to the enterprise. Additionally they use web-enabled tools to support customer requirements.

The implementation of a major IT system is much like the Transformation-to-Lean Journey. It requires strong leadership, competent process managers within the implementation team, recognition of the cultural impact of such systems and the key role that education and training plays in the success of the implementation. Recent implementation Best Practices for integrated ERP systems incorporating parallel value stream mapping with the implementation process have significantly reduced the implementation cycle, so that 12 to 15 months from initiation to completion have been realized. IT system suppliers such as SAP have recognized that suppliers to OEMs would also benefit significantly from such systems and are responding with less complex versions with reduced implementation cycle times and implementation cost.

Some companies have adopted "Best of Breed" information systems. However, these systems are subject to loss of time and accuracy while the information transacts across systems. Best of Breed adopters also have to deal with the issues of version and data synchronization control. Average maintenance cost of $1,500 per legacy interface on an annual basis is another issue. Despite these important issues, Best of Breeds can seem less “formidable and therefore easier to implement from a people perspective and in spite of the technical issues dealing with synchronization and interfacing, are appropriate to certain very large and established environments.

4.2.1. The Boeing IDS example

The Boeing engineering organization approach to Lean emulates elimination of “engineering” waste (waste from errors occurring in engineering, scrap or rework of data, waiting for information or data, transport, inventories). Applying a familiar manufacturing view of waste helps capture the value of removing it and improving efficiency. In the context of engineering, the value stream is the flow of data. Simulation and a comprehensive 3D-design capability is the centerpiece of the design product. The complete technical data package, including notes and all relevant manufacture, quality, test and related support data are contained in the engineering release. For current and future programs the data package is a single all electronic data base release. This

includes the model definition to be used by suppliers. At Boeing IDS St Louis, this effort has led to major reductions in cycle time and costs.

For its IT infrastructure, Boeing IDS has decided on a "Best of Breed" approach using a WDS (now Manugistics) core interfaced with its financial systems and the IMAN PDM. This approach has been approved by the IDS operations Council, chaired by John Van Gels. It provides a high level of functionality but at a significant decrease in interoperability and increases the difficulty for the transition to a leaner IT infrastructure. The interfaces and integration process of such a system are always more expensive to implement and maintain. However, it is easier to implement because it requires less cultural change and impact on operating efficiency during the transition to a new system. This choice suits best the IDS corporate culture, and provides positive results to the organization.
For example, at Boeing IDS drawings and specifications are now available to suppliers within 1 to 5 minutes of the request vs. previous cycle times of 2 to 10 days; CATIA, STEP, and IGES produced files are now available in 1 to 10 minutes, a major improvement over earlier metrics. The percent of electronic transactions may top out at or about 95% with a max/min inventory level ratio reduction from 4 to 2 based on a cost/benefit analysis

4.2.2. The Lockheed Martin Commercial Space Systems example

The SAP A&D system used at LMCSS[13] provides the backbone of all enterprise IT transactions. A careful definition of processes through value stream mapping and Kaizen events helped achieve an excellent ERP implementation. The IT system configuration resulting in a single BOM with date effectivity constitutes a Best Practice approach to efficient and high quality design and manufacture processes. It offers rapid responses to ongoing operations and is therefore a critical enabler of all cycle time reductions.
This implementation helped customize floor modules, and provided color-coded visualizations to enhance the visual aspects in the shops. All designs are electronic and both the PDM and ERP systems are configured to allow suppliers to access the latest design or manufacturing information and reflect this in their design or production activity. The SAP version at Newtown is now the standard system for the Lockheed Martin's $6 Billion Space Business area. Today, all performance metrics are obtained from the IT system in place. More details of this Division of Lockheed Martin Corporation can be found in Appendix C.

4.3. Role of Government

The companies that answered the survey had varying views of the role of the government and its actions in their Transformation to Lean process. In some cases, the company invited DCMA and other government agency personnel to participate in its

[13] interfaced with a Metaphase V.4 PDM system

Lean events. For example, Rockwell Collins conducted joint Lean events between their service center operations and the DCMA in Cedar Rapids (DD-250, data integrity, and process integrity events). Boeing held JDAM events with its local DCMA representatives. The Boeing Quality function worked jointly with the DCMA to conduct a value stream mapping. In all, 31 separate process initiatives have been conducted and were recognized by the DoD and Undersecretary of Defense. Boeing has also worked with the US Air Force Air Logistics Center in Warner Robins, Georgia in benchmarking events with the Rockwell Collins Atlanta Service Center.

As a subcontractor to primes, Rockwell Collins works very closely with Boeing, Lockheed Martin and Raytheon, among others. In these joint efforts like in most change efforts, there are boundaries or concerns that arise. For example, a change to timesharing polices brought up issues and barriers between Rockwell-Collins and the DCMA However, the key points and lessons learned are that both the company and the government were able to work the issues together and solved them to the satisfaction of both parties.

Conversely, certain companies found the government customers in general want to bake potential cost savings into cost estimates as soon as an idea germinates for possible improvement, without regard for likelihood of success or validation. Lean and ERP tend to drive high customer expectations for reaping savings and subsequent forward pricing for contracts diverts all savings benefits to the customer. In an area such as shipbuilding or high value satellites, there is generally a single customer and low volumes: if verified, the impact of Lean on product cost evaluation should benefit both the client and the contractor. However, in cases like the Boeing F-18 Forward Fuselage ECP, a very successful Lean implementation so drastically decreased the costs below estimates that Boeing was concerned the current DoD cost estimating techniques[14] may discredit future estimates and their cost credibility. A recommendation that relevant government cost estimation models be for an industry Lean operating environment is noted in Section 7.2.

For the supply chain, the role of the government generally reduces to one of site oversight, source inspection and product acceptance. In particular, for critical component companies with $20-50 million revenues, a successful implementation of Lean Principles and Practices means achieving the shortest possible response to customer orders needs and changes along with the cost reductions that generally follow the well executed processes that lead to these reduced cycle times. Unfortunately governmental agencies have to reduce their operations cost, which limits the availability of their personnel and their task efficiency. In particular such limitation on the DCMA Quality personnel often makes them a bottleneck and ties up the product the customer needs in queue for several days. This represents a significant loss of incentive to these small contractors. As will be noted in recommendations, for consistent high quality suppliers, a movement to inspection at destination or to keep within Lean practices obviates the need for such inspection.

[14] that do not incorporate Lean benefits

4.4. Role of the Supply Chain

During the April 27, 2002 briefing to General Harrington and his DCMA staff, it was noted that the US Supply Chain was the weak link in bringing the US A&D industry to a sufficiently high level of Lean implementation to achieve the system affordability, quality and responsiveness that the current threat environment dictates. In that report it was estimated that the degree of Lean implementation by suppliers ranged between 10 and 15%. It was also reported that several suppliers, members of the AIA Supplier Management Council, had aggressively adopted Lean Practices and Principles: they are benefiting significantly from increased revenue, new business and the ability to respond rapidly to new customer requirements. The DynaBil Company is representative of those small suppliers who have embarked on long term Lean programs.

AIA member company management has recognized this problem and has instituted aggressive corrective action programs to address supplier issues. They provide education and training, and identify selected resources of consultants or entities like the NIST MEP program, which provides valuable training to local area suppliers. The AIA Supplier Management Council has established specific classes on Lean, contract terms and conditions flow down of such terms. Issues such as quality and EDI are also studied, among other key areas of supplier concern. In April of 2003 the SMC held a Lean Master Class[15] to highlight the expectations of customers such as Boeing and Sikorsky. The class also demonstrated how certain small companies succeeded in their transformation to Lean and the significant benefits they achieved. However, in terms of improvement in their degree of Lean implementation, many of the class instruction and support resources are yet to be fully implemented.

One of axioms that came from “The Machine that Changed the World” was the importance of long term relations with suppliers. This changed this relationship paradigm from “compete all, compete often” to one of strategic and/or long-term relationships. This results in a natural reduction in the supply base. This reduction continues today as prime contractors and major subcontractors are reducing their world wide supply base. By defining suppliers as “preferred, long term, strategic partners, joint venture partners, etc” and giving them substantial work. Their customers expect improved cost, quality and other attributes that enable a strong prime customer-supply network “ensemble”. Suppliers have a responsibility to seek out “Lean” for their survival and competitiveness as well as the competitiveness of the prime contractor “ensemble”

The degree of Lean implementation that this segment of the industry will adopt still remains an issue, even with the major emphasis on this improvement expected by their customers (prime contractors and tier 1 suppliers). The above mentioned Lean Master Class provides several examples of prime contractor expectations of a supplier and also provides specific actions taken by several exemplary suppliers to meet that expectation.

[15] the Lean Master Class was held at the Spring Meeting of the AIA SMC in Long Island, April 24 and 25, 2003

4.4.1. The Boeing IDS example

Across the eleven Business units of IDS there are 6,193 suppliers involving $22.63 Billion. However, 80% of this cost is paid to 175 suppliers. Only 5% of Boeing IDS' suppliers are lean-engaged, and Boeing wants to extend its philosophy to the rest of its suppliers since they are responsible for 70% of the Boeing product cost. Doing this requires establishing aligned goals, objectives and metrics, appropriate sharing of consistent information and common systems and tools. Boeing is one of the few companies which trains at no direct cost to their suppliers. Boeing helps its suppliers assess their Lean status. This practice contributes not only to Boeing's cost improving effort, but also to the entire industry as competitors also have access to Boeing's suppliers.

Everything is done to promote a more effective supplier and a more collaborative relationship. This Boeing involvement helps to develop an appropriate atmosphere for negotiated savings that are of benefit to both parties. The burden incumbent to the supplier is to show Boeing tangible benefits from this significant Boeing involvement.

Boeing's approach to suppliers is to apply a Preferred Supplier Certification Process to characterize suppliers as Gold, Silver or Bronze level suppliers, and all of the rest. Gold certified suppliers get additional "perks" including the opportunity to lead Boeing IPT teams. Program teams identify critical suppliers, and, with the help of the Supplier Development function, identify additional investment that will enable improved supplier performance, development plans to reduce waste, participate with AIW (**Accelerated Improvement Work**) teams as appropriate, educate and train in TPM, 5s, Six Sigma etc. Critical suppliers have applied the Boeing Lean Manufacturing Assessment Tool (LMA). Examining their ability to move up the value chain and their use of Model Based Definition, e-commerce, kitting, and point of use delivery assess supplier readiness.

The Program Office has developed and applied supplier assessment methodologies including use of BEST[16], assessed a representative number of suppliers to capture their programs supply chain current status. Assessments are conducted once a month. Boeing IDS has Supplier Management Integrated Teams (SMIT) that help suppliers improve, and has also secured third party funding for this effort. There is a Supplier Training Program partly supported by the Illinois Training Program. Other states (CA, WA, MO, OH) are also providing such training programs.

Boeing Philadelphia Rotorcraft Division has focused on helicopter final assembly as its core competence with most major subassemblies outsourced. Consequently Lean supplier and procurement initiatives have focused on a Lean supplier community using value stream analysis as the primary tool for streamlining procurement processes with business rules and use of IT systems. Prior to these Lean activities some 70-80% of procurement activity was classified as non-value added. Results to date include 95% on time part availability and 30% reduction in SM&P costs. These results are largely dependant on the IT systems initiative. Specific Lean supply initiatives include a 40%

[16] Boeing Enterprise Supply Tool

reduction in suppliers, expanded use of the electronic supply chain (noted above), CBO (Consumption Based Orders) reflecting the inventory max/min objective and reallocation of more available procurement personnel to focusing on high value and critical items.

4.4.2. The Lockheed Martin Commercial Space Systems example

LMCSS has initiated a drive to reduce the number of suppliers while increasing the competition amongst its supply chain. This effort comes at a period where suppliers tend to consolidate or leave the space systems market because of the severe market crisis and very high quality required.
Suppliers to LMCSS are expected to be Lean, and LMCSS helps them through training, green belt programs, value stream mapping and BPR. LMCSS verifies the leanness of its suppliers by analyzing their cycle times, product quality and costs. The fully integrated ERP IT system is a critical enabler of such measures.

LMCSS followed a principle of only ordering what they needed, demonstrating their commitment to the Lean principles. To drive prices down, they worked with the suppliers to eliminate waste in their transactions. . When the Market downturn hit, this approach minimized the impact across Lockheed Martin's supply chain, resulting in strengthened relationships as a result of the confidence suppliers had in their Lockheed Martin customer.

4.5. Barriers and Issues

The Transformation-to-Lean journey is primarily a cultural one, earmarked by needs for strong executive office leadership, in-depth communications to and with the work force. In particular the work force must understand the end result of a Transformation- to Lean could be a work force reduction necessary to improve the overall company competitiveness and secure those jobs remaining. This is clearly a very sensitive subject, for all companies and one that must be handled very carefully. In certain cases, as with the DynaBil example, sharply improved competitiveness has added substantial business, more than offsetting temporary workforce dislocations. It should be stressed that in other cases improved competitiveness has brought more orders that offset outsource decisions.

The most successful at Lean implementation among the industry survey respondents took a systems approach to the TTL process and underwent technical and social re-design efforts. For example, one company integrated into its Lean Roadmap and Lean education the Gailbreath Model in social change. When it first began its Lean implementation program several years ago it first engaged the workforce to ensure alignment, education, support and sustainment. With time, more emphasis has shifted to middle and executive management (all forms of leadership) to ensure line of sight, immersion and an understanding of these social elements of change. They recognized that a misinformed or under-informed workforce generates resistance. To mitigate this, they conducted formal and informal communications in variety of formats to ensure both

status and direction. In addition, they held multiple “town hall” meetings, state of the business and listening sessions at all levels to ensure the Lean message is consistent and pervasive. Conferences for all leadership and Lean Event leaders are held quarterly, along with quarterly operations specific sessions. Skip level meeting with the workforce is held as well. The company established a robust training program via the Lean certification program, as well as joint Union/Leadership events to maintain positive employee relations in represented areas. The results are a more galvanized work force, focused together on what is takes to win and united in their for excellence in all they do. The best representation of the results is this company’s strong growth in sales and financial performance and ability to respond and recover even in difficult national and international events: the current stock price is higher than before the September 11 attack.

In customer relations, those who felt they had been most successful are those that have accepted Lean and other similar improvement philosophies as an operating paradigm, i.e., working with customers and suppliers on the generation of shared value whether in the guise of Lean or other improvement programs. However, when market or program conditions indicate that layoffs are the only solution it is still difficult to explain that without Lean implementation it would have been more severe.

4.5.1 The Boeing IDS example

The Boeing Rotorcraft HR policy now gives more recognition to the key value of employees and their involvement in the company. Boeing has established employee involvement teams, led by the Unions, staffed by the Unions and supported by management / support personnel.
The paradigm captured by the phrase “Lean = less employees are needed” is no longer the mindset at Boeing Rotorcraft. But significant changes within the workforce mindset have been observed, as they now understand that 60% of something is better than 100% of nothing. This is due to a substantial communication effort delivered by Boeing to its employees. Work packages slated to go out are explained to the Union and jointly staffed teams are put in place to work business case scenarios to arrive at the best business-work force decision possible.

4.5.2 The Lockheed Martin Commercial Space Systems example

The Newtown management had the choice of a large population of IT professionals that had supported Lockheed Martin Marietta, General Electric and RCA legacy systems for many years. Newtown management hand picked the IT implementation team of the new integrated system for their adaptation qualities. The economic situation made it initially difficult to prove the value of the new system. However, as a result of an aggressive and sustained effort of communication (consensus-based decisions for enterprise-wide decisions) and inclusion of the different stakeholders, including the government, the

system is used as the primary data source for all management and process decisions today.

5. Findings

5.1. Introduction

The findings summarized in Section 1.0 represent the industry team's assessment of the "real" degree of US A&D industry transformation to Lean progress and status as well as observations and insight from the interactions with the industry.

This assessment is based on the two primary sources of information planned for this activity: the responses to the survey sent to the GEIA member companies and the inputs from the AIA Supplier Management Council members. Additional follow-up site visits and teleconferences were made to selected prime contractors and suppliers to supplement information obtained from survey responses. These site visits dealt with crucial information that was not directly captured by the survey. The assessment team unveiled findings on implementation approach, human resource motivation, and issues and barriers that could lead to meaningful recommendations to both government and industry. It should be emphasized that this was not a classical statistical study since the wide variation in companies, products, organizational structure, mission and resources available precluded such an effort. Further, each company's POC for this assessment would bring their own perspective and personal view of their company's status. Therefore the results of this effort should be considered as an estimate of the industry's leanness status and its values.

5.2. Details of each finding

5.2.1. Degree of Industry Lean Implementation

75 companies answered the survey, participated in site surveys and visits or provided other information via telecon or email. Many of the responses included company confidential material and were handled accordingly (survey results confidentiality and site visit NDA forms). Their inputs provided the information to draw the findings described below.

Prime/major contractors provided their estimates of their degree of Lean transformation, ranging from a low of 15% for certain of their Divisions or Business areas to highs of 80%. Some companies claimed achieving more than 80% leanness thanks to value stream analysis and process simplification in their enterprise IT system. Those reporting around 60% leanness were generally those with substantial manufacturing operations.

Interestingly, many of the service related companies[17] ranked low in their internal Lean implementation efforts while claiming products that enabled Lean. There were however exceptions.

To arrive at a range of implementation for the group of primarily major or prime contractors (members of the GEIA) the following approach to their degree of Lean implementation was taken:

1) Companies reporting their degree of Lean implementation according to one or more of the models described in section 3.3.
2) Companies reporting LESAT assessment results (current capability of 3 was equated to 60%).
3) Companies reporting percentage of workforce trained in Lean tools and techniques, including Kaizen events, Six Sigma process enactment or other Lean education and training. This was equated to the percentage of Lean implementation.

The above three approaches represented the major portion of responders including the major/prime contractors, with a Lean status reported between 50 to 60%. This percentage is probably high but demonstrates the commitment to Lean of these companies.

The remainder of the responses fell between those with little (20%) or no (0%) Lean implementation, and represented 20% of the answers received. Therefore, it was decided to degrade the overall range of this set of companies by 10% resulting in a final range of 45 to 55% with a mean value of 50%.

Unfortunately the excluded respondent segment may have much more than a 10% impact on the performance of those with higher rankings as this segment includes the IT system providers and associated implementation services. Also, akin to the government role (Finding 8), the industry is significantly impacted by those with the least progress in Lean. **For Lean to have the major impact and benefits to the industry, the industry as a whole needs to reach levels consistent with leaders of the industry.**

The other crucial class of companies is the suppliers. As expected, the degree of Lean implementation was non-existent for many, well implemented by a few. Some reported not having enough resources to even assess the value of Lean to their companies. For others, the expectation of their customer for their aggressive involvement in Lean was their only connection to the initiative.

Consequently, estimates from the AIA SMC members indicated that the degree of Lean implementation ranged between 10 and 20% at best. Again, even this level is misleading since it only takes a limited number of "non-compliant" critical item suppliers to significantly affect the design, development and manufacturing cycles of their customers. Although it can be argued that these will be driven from the market place by competitive forces, some possess critical capabilities that take time and resources to replicate.

[17] IT suppliers, A&D consulting services…

The AIA reports that the 70% of final system/product delivered accrue from supplier furnished materials and services. Using the above values for the industry classes chosen the degree of Lean implementation of the US Aerospace and Defense industry lies between 25 to 35%. This is in line with results reported earlier and emphasizes the need for a strong motivating role by all involved, particularly the prime contractor community and government.

Recognition of the supplier status has initiated an extensive in-depth program by the AIA Company membership and their CEOs. This program aims at fully supporting the AIA SMC members with all forms of education and training, dispensed by AIA major contractors but even more so by the SMC. SMC (VP's and Directors of Supply Chain Management) are employing the NIST MEPs (National Institute of Standards & Technology Management Education Program) to educate and train their supply base in Lean. This Council has developed various master classes, including a Lean Master Class. It has made arrangements with the Alliance of Supplier Excellence (at no cost to suppliers). The SMC also supports simplification of various transactions between customers and suppliers and all forms of activity that would eliminate waste and redundant effort. A CD that represents the Lean Master Class offering can be obtained from william@aia-aerospace.org. This effort, coupled with aggressive prime contractor supply Chain Management support services, support to increased funding for the NIST MEP and/or Lean specific consulting services provided by Lean Horizons Consulting among others, should have a major positive impact on this critical component of the industry.

5.2.2. Lean Initiative in the Supply Chain

As noted earlier, the supply chain is the Achilles Heel of the A&D Lean implementation status. Finding (1) indicated the low level of Lean implementation in this segment of the industry and the impact it has overall. Also noted is the substantial effort provided by the AIA to remedy this circumstance and the key contribution made by prime contractors to incentivize, educate and train and share its Lean implementation best practices with suppliers.

The goal is to reduce supplier cost and cycle time with improved quality and share in the cost savings such success would engender. In many cases, those that are managing supply chains and are members of the AIA are also those who are developing programs and projects to simplify and eliminate duplication through the AIA SMC. The primary mechanism for this SMC effort is fuelled through a series of Master Classes which address the following supplier issues:

- Lean implementation and the expectations of customers. Reference 7 comes from the CD of the Lean Master Class held at Northrop Grumman Long Island facilities on April 24, 2003. It contains customer expectations from Boeing, Perkin Elmer Fluid Dynamics Division, and Sikorsky Division of UTC. It also presents

specific Lean Implementation plans, the resources they utilized and the significant results and benefits they enabled. The SMC has also arranged free education and training for suppliers from the Alliance for Supplier Excellence, a California based non-profit organization that has demonstrated a wide range of Lean competencies. The SMC has the goal to make the Master Class program a web based 8-hour class through the Defense contract Management College.

- DoD and Prime Contractor Terms and Conditions Flow Down and their simplification and standardization. This represents an area of significant cost and extra effort with little added value, in most circumstances. Both prime contractor and supplier representatives are working to simplify and isolate only critical material.
- Electronic communication of all transactions between customer and suppliers. A specific study group is working to standardize all transactions and the various templates each company imposes on its suppliers vs. one AIA approved form. The goal is to obtain electronic communication links that are not bogged down with forms carrying duplicative and redundant information.

Among prime contractors Boeing IDS supplier management program provides suppliers with low or no cost resources. A particular example is the NIST MEP programs which have centers located in virtually every state. The April 2003 AIA SMC Lean Master Class[18] mentioned earlier contains a detailed description of this Boeing initiative. Most prime contractors have similar programs, usually directed towards the most significant of their suppliers but available to all suppliers in their chain. Certain companies rely primarily on the demonstration of the value of Kaizen events with their suppliers and have achieved excellent results through this mechanism. Lockheed Martin Commercial Space Systems has exercised this approach across its supply chain.

Lastly and probably most important, customers who understand the positive impact of a Lean organization, have communicated to their suppliers that they are expected to understand, undertake and sustain a Lean organization and to expect to share the benefits with them and their ultimate customer. Evidence that this has not happened across the industry is anecdotal occurrences of customers requiring supplier to finance and carry inventory for them. This has hurt small businesses in particular.

5.2.3. Keys to Achieving and Sustaining Lean

For large diverse organizations like Boeing or Lockheed Martin and small niche type suppliers like Marotta Scientific, executive office leadership and "corporate" leadership of Lean initiatives are absolutely critical, as is the case with any cultural transformation project. It has also been observed that modern, integrated business systems (ERP, PDM) enable the Lean transformation. Success in such transformations is usually measured in years: IBM and Accenture research studies suggest cultural change takes

[18] the Lean Master Class was held at the Spring Meeting of the AIA SMC in Long Island, April 24 and 25, 2003

typically 5 years. However, first impressive results can be obtained in as little as six months as demonstrated by companies such as DynaBil and by consulting firms such as Lean Horizons Consulting and the Center for Excellence in Operations. But the need for continuity, consistency and competence is incumbent to leadership to maintain the Lean journey. These same studies have shown that greatest resistance comes from the middle management sector that feels most impacted by major process change.

The Boeing Company includes Lean Excellence as one of only three Core Corporate Competencies. They recognized the amount of time required to achieve this significant cultural change. As a consequence they established what the assessment team considers a Best Practice Process for instilling, maintaining and building on Lean success. From the Corporate Lean POC, Jim Davis, to every Boeing operating entity, Lean business objectives, goals and financial benefits are described in ever increasing levels of difficulty for the entity involved. In the definition of their year forward, program and functional personnel share objectives, measures and benefits to the organization. Each year the bar is raised, as they become more skilled in value stream analysis, process simplification and Lean accomplishment. The process is modeled after the SEI maturity model (one to five levels of performance) and is reviewed by both the senior management of the function and by an independently appointed evaluation team from all sectors of the company.

For other companies, promotion and recognition is awarded for their contribution to the company's Lean program. Suppliers find that bonus arrangements are particularly effective: these are based on a series of metrics such as bottom line financial performance, quality of delivered product, and customer evaluations. However, such methods require an absolute level of integrity among executive ranks, and a willingness to share and explain the bonus awards based on these results.

5.2.4. Two Distinctive Approaches to Lean Implementation

Analysis of the fundamental approaches prime contractors employed to both implement and sustain their Transformation to Lean indicated an important difference in how their Information Technology architecture was deployed to support their overall Lean initiative. These two approaches are defined as "Best of Breed" interfaced IT application programs to support enterprise processes and "modern integrated IT systems" capable of end to end enterprise transaction processing. Single instance implementation of such integrated enterprise systems further enhances the organization's ability to continually improve their Lean processes. The Boeing IDS "Best of Breed" architecture is a finely tuned sophisticated set of both acquired and locally modified application programs for MRP II production planning, engineering data capture, programs that using and control among the many elements of functionality complex products require. Extensive effort is required to maintain proper version control of each application as well as maintain and extend functionality as requirements change. See Appendix B for more detail from minutes of this site visit.

An excellent example of the integrated approach is the SAP A&D ERP system installed at Lockheed Martin Newtown Commercial Space facility. Their integrated system is interfaced only to the MetaPhase PDM system. It embeds Lean processes, operating and management metrics, and real time operating decision data. This data transacts seamlessly from engineering technical package release to manufacturing and distribution. Lockheed Martin maintains this "integrated architecture" of two robust single instance enterprise systems is key to sustaining their Lean processes at greatly reduced cost. See Appendix C for more on this site visit and additional insight into this approach.

It is apparent that IT systems are a critical enabler of Lean. How well IT systems support Lean is a critical consideration for organizations reviewing their IT system strategy and considering future changes or additions It is also important for IT system developers to consider how their product may be adapted to smaller companies and how these systems may be used to imbed Lean gains into their enterprise processes.

5.2.5. IT Systems and Lean

Two major classes of enterprise-wide IT systems currently address the functionality requirements of large complex engineer-to-order companies: the Enterprise Resource Planning, ERP, and the Product Data Management, PDM. An ERP focuses on all enterprise processes with limited functionality for engineering design and development processes. A PDM focuses on design and development processes, with minimal functionality in all other enterprise process domains.
Unfortunately the character of transactions dictate the formulation of each: engineering systems are dominated by large design files, while the manufacturing processes are transaction dominated. Companies try to have the maximum degree of IT integration to minimize the transaction train complexity. However, specialized application programs for various functions[19] have become integral with the processes key to a companies competitive capability. Such arrangements counter the Lean philosophy of minimizing waste and do not in general embed the results of value stream analysis and mapping. This is unfortunate as integrated process train calculations are repetitive in nature and provide a very effective way to integrate Lean analysis and sustainability over time.

Lockheed Martins Commercial Space Systems has demonstrated the strategic value of employing enterprise IT systems as the primary mechanism to capture Lean progress[20] (Appendix C). The implementation was value steam analyzed and mapped through the company's Lean initiatives. The result is the implementation of the SAP A&D ERP system interfaced with the Metaphase PDM system: this enterprise wide integrated IT system manages all key processes, maintains Lean performance metrics, and provides

[19] like MRP2, work station planning, human resource management, customer relations management (CRM) and their customization to the enterprise's needs
[20] although most product is produced for DoD and special agency applications

the essential real time operating feedback for immediate and accurate actions. A single Bill of Material generated in the PDM system greatly simplifies the conversion of engineering data to work station instructions.

A strategic vision of how IT would best support the company's Lean vision was crucial to the choice of processes embedded in both systems. The fact this was a Greenfield site certainly provided a greater opportunity to strategically decide on its IT plans. However, it does not preclude companies from using their ERP systems to embed the results of value stream analysis into the disciplined structure of such systems.

5.2.6. Expanding the company Lean Initiative

For many years the focus of companies' Lean initiatives has been on the factory floor where the many processes required provided a "target rich" environment. Tools and Techniques such as Kaizen events, 5s, Six Sigma were reasonably easy to define and execute. But as the LAI Lean Enterprise Model clearly defines, a holistic approach to Lean involving the total enterprise is necessary. This is particularly relevant to the major contractors of the A&D industry as they are predominately Engineer-to-Order organizations. As shown in Figure 1 earlier on the effect of early program concept and design decisions, the real impact on systems and products emanates from the design function. Consequently most companies, in their survey and site visits responses, highlighted their drive to extend Lean from manufacturing to the engineering function. Among others, the goal is to reduce waste, queue times, excess waiting for downstream technical information, and use Six Sigma quality metrics on engineering technical data packages.

For example, Boeing St. Louis combined major emphasis on modeling and simulation with the objective of Six Sigma technical data packages to bring down by 40% the F-18E/F Forward Fuselage ECP cost. The first article was built from this technical data package which includes all manufacturing work instruction, tooling and test requirements. The all-electronic design of complex aircraft is not new. However, the integration of Six Sigma engineering processes, the value stream analysis and mapping leading to process simplifications, and the use of effective PDM and ERP systems enable rapid implementation of the system concept. Extremely short development cycle times as well as production efficiency were observed with the Boeing JDAM facility in Clayton, Missouri. Similar results were observed at the Lockheed Martin Commercial Space facility in Newtown, PA. More details of this shift are included in the minutes of the team's site visits, Appendix C.

5.2.7. Impact of LAI on the Industry

Company survey responses and site visit discussions pointed out that they had embarked on a number of Lean initiatives before they were formally embodied in the several resource documents published by the LAI consortium. However, they found that such resources and research material was extremely valuable in providing the strategic

perspective, framework, prioritization and consistency that has led to the momentum for Lean implementation in the industry today.

Most of the major prime contractors were members of the LAI Coalition and had the advantage of the networking such relationships provide. Information such as Best Practices, tools, methodologies and insight were subjects reviewed and debated during seminars, conferences and discussions and were frequently incorporated into their Lean initiatives. Most also were aware of the value of the Toyota Production System to significant automotive industry improvements, of the flow system instituted by Dell and its rise to prominence in the PC industry and of IT system developments, which integrated the enterprise, among other 1990s development and manufacturing process enhancements and began to incorporate relevant elements of these improvements into their operations.

However, a significant and critical point made by all was that the framework established by the LAI (LEM, TTL Roadmap, LESAT etc.) provided a better understanding of the Lean Transformation journey. It helped explain that successful transformations would in general lead to a much more competitive position and more business. It also meant that work force freed up by the initiative could bring back certain work that had been outsourced during heavy workload periods. LAI pointed out that a smoothing and stabilization of employment was one of the key benefits of this undertaking. As noted earlier in this report, products like LESAT became a very useful resource for gap analysis and are used by approximately 50 percent of the companies responding in its current form.

In hindsight, inclusion of the supply community in the LAI coalition would have been extremely valuable in achieving the momentum that the prime contractors and the AIA SMC are now trying to achieve. Both LAI and AIA SMC are focusing on this area at this time.

5.2.8. The Role of the Government Agencies

Although mentioned in the surveys, the site visits revealed a mixed view of the role of the government.

In certain cases, with Rockwell Collins as an example, very cooperative working relations with the DCMA and with other government agencies resulted in mutually agreeable outcomes of issues such as changes in time keeping, inspection methods. Both parties shared the same view of how their collective actions could benefit Lean initiatives despite previously tightly held positions.

In other cases, Lean engaged companies felt that the government was quick to roll up projected gains in cost and cycle time into program readjustments and forward pricing rates. A need for even handedness was expressed with reasonable time and effort

allocated for initiative verification and validation. This was particularly the case for large, limited items such as satellites or shipyard products.
Some suppliers experienced serious product buy-off delays and extended cycle time due to lack of timely government presence for these functions or personnel unfamiliar with the assigned duties. Particularly subject to such problems are the suppliers with $20-50 million in revenue and where certain Source Inspection Requirements had been specified by the contracting officer or prime contractor. This is a serious image issue these suppliers need to explain to their workforce in the midst of their Lean initiative efforts.

Suggestions such as destination inspection or even no inspection for highly rated suppliers were suggested in lieu of the imposed source inspection requirement.
A supplier used the expression "a rising tide lifts all boats": every organization associated with the industry has to recognize and perform their part in order to create a Lean A&D industry, including the government agencies involved.

5.2.9. Lean Best Practices: the next step

The gains on an individual company of a successful transformation to Lean enterprise are so significant that its translation to the industry as a whole would represent major savings to the acquisition of systems and to the industry's agility to respond to uncertain and unpredictable threats.
During this industry team's assessment process numerous Best Practices were noted, from material presented as well as the responses to the survey. It is recognized that a Best Practice at one company with its unique culture and organization structure may not be a Best Practice at a quite different company with its version of unique culture. However, it is felt that these circumstances occur at the margin of most companies' operations and that there are valuable guides to Best Practices as well as the benefit data from their implementation. In most cases the actual implementation process is the most valuable information. The team suggests that a "Transition to Lean Best Practices" akin to the "Transition from Development to Production"[21] would be an important contribution to sustaining momentum across the industry as a whole.

5.3. Overall view of the LAI contribution and influence

The Lean Aerospace Initiative has been very influential in providing a framework for assessing the degree of Lean in a company and a high level methodology for implementing Lean Programs. To quote a senior manager from Boeing:

- *"Before LAI we were throwing darts".*
- *"LAI gave us structure. Now that we have the structure, we are more tied into the enterprise".*

[21] led at the time by Mr. Will Willoughby of Navair and supported on the civil side by Mr. Joe Shea of Raytheon Corporate

- *"We knew we were doing good things, did not see improvements into the bottom line. Now we see improvements in the bottom line".*
- *"Value stream mapping can show improvement in the bottom line".*
- *"Unit costs and defects have positive trends".*
- *"AIW scenarios: good educational value".*

In the surveys we conducted of major prime contractors like Boeing and Lockheed Martin, we found that the companies looked at the LAI methodology carefully. Then, based on it as well as their own experience, developed their own assessment methodologies and implementation programs.
The prime contractors in particular also developed a framework for Lean Assessment and Lean Implementation, which they are communicating to their supply chain. The degree of penetration in the supply chain is not uniform as noted earlier More attention and consistent, detailed methodologies and templates are needed, particularly for the lower tiers.

6. Summary of Best Practices

- Determine which enterprise processes are strategic. Then use Lean methodologies, Kaizen events, Master Kaizen –value stream analysis– to take an introspective look at streamlining these processes. This step should proceed as much as possible in parallel with any enterprise system implementation.

- Continue continuous improvement of the processes in a systematic way across the company. In particular embed value streamed processes in a robust enterprise IT system; use the savings to advance Lean initiatives. Establish goals for improvement for each managing unit and measure achievements on a regular basis, again emphasizing the functionality of enterprise systems, especially integrated systems, to produce the real time process performance against pre-established metrics.

- For most companies it is important to have a Lean Program managed from corporate with a network of Lean focus points throughout the organization. This program can then use the readily available metrics described above and recommend an appropriate new system or fine tune one already in place. Use this system to manage the continuous thrust towards a Lean organization.

- For smaller organizations, the Kaizen and six sigma methodologies can be applied and enterprise systems selected to fit the need and budget of such companies.

- Ingenuity, initiative and imagination should be encouraged. An example of such is the mixed mode manufacturing system implementation of Lockheed Martin Space Systems.

- Provide companies in the second tier of the supply chain with tools to implement Lean. Note that there are excellent consulting companies and individual consultants that provide such a service to the second tier. In turn, the second tier can assist their lower level suppliers in a similar manner.

- Work with the government, particularly the DCMA, to streamline processes for quality and contract administration for suppliers in particular.

- For major systems implementations, one must carefully consider the survivability of legacy systems. There are two extremes:

  1. Abandon essentially all legacy systems and replace with a COTS software package.
  This approach provides a Lean slate and integrated COTS system. Examples of this approach are found at Lockheed Martin Commercial Space Systems, at Raytheon Aircraft and Rockwell Collins The disadvantages are the higher initial risk, the potentially high cultural shock and the possible loss of valuable functionality if not done properly. This approach is most suitable for Greenfield environments or for situations where the legacy systems are so obsolete that they need essentially complete replacement. .
  2. Select a "best of breed" approach, where selected legacy systems may be kept or individually replaced, and optimal solutions for different functions are selected.
  This approach has the advantage of being less severe, and allows the preservation of some favorite functionality. The selection of "best of breed" solutions provides enhanced point solutions and a more gradual transition, somewhat minimizing cultural shock. The disadvantages are longer implementation time and considerable risk and cost in the integration of all these solutions. This approach has been selected in most of Boeing IDS and Lockheed Martin Aeronautics.

  In both approaches the work of the Lean Program should provide the foundation of processes to be used in the new system. Implementation of an enterprise system is essential to provide a backbone to the Lean programs and institutionalize Lean processes

7. Conclusions and Recommendations

7.1. Conclusions

1. Significant value and benefits to the US Aerospace and Defense Community have been derived by the major contractors' implementation of Lean Principles, Practices, tools and techniques. These efforts were primarily aimed at enhancing their competitive position in the market place. The Lean Aerospace Initiative has been very influential in providing a framework for assessing the degree of Lean in a company and a high level methodology for implementing Lean Programs. "LAI gave us structure. Now that we have the structure, we are more tied into the enterprise". Because the LESAT methodology is relatively high level it is mainly used for strategic and "gap" assessment purposes. For more in depth purposes, most contractors have developed their own assessment methodology to be used for detailed implementation initiatives. However, the influence of LAI enables these methodologies to tie into the enterprise.

2. The low level of Lean implementation with the supply chain seriously degrades the overall positive industry impact of Lean implementation by major companies.

3. Suppliers, in general, have little direction or guidance on Lean values and benefits except from selected program or divisions of major companies: support or encouragement from government agencies involved is limited. The prime contractors all have Lean educational programs and initiatives aiming at helping the supply chain to become Lean. Many of these programs are excellent but the penetration to the all levels of the supply chain is still incomplete. A more detailed methodology, available in the market, would enable lower tier suppliers to initiate quantitative Lean Assessments and develop effective Lean Programs and strategies.

4. The LAI has been a positive factor in Lean sustainment with its focus on enterprise integration framework, assessment and guidance resources.

5. The AIA and its Supplier Management Council has provided aggressive crucial support, guidance and access to low cost US Lean resources to bolster the Transformation to Lean journey of suppliers to this industry.

6. US government agencies, both at the DCMA and Program level need to present a more proactive supportive environment to the A&D industry, particularly components that constitute the supply chain.

7. Successful Lean implementations are characterized by leaderships recognition of the crucial role of cultural change, workforce involvement and strategic application of enterprise IT systems.

8. Government cost estimation algorithms and systems need reconsideration and probable adjustment to reflect the major cost and cycle time benefits accruing from companies successful Transformation to Lean to avoid disqualifying quotations featuring low cost and short development cycles.

9. Best Practices observed represent an invaluable industry inventory, which should be exploited.

10. Kaizen and Six Sigma process events are the primary means to Lean Implementation. In general they do not encompass the enterprise strategy, vision and priority, and do not explain on their own the level of benefits the successful Lean implementers have achieved.

11. Effective implementations of enterprise systems (ERP and PDM) can take advantage of the Kaizen work done to generate effective processes. They can then provide a backbone to support the Lean Enterprise as well as the metrics needed to manage the Lean Program. For any reasonably large company, enterprise systems are essential to support and enable and institutionalize effective Lean Programs.

7.2. Recommendations

1. **The highest management level in the contractor's organization should sponsor Transformation-to-Lean Programs. The DCMA representatives should be included in the planning and support of the Lean Program.**

2. **Since Change Management and cultural change are key to success of Lean Programs this aspect of the work needs to be given the highest priority by all organizations, institutions and government agencies.**

3. **The DCMA should review its policies, practices, guidance and support to Transformation to Lean initiatives of the industry to provide consistency, uniformity, and evaluation of company Lean proposal projects, required system descriptions and forward pricing. DCMA components should perform a value stream analysis on their own processes to insure that they are in step and support the Lean processes of the contractor.**

4. **DoD and supporting government agencies and supply chain customers should review the requirements for source and destination inspection and validation actions for demonstrated high quality suppliers.**

5. **The AIA and its SMC should receive strong government support and involvement in their supply chain improvement initiatives.**

6. **A&D companies should review their use of IT systems so that they embed the value stream analysis in their IT systems to sustain the gains derived from their Lean Transformation.**

7. **Implementation of IT systems should follow best practices such as those described in this report.**

8. **"Crosstalk" association member companies should participate in a collection, synthesis and communication of enterprise Lean Best Practices as continuing their focus on the industries "Transformation to Lean".**

8.

Glossary

A&D:	Aerospace and Defense
AIA:	Aerospace Industry Association
AIW:	Accelerated Work Improvement (Boeing IDS)
BAC:	Boeing Aircraft Commercial
BEST:	Boeing Enterprise Supply Tool
BOM:	Bill of Material
CAD:	Computer Assisted Design
CAE:	Computer Assisted Engineering
CAM:	Computer Assisted Manufacturing
CBO:	Consumption Based Orders
COTS:	Commercial Off-The-Shelf
DARPA:	Defense Advanced Research Projects Agency
DCAA:	Defense Contract Audit Agency
DCMA:	Defense Contract Management Agency
DoD:	Department of Defense
EIA:	Electronic Industry Alliance
ERP:	Enterprise Resource Planning
GEIA:	Government Electronics and Information Technology association
IDS:	Integrated Defense Systems
IPT:	Integrated Product Teams
IT:	Information Technology
JDAM:	Joint Direct Attack Munitions
LAI:	Lean Aerospace Initiative
LEM:	Lean Enterprise Model
LESAT:	Lean Enterprise Self-Assessment Tool
LGT:	Lean Guidance Team (Northrop Grumman)
LMA:	Lean Manufacturing Assessment (Boeing IDS)
LMCSS:	Lockheed Martin Commercial Space Systems
M&S:	Modeling and Simulation
M^3:	Mixed Mode Manufacturing
MIT:	Massachusetts Institute of Technology
MRP II:	Manufacturing Resource Planning II
NDIA:	National Defense Industry Association
NIST MEP:	National Institute of Standards & Technology Management Education Program
PDM:	Product Data Management
POC:	Point of Contact
SMC:	Supplier Management Council
SMIT:	Supply Management Integrated Teams
TBM:	Time Based Management
TPS:	Toyota Production System
TTL:	Transition to Lean

USAF: United States Air Force
WDS: Western Data Systems, Inc.
WIP: Work In Process

A.

APPENDIX A

A.1. Industry Assessment Team

The industry Association team members who were assigned to this DCMA Action Request by their respective associations are listed below by their respective Association Points of Contact for the Crosstalk Coalition:

Association Points of Contact:

- Government Electronics and Information Technology Association, GEIA (A Segment of the Electronic Industry Alliance, EIA)
- Mr. Dan Heinemeier, President, GEIA
- Aerospace Industries Association, AIA
- Mr. William Lewandowski, Vice President, AIA Supplier Management Council
- National industrial Defense Association, NDIA
- Ms. Ruth Franklin, CODSIA Officer

Assessment team:

- Appointed by the GEIA, Mr. Thomas E. Shaw, Chair of the Industry Association Lean Assessment Team
- Appointed by the NDIA, Mr. Walter Berkey, Lockheed Martin Company
- Appointed by the AIA, Ms. Kimberly Eakins Largent, Honeywell

Members Added by the Chair:

- Mr. Alec Lengyel, Executive Manufacturing and Technology Consultant, GEIA
- Mr. Dan Silva, Accenture, GEIA Member Company

- Added by the LAI for Site Visitations and Report Assistance, Mr. Gregoire Ferre, MIT Research Assistant, IT and Lean

A.2. Survey Questionnaire

Survey of US Aerospace and Defense Industry Lean Aerospace Initiative (LAI) Practices Implementation

Background: For approximately the past decade MIT has led a consortium of US Aerospace and Defense firms, Government Agencies and unions in a major research effort to apply the lessons learned and results of the Toyota Production System (TPS) to the US aerospace industry.

This effort has resulted in numerous projects, the results of which have been documented in several significant reports. Such include the overall meta principals and 12 practices that summarize the findings of the program, a "Transformation to Lean" Roadmap, a Lean Enterprise Self-Assessment Tool with instructional documents for its application, a beta test of 10 companies using this tool in a joint venture with the UK equivalent consortium and finally, a book consolidating all of these findings and actions scheduled for release in March 2002, published by Palgraves Publishing. More information about the MIT Lean Aerospace Initiative (LAI) may be found on the LAI web site at http://web.mit.edu/lean.

Unfortunately, there has been a substantial amount of anecdotal discussion about the extent of Lean Practices penetrating the US Aerospace industry and its benefit to both the companies involved and the ultimate recipient of these benefits, the US Department of Defense and associated agencies such as NASA etc. This situation has led to one government agency, the Defense Contract Management Agency (DCMA) and its Commander, General Edward Harrington, to raise this issue during a discussion of Acquisition Reform topics at his latest DCMA/DCAA/Industry Association (GEIA/EIA, Government Electronics and Information Technology/Electronic Industries Alliance; AIA, Aerospace Industries Association; and NDIA, National Defense Industrial Association) "Crosstalk" meeting. As a result of the ensuing discussion the above Industry Association was asked to conduct an assessment of the extent of lean practices implementation with the Aerospace industry, including both prime contractors and the industry suppliers and what had been learned from their lean implementation initiatives. Of particular importance from the suppliers' viewpoint were issues that they confronted in their relations with prime contractors and the government. In addition to the above what has been learned from both those that are currently part of the formal LAI consortium and those not a member of the LAI, especially the supplier network.

Because of the increasing importance of both applications and IT software, companies that are part of or support the Aerospace industry and that are members of the above Associations were considered an important element in this assessment and are being solicited for their response to this survey. In general such entities are not a part of the

current LAI and this assessment is to include those as well as traditional discrete manufacturing and engineer-to -order companies.

Thomas E. Shaw, of Accenture, Chair of the GEIA (Government Electronics and Information Technology Association, the government component of the Electronic Industries Alliance), Systems, Standards and Technology Council was assigned to chair this investigation.

To carry out this investigation representatives from the Industry Associations noted above have provided representatives, including members from Lockheed Martin, Honeywell, BAE, SAP and Accenture. This assessment is due to be reported out at the next DCMA "Crosstalk" meeting scheduled for April 29, 2002 at DCMA facilities.

An earlier project to determine the Industry Associations view of the value of the LESAT to a typical government agency, in this case the DCMA had been completed and transmitted to the DCMA. A summary of the team's findings and recommendations are available upon request of this project's chair.

The survey approach has been decided as the mechanism to gain a preliminary assessment of the extent of lean within this industry to be followed up by selected in-depth interviews to validate the survey results and obtain a more in depth understanding of that company's Lean status and ongoing activities. This survey should be considered as an effort to assess the overall enterprise or company approach to Lean and its benefits rather than focusing specifically on the LAI Construct and case examples as has been much of the effort of the LAI Consortium.

It should be noted that several other components of the Aerospace industry are addressing the issue of lean. Key among these is that of the AIA Supplier Management Council led by Mr. Bill Lewandowski, Vice President, Supplier Management Council. Members of the AIA Supplier Management Council (SMC) have included their set of questions of key interest to their members as a component of this survey. Their survey questions of Section 2 will help the AIA focus the meeting that will take on March 21, 2002. It is particularly important to those responding to the survey request that Section 2 be given first priority in your response since this input will be of great value to the above noted meeting on March 21; the Section 1 response can follow.

The team is well aware that this survey is being sent to those companies that are members of the LAI Consortium and that their efforts are documented and part of the Consortiums intellectual database, as noted above.

Since the objective of this effort is an overall assessment of the extent of Lean Practices penetration within the industry rather than an in-depth examination of the particular company's efforts and is an attempt to provide a level of consistency between the

diverse companies of this industry it was decided to include these member companies as well.

THE SURVEY INSTRUMENT:

The concept here is to avoid a lengthy and extremely detailed instrument such as the Baldridge Quality Assessment but to provide a set of very specific, enterprise level types of questions that the company lead POC (Point of Contact) for Lean or the appropriate company executive can respond to in a limited time frame. The follow up of meeting with selected companies would be key to insuring that the team has interpreted their response properly and driving out specific status or initiatives that they are willing to share with the team; however, an overall status is needed to provide the assessment requested by the DCMA. It is important to emphasize that this project is an industry driven one and is not guided by either the MIT Consortium or the DCMA or any other government agency.

The current survey is a set of 25 questions divided into two Sections. Section 1 is for overall enterprise/company Lean assessment; Section 2 focuses specifically on supply chain issues. For clarification or other information please email them to the chair, Thomas E. Shaw, email tedwinshaw@aol.com or call at (617) 489 7128. Please note the priority placed on Section 2, Supply Chain issues.

Because certain companies may wish to maintain their response as Confidential all correspondence should be returned to the Chair through the above contact information or mailed to the Chair, 30 Winter Street, Belmont, MA 02478. All responses classified as Company confidential will be segregated and only analyzed by the Chair.

All responses are requested to be returned by COB March 15, 2002.

Survey Section 1

1) Is your Corporation/Company/Division/Business area a member of the MIT LAI Consortium; if so, for how many years; please identify the specific component(s) by providing the formal address and relevant contact information and either the current assigned Lean Executive responsible for your Lean initiatives or that person charged with responding to this survey and being our industry Team formal contact.

2) Summarize the primary products and services of this entity or what web site address can provide this information

3) Has your entity utilized the MIT LAI LESAT (Lean Enterprise Self-Assessment Tool) officially as part of the consortiums Beta test program or unofficially to assess your current state of Lean?

4) If so, what was your overall rating and your assessment of its usefulness in assessing your company's state of "Lean"

5) Does your entity plan to use the LAI "Transformation to Lean" roadmap as its primary guide to achieve its Lean objectives and if not, does it have a strategic vision of how lean practices, principals etc. will be integrated into and support the overall strategic vision, goals and objectives; if so, please summarize this relationship and the expected time frame over which these actions will be taken and their expected specific benefits as defined below and the metrics by which their achievement will be monitored and reported

a) Improve profitability by reduction of all key process cycle times, redundancy of systems, increase of inventory turns, etc.

b) Improve quality of product and services

c) Sensitize the entire organization to principals and practices of the Lean paradigm

d) Educate and train all staff in principals and practices of Lean

e) Organize lean projects for individual persons, team or units to implement

6) What specific Lean projects do you have underway; please identify, describe and summarize the specific value expected from each project and the metrics by which their achievement is monitored

7) What is your estimate of the percentage of implemented lean processes/operations to the total number of lean characterized processes of the entity. This is the key question of the survey and may be answered by one or more of the following methods

a) In a Life-Cycle Engineer to Order, complex product discrete manufacturing entity. There are approximately 325 to 350 significant processes; our interest is in how pervasive the lean initiatives are in these operations. Some anecdotal numbers indicate only 5% of industry has adopted and institutionalized lean practices. We are trying to be as specific as possible by basing penetration on number of lean processes as a percent of total processes. If you have analyzed such processes and completed a lean initiative for such than the percent lean implementation would be the based on those implemented to a lean mode divided by the total number of enterprise processes. We would also like to know how many others might be planned for lean implementation and which you consider having the greatest leverage for bottom line or other benefit to your organization.

b) Another approach to this issue is what percent of the Life cycle high level processes are lean or percentage of that process is lean, e.g., such high level process include Concept Definition, Concept Development, Manufacturing, Distribution, Logistics and Support. Using your cost of these operations, as a benchmark for calculation than those, which are considered lean (and their costs) can be ratioed by overall operations cost

c) A "ROM" estimate based on overall knowledge of the your overall Lean implementation plan and its progress to date.

8) What research or resources did you utilize or plan to utilize to identify/select and prioritize your lean projects, i.e., MIT LAI results, and literature review, other

9) What KPIs (Key Performance Metrics) and or metrics has your entity selected as standards to quantify the gains/benefits derived from implemented lean initiatives/projects? These may be the same as requested in Question 6; if so simply indicate such is the case. These are metrics assigned to specific on-going or completed projects. Please note that these are metrics assigned to specific projects where question 7 deals with the enterprise as an entity.

10) If you have lean projects underway what percent are based upon, or use IT systems such as CAE, CAD, CAM, CRM (Customer Relationship Management), PDM, ERP, B2B or the Web as a major factor in achieving the level of leanness planned

11) Of lean initiatives projects implemented or planned what level of supervision/management is assigned responsibility for their accomplishment and continuing success

12) Do you visualize the Lean Initiative to be a long term undertaking or a short term, short cycle response to the current view of industry and government

13) For lean projects planned or underway in what manner are local government representatives involved; please describe, i.e., IPD teams, other

14) In your view should local government representatives be involved and if so, in what role(s)

15) What contractual issues or barriers have you encountered or anticipate in your implementation of lean practices, i.e.,

a) contracts with customers, e.g., sharing of benefits/cost savings

b) contracts with government customers, e.g., overhead negotiations, cost benefits allocation, etc.

16) What internal cultural issues or barriers have been encountered as your lean practices significantly change previous processes

a) executive level resistance

b) middle management resistance

c) operating level resistance

17) What actions has your organization taken to counter internal resistance to lean practices implementation and use; please summarize actions and observed results

18) What external issues have been encountered in your transformation to lean, e.g., lack of customer understanding of lean or willingness to partner on lean implementation actions?

19) Do you conduct or implement your lean initiatives under a specific company named program title or campaign that essentially is a Lean initiative; if so, what is its title and in what way does it differ from the MIT defined Lean program as best you understand it.

20) Has your entity previously responded to or answered a "Lean" type of survey or request for Lean information; if so, would you share a copy of your response with our team and the specific contact for this information

Section 2: The Lean Program and Your Suppliers

1) Do you encourage suppliers to have Lean Programs in their facilities?

2) If yes, how do you communicate this to your suppliers? (You can check more than one)

___As part of the subcontract/purchase order;

___As a requirement in your supplier rating system;

___As part of being in one of your preferred supplier programs;

___As part of customer-supplier workshops on Lean;

___Other (Explain)

3) What do you communicate to your suppliers as your requirements for their Lean Program? (You can check more than one)

___No requirement;

___MIT material on Lean;

___Your own material on Lean;

___6 sigma material;

___Other (Explain)

4) How do you assess supplier's successful compliance with your criteria for having a satisfactory Lean Program? (You can check more than one)

___No assessment;

___On-site review and discussion;

___Supplier submitting material and data for your review;

___Customer-supplier workshops;

___Other (Explain)

5) Please name the person in your company that leads your SUPPLIER Lean Program:

Name_____

Phone_____

Fax_____

Email_____

A.3. Crosstalk Briefing of April 27, 2002

Assessment of Degree of Aerospace and Defense Industry Implementation of Lean Principles and Practices

Thomas E. Shaw
Chair, SSTC, Government
Electronics and Information
Technology Association
(an EIA Sector)

William Lewandowski
Vice President,
Supplier Management Council
Aerospace Industries Association

DCMA/DCAA/ Industry Crosstalk
DCMA Headquarters
Springfield, VA
April 29, 2002

1

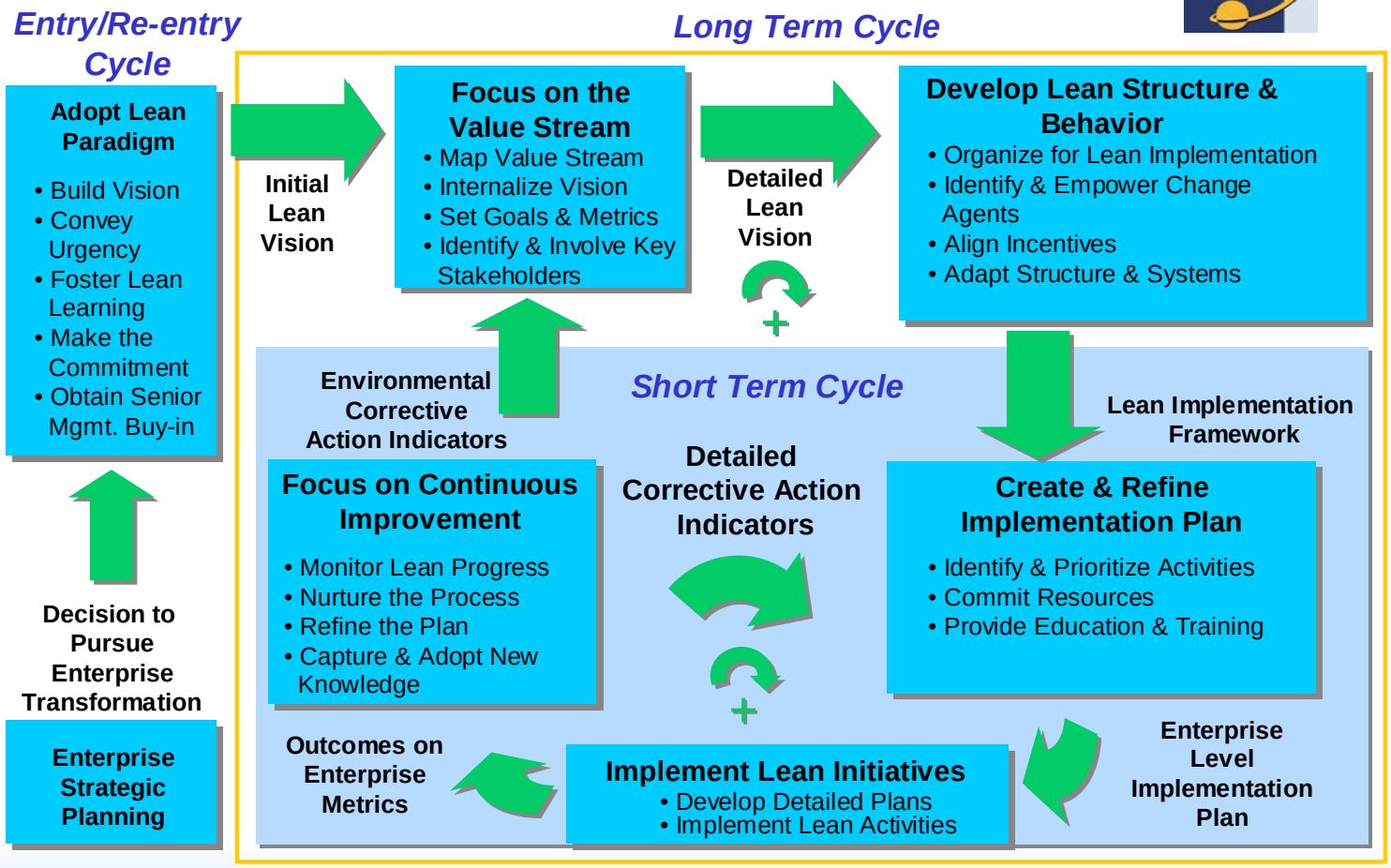
Agenda

- Objective of Assessment
- Approach
- Methodology
- Key Survey Questions
- Findings to Date
- Supplier Relationships, Findings and Issues
- Conclusions and Recommendations

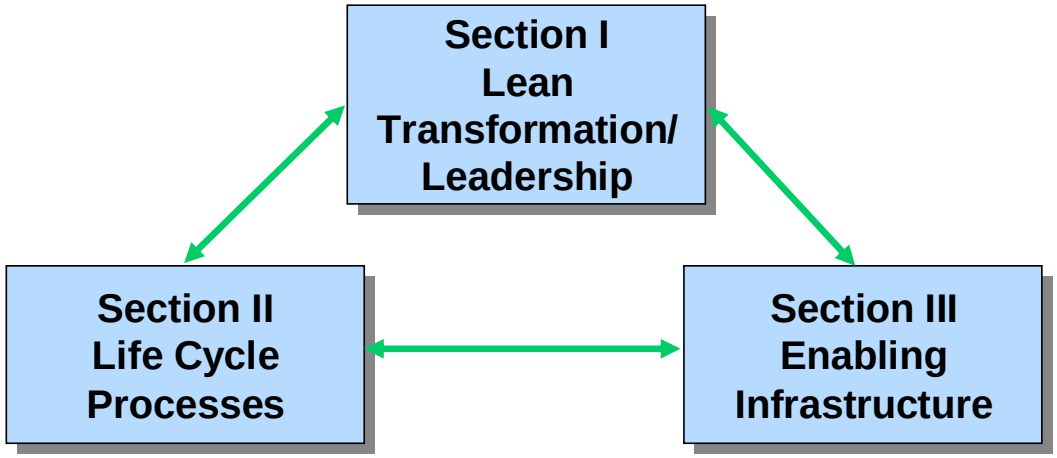
Approach to Assessment Based on Content and Scope of Lean Transformation Process and Lean Enterprise Self-Assessment Tool (LESAT)

- Lean Transformation Process Summarized in Lean Transformation Roadmap
- LESAT Provided Basis for Scope of Companies Involved
- Industry Association Member Companies Provided Team Members and Classes of Companies Defined by LESAT Scope (Team Included LMCO, BAE, Honeywell, SAP, Accenture)
- Survey Instrument Selected as Primary Basis for Assessment

Lean Transformation Roadmap



Structure of LESAT Assessment Matrices (The Overarching Organizing Structure)



Lean Transformation/Leadership - the process 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

Enabling Infrastructure - the processes that provide and manage the resources enabling enterprise operations

5

Lean Transformation/Leadership (Transformation to Lean Links)

- Enterprise Strategic Planning
- Adopt Lean Paradigm
- Focus on the Value Stream
- Develop Lean Structure and Behavior
- Create and Refine Transformation Plan
- Implement Lean Initiatives
- Focus on Continuous Improvement

Life-Cycle Processes (Transformation to Lean Links)

- Business Acquisition and Program Management
- Requirements Definition
- Develop Products and Process
- Manage Supply Chain
- Produce Product
- Distribute and Service Product

Enabling Infrastructure (Transformation to Lean Links)

- Lean Organizational Enablers
- Lean Process Enablers

LESAT Assessment Example

Enterprise Strategic Planning (the Decision to Pursue a Lean Transformational Strategy)

Diagnostic Questions

- Are enterprise leaders familiar with competitive gain from Lean?
- Has a suitable strategy for growth been identified to utilize resources freed up by improvements?
- Has full leverage of the extended enterprise stakeholders been incorporated into the strategic plan?

Lean Practices

- Integration of Lean in strategic planning process
- Focus on customer value
- Leveraging the extended enterprise

Typical Indicators

- Lean implementation is included explicitly in the enterprise strategic plan
- Enterprise employs a formal process for determining customer value
- Risk and responsibilities are apportioned when leveraging the extended enterprise suppliers and partners

LESAT Assessment Example

Lean Organizational Enablers

Must be redefined such that they support lean implementation

Diagnostic Questions

- Are the information technology systems compatible with stakeholder communication and analysis needs?
- Can stakeholders retrieve financial information as required?
- Do finance and accounting measures support lean implementation?

Lean Practices

- Enabling the lean enterprise with information systems and tools
- Promulgate the learning organization

Typical Indicators

- Compatible information systems and tools exist across the extended enterprise
- Information systems facilitate fast and effective transfer and retrieval of information required
- Information systems and tools complement lean processes and practices and are easily adapted to accommodate change

LESAT Assessment Example (Cont'd)

Enterprise Strategic Planning

Lean Practice - Integration of Lean in Strategic Planning Process

Level 1 - Concepts and benefits of lean principles and practices are not evident in culture or business plans

Level 3 - The growth implications of lean are understood and lean implementation plans are formulated, but not integrated, into the strategic plan

Level 5 - Strategic plans leverage the results of lean implementation to achieve growth, profitability and market position

Survey Instrument Focused on Quantitative Implementation Status and Supply Chain Relationship

- Assessment Results Highly Dependent Upon "Implementation" Model(s)
- Supplier Relationships and Involvement in Lean Aerospace Initiative Key to A and D Industry Widespread Adoption
- Benefits of Implementation also Addressed
- Survey Composed of 25 Questions (5 Address Supplier Relationships)

Classes of Industry Association Member Companies in Survey Encompass Scope of Transformation to Lean

- Prime Contractors; Lockheed Martin, Boeing, etc. (Many Already Members of LAI Coalition)
- Avionics and Electronics; Rockwell Collins, Honeywell, etc.
- IT System Developers and Implementors; Oracle, SAP, Accenture, etc.
- Specialty Suppliers; Harris, Mentor Graphics, etc.

Implementation Assessment Models Considered for Survey

Quantitative Implementation Methodologies

1. Percent of enterprise major processes converted to “lean” state (derive from PDM, ERP implementation process)
2. Percent of typical product/system life cycle processes converted to lean (concept definition to distribution, logistics)
3. Percent of industry suppliers converted to lean practices and their contributed value to prime contractors
4. Percent of workforce/staff trained and proficient in lean practices
5. Percent of organization components converted to lean practices

U.S. Aerospace and Defense Industry Lean Implementation Assessment Survey Key Question Example

Question:

What Is Your Estimate of the Percentage of Implemented Lean Processes/Operations to the Total Number of Lean Characterized Processes of the Entity? This Is the Key Question of the Survey and May Be Answered by One or More of the Following Methods.

A) Enterprise Major Processes Lean Ratioed to Enterprise Major Processes Total (for Typical ETO Discrete Manufacturing Entity this Ranges From 325 to 350)

B) Percent of High Level Life-cycle Processes, i.e., Concept Definition, Development, Manufacturing, etc. Transformed to Lean

C) An "ROI" Estimate Based on Overall Knowledge of Your Lean Implementation Plan and Process to Date

US Aerospace and Defense Industry Lean Implementation Assessment - Findings to Date

Results to Date

- LESAT (particularly section 1) is key first process step to initial transformation to lean (over 95% of activities, questions, and indicators relevant to government and industry)
- LESAT utilized as a strategic tool
- Transformation to lean roadmap generally customized to each company/organization strategic need
- Most prime contractors have a “lean certification” program, consisting of multiple levels of proficiency
- Maximum level of lean implementation (measured as a percentage of work force trained) at prime contractors in 50 - 60% range, supply network at 5 - 10%
- Based on ratio of supplier to prime contributed value (60% supplier, 40% prime), it is estimated that US A&D Industry level of lean implementation ranges between 25 and 30 percent

US Aerospace and Defense Supplier Industry Lean Implementation Assessment

Supply Chain Target Audience

- AIA Supplier Management Council
  - 180 Members (Small Shops to Large Divisions of Corporations, i.e. Pratt & Whitney at UTC)
  - Most Suppliers to Both Commercial and Defense Industry
  - Most Do Not Have Resources to Commit Full Time Director or Manager of Lean and Lean Relationships
  - Some Exceptional Commitments to Lean, Some Becoming Aware From Their Customers, Some From Their Peers

WORKSHOP ON SUPPLIER "LEAN"

- AIA Member company presentations to
  - Each other
  - Suppliers
- Questions answered by presentations
  - How do you communicate?
  - To whom do you communicate?
  - What requirements do you communicate?
  - How do you assess?

Participants

- AIA Members
  - Boeing
  - Lockheed Martin
  - Raytheon
  - UTC
  - Northrop Grumman
  - Hamilton Sundstrand
  - Pratt&Whitney
- Suppliers
  - Marion Composites
  - Avionics Specialties
  - Cohesia
  - Ferco Tech
  - Sechan Electronics
  - Sypris Electronics
  - Tru Circle

US Aerospace and Defense Supplier Industry Lean Implementation Assessment (Cont'd)

Exceptional Suppliers Committed to Lean (Examples)

- Spectra Lux (Avionics) - Kirkland, Washington
- DynaBil Industries, Inc. (Mechanical Components)
  - Coxsackie, New York

Transformation to Lean Process Through Primes

- Few identified by Program Offices
- Help provided (Workshops,Inplant support)

20

US Aerospace and Defense Supplier Industry Lean Implementation Assessment (Cont'd)

Issues

- No support for standard approach
- No Reciprocity Among Companies or Company Divisions or Business Areas
- Limited support for general supply base, yet want every supplier to be "lean"
- Some suppliers view: distrust of customer intentions, way of cutting personnel

AIA Action

- Creation of Lean Master Classes to convince associate members to establish a "lean" program and to lead them to sources on how to develop a program

PURPOSE

- Master classes part of the SMC Initiative
  - "Creative Collaborations"
- Identify important areas for associate members future business planning
  - Advanced Quality
  - "Lean"
  - Electronic Business
  - Negotiation of subcontract terms and conditions
- Present insights in each identified area by the experts to guide the planning process

SCHEDULE

- April 2002- Develop master classes curricula including content, speakers, and duration
- May-Sept 2002- Plan and prepare for master classes
- Oct 2002- Associate members attend first master classes at Fall SMC Meeting
  - Duration Goal: No more than 11/2 days

23

US Aerospace and Defense Supplier Industry Lean Implementation Assessment (Cont'd)

Overall

- Approximately 5-10 Percent of Supplier Industry Involved in Various Phases of Lean (Awareness to Full Company Implementations)
- Most Prime Contractors Have Supplier Relationship Contacts and Extensive Support for Few Suppliers;
- Lack of Industry "Standard" Approach to Lean, and of Responsibility for General Supply Base Limiting Implementation
- Master Class with Outstanding Support from AIA Member Companies Helps Implementation

Lean Aerospace Initiative and its Level of US A&D Industry Implementation

Conclusions

- LESAT is a valuable tool for both strategic and operational improvement of all company/agency processes
- The transformation to lean roadmap provides a excellent baseline for the lean journey
- The supplier network is key to expanding the value of the LAI to US industry; current flow down from primes to suppliers predominately on program only basis
- The lean evolution is moving from the manufacturing domain to the extended enterprise and to a “lean industry”

US Aerospace and Defense Industry Lean Implementation Assessment - Recommendations

1. A Formal Report on This Action Item Be Prepared and Provided to Industry and Government
2. Immediate Attention Should Be Focused on a More Consistent and Standard Relationship Between Prime Contractors and Suppliers
3. Best Practices and Specific Meaningful “Lean Implementation” Examples Should Be Emphasized Via Mechanism Similar to Willoughby Transition to Production and Best Practices Templates and Practices

A.4. Selected reports of site visits/survey responses

A.4.1. Rockwell Collins

Rockwell Collins created from these tools a Lean Certification program to sensitize its organization to Lean Principles and Practices. The program consists of four levels (Associate, Champion, Principal and Master), where Master is consistent with the Six Sigma master black belt program. Most of the 10,000 Rockwell Collins employees have received Lean training and participated in Lean events such as Kaizen and Six Sigma. 60% of their workforce has attained Lean Associate certification, and the company counts over 50 Lean Masters. Each member of the Executive Team has been trained in value stream mapping and analysis.
Based on this large corporate wide exposure and assimilation of Lean, the Rockwell Collins Lean CPO estimates that the company's degree of Lean implementation is approximately 60%.

At the macro level Rockwell Collins is implementing a Core Process Optimization (CPO) program. This program consists of a series of projects/events based upon the five core processes of the company:

- Pursuit and Order Capture
- Strategic and Financial Planning
- Design and Development
- Build
- Service and Support.

The metrics for the CPO are the same metrics employed by the enterprise. They are called the Rockwell Collins Lean Scorecard and consist of the following:

- Superior Customer Value: customer acceptance, on-time delivery, manufacturing cycle time and product development cycle time
- Sustainable and Profitable Growth: sales growth, free cash flow, return on invested capital, earnings per share effectiveness (cost of nonconformance, sales per employee, and capture rate for commercial and government programs)
- Global Leadership: market share for commercial systems and for government systems
- Best Place to Work: safety performance rate, voluntary turnover rate, and best place to work employee survey.

Rockwell Collins focuses on applying all of their Lean background to the office environment, having addressed the manufacturing domain in their initial initiative. In general they use three criteria for insuring appropriateness of Lean events and determining priorities for resources or funding:

- The event ties to their value stream mapping

- The event drives customer value
- The event contributes to their Lean scorecard performance.

To establish strategic priorities, they use the outputs of their CPO process, LESAT assessment scores, and their business planning processes (strategic, financial, operating and Lean plans).

In addition to the company metrics noted earlier, additional metrics are utilized in order to be consistent with certain key customer programs. Those metrics are include product test yields, percentage of customer units repaired in less than 3 days, customer satisfaction/scorecard programs. For example, Boeing Gold, FedEx's Platinum, American Airlines Platinum programs, and the U.S. Coast Guard yearly contract review rating of "Excellent", etc.

A.4.2. Marotta Scientific, August 21, 2003

Executive Summary:

Marotta Controls is a second and third tier company with a niche market in custom valves. Its management has recognized that lean operations are necessary to reduce cycle time and improve quality to sustain and grow its market share. Its successful lean manufacturing activities were accomplished without recourse to the Lean Aerospace Initiative. It is currently looking to apply lean principles to the company functional areas upstream from the manufacturing process.

Company Profile

Marotta Controls Inc. is a 60-year-old Engineer-to-Order complex Value Company with ongoing operations principally located in Montville, with auxiliary activities in Ireland and the UK. The workforce is non-union.

Marotta has revenues of approximately 32 million/year and a reputation for very high quality products and rapid response to customer requirements. Their balanced pressure design is the key to their market position providing higher margins of safety for a given pressure requirement than other valve designs. Earning a steady revenue stream of 12 to 15 million dollars per year coming from the installed base, Marotta makes almost two thirds of its revenue per year on new orders to new requirements. For that reason, Marotta is primarily an engineer to order (ETO) company and relies heavily on its R&D division to maintain their technical and quality leadership.

The main Montville, NJ facility and corporate headquarters employs 155 people and accounts for $28 M. Black contracts account for $2 M (listening devices), and the rest of the revenue comes from Marotta’s Ireland division (Devtec Limited: design,

development and manufacturing of mechanical systems and components for aircraft and launch vehicles such as Ariane), Marotta's UK division that accounts for $1.5-2 M (Polyflex Space Limited: design and manufacturing of high performance pneumatic components for space applications such as thruster valves),

Marotta has "a lot of breadth but not a lot of depth"; they manufacture very different products generally in small quantities. It is a job shop, make-to-order or engineer-to order, and does not produce very many of the same things from month to month.

Mark writes a quarterly email to inform the employees about the status of the company. In terms of involving people in the change, having metrics that brings incentives is very important. All the managers at Marotta are on a compensation incentive program: they have enterprise-wide metrics and job-specific metrics on which they are evaluated and which impacts their salary. Furthermore, bookings, gross margin, quality index and shipments impact every employee's salary and bring incentives to the entire company. The metrics are presented on a quarterly basis, so everybody knows where they stand.

Lean Initiatives

In the early 1990's, non-competitive lead times, degraded quality and uncontrolled costs forced Marotta to undertake a major overhaul of key enterprise processes. Agility is vital, as they never know what the next month of production will look like as every order has its own requirements. Therefore it was difficult to apply the lean cookbook as inspired by Toyota.

A virtually new management team was installed with background in Lean. They brought in Steven Fox as VP of Operations as a change facilitator. They did a lot of reengineering to achieve better cycle time and quality. Marotta used to be a vertically integrated company. They decided to get rid of the non-competitive operations by outsourcing to focus on core values. They could no longer afford making nuts and bolts when others do it cheaper. On a SKU base, more than 50% is outsourced. But there are prerequisites to outsourcing operations. For example the mills must be US based if possible. As a result of that, the supply base expanded, and then contracted again to provide high performance.

They tried to do things smoothly because change did not suit the culture very well: they avoided mentioning too many buzz words such as "lean" as they were not well perceived after the ERP and PDM changes. They focused on redefining responsibilities and ameliorating lead-time, among others. Sacred cows had to be knocked down, while reducing the frustrations of the employees.

Although familiar with the LAI Lean Enterprise Model Principles and Practices, the new team chose the ISO 9001 standards as their baseline for process improvement. Indeed, these standards appeared to be more in reach of their organizations implementation

capability than the LAI templates. Those efforts resulted in reduced standard product average lead-time from 26 to 6-8 weeks, improved quality at initial test, and led to highly responsive customer agility.

The Marotta team acknowledges the value of a DARPA program entitled SCOPE during their supply of valves to Aerojet. Thanks to SCOPE, suppliers were shown the value of program management, and benefited from Lean activities and events. This was an important indicator for Marotta that significant improvement in their processes could be achieved and validated their lean initiatives.

Marotta management also strongly supports the activities and programs of the AIA Supplier Management Council and plans to take greater advantage of their benefits. This industry team feels that Marotta through its currently demonstrated performance is a prime example of the critical item suppliers to the US Aerospace and Defense industry.

Other Business Issues and Concerns

The company also faced CAD/CAM issues: which system should it adopt between ProEngineer, Windchill, Unigraphics and so on. The finally chose ProEngineer[22]. They needed to digitize their product database. They included everything that was active in the last 5 years plus special requests. Software issues and training issues were entwined to make it a delicate problem. Culture changes, internal performance and lead time impact were major issues that had to be addressed.

Since between 25 and 30% of revenue filters through R&D: they are in constant product development. The bills of material can go up to over 100 line items, although 60 to 100 is the normal range. They still struggle with PDM issues. In particular, they would like to have a more seamless flow between engineering and manufacturing. They try to use one enterprise bill of material system.

Discussion topics

Relationship with governmental institutions:

Most of the customer concerns Marotta has are with the Navy. Some of the government related issues are “maddening”.

Marotta is a DCMA inspected organization. Marotta’s management feels the DCMA does not contribute significant value to its operations. The DCMA people are viewed as “individual contractors”, with obscure management, and few metrics to control the work. Sometimes the DCMA agents are perceived to be solely responsible for delivery delays, due primarily to the acceptance at origin issue

[22] Windchill was overlooked because it overlapped too much with the ERP system.

Marotta's management wishes that DCMA would have a better understanding that Marotta has a business to run in order to survive. Since it has demonstrated both high quality and aggressive delivery schedules, it would make more sense to have product acceptance at (customer) destination and to have the DCMA review the internal processes in quarterly visits, similar to the ISO approach.

PDM to ERP:

The engineering bill (E-BOM) and the manufacturing bill (M-BOM) are more or less the same, as the EBOM is loaded into the manufacturing system by formatting into Excel and then transformed into MBOM. However there are lots of coding, relationship issues that are cumbersome and labor intensive. From an engineering point of view, the EBOM is correct, but the Item Master codes and special fields that engineering does not maintain are therefore not populated in a timely and effective manner. They are still trying to cope with making engineering change orders move smoothly through the organization.

.

Lean:

Mark and Steven were at an AME lean class two years ago in Boston. Marotta employs several APICS certified people and one is an APICS certified instructor.

At Marotta, they try to look at the business as a process, so engineering could be a more effective member of the lean enterprise.

Marotta had the opportunity to work with AeroJet at the precise moment the air force gave money to certain companies to foster their supply base performances. Boeing, Aerojet, Raytheon, and Honeywell were given money to implement lean at the 2nd and 3rd tier supplier base and to target lean activities like Kaizen events… The beneficiaries of this project were to monitor, measure and report the impacts of lean on them. At Marotta, they had education on 5S, management training, BMP process, and performed before and after measurements that allowed getting meaningful feedback results This came at a time when they were wrestling with the non production softer areas to bring in lean and eliminate waste in the company. Internal improvement process review was crucial. Marotta is still in the early stages of this effort and barely seeing its fruits

If LAI and its tools (LESAT, LEM) did not exist, these efforts still would have been developed. The truth is that Marotta knows LAI only through its customers, and mainly Aerojet. In fact, besides Aerojet, Marotta's customers do not seem to implement lean. Apart from Aerojet, they don't do lean nor they don't expect lean from Marotta. At Marotta, lean really brought great performances (on time deliveries have been pushed above 90% quarter to quarter, cycle times are down to 6 weeks). Lean and ISO 9001 satisfy internal needs and requirements, and to satisfy customers).

If lean had not existed, Marotta still would have done what they did. But lean provided a tool (how to organize the shop floor). In accord of that is the need for a mindset change. People are much more comfortable with a full inbox; they needed to see that this is exactly the problem!!!

The areas of opportunities for lean are going to be in the softer areas, in engineering, sales marketing and IT especially. The requirements information flow is a critical issue. Everybody still wants their unique paper tools and format. Moving to electronic versions for everything and electronic processes is a way to make the business more efficient. For instance electronic approval of documents via email is much quicker than paper.

Quality:

Quality insurance is a very important issue and has also gone through major modifications as Marotta went to ISO 9001. Kevin Latchford helped set the metrics to find out where the problems really were. In the machine shop they were performing very well but the problems were seen as occurring earlier in the process with ineffective or non timely flow down of the specific customer requirements. It was recognized that everyone working on a project needs to know order status and product configuration in order to insure quality.

They use a gate approach. Because the quantities are small, you cannot invest too much in prototyping, analysis and testing: Marotta is not Chrysler. 2 or 3 pieces may be the maximum quantity produced, so there is a limited analysis of the products. There may be some iteration at that point that might not have been picked up. But questions like realistic schedules and the consequences of inaccurate bills of material are seen as daunting business tradeoff issues.

IPTs:

Marotta uses IPTs, a concept developed as a key point of the process introduced.5 years ago. Marotta tried to have a detailed outline of IPT processes, with standardized steps and a focus on team dynamics, peer reviews and inter-departmental reviews etc… IPTs are multidisciplinary, with primary members that make the core of the team and secondary members that can come and go, depending on their function and the impact of the team. Managers have to go through a class to be able to deal with IPTs and do problem solving, program management. Effective communication was a specific concern. The program management process was standardized to achieve greater efficiency, and bring in lean into engineering. They are pushing more and more up the line to eliminate waste.

B. APPENDICE B: Boeing IDS

B.1. Site report: Boeing IDS St. Louis, May 21, 2003

B.1.1. Executive Summary:

Boeing St. Louis is the Boeing IDS[23] lead organization on the majority of Lean Enterprise Initiatives, with specific emphasis on Engineering, Manufacturing, Supply Chain Development and Enterprise Systems IT architecture and application programs.

Since the early 1990's Boeing St. Louis has undertaken major process improvement initiatives in engineering and manufacturing to significantly reduce aircraft and missile system development cycle time and costs for development and manufacturing. Inspired by DARPA[24] projects and paralleled by the MIT led Lean LAI[25] consortium, IDS formulated Lean principles, frameworks, and best practices to guide their initiatives.

A RAND Corporation paper published in 2001 summarized the state of Lean Manufacturing in the Defense Industry. A comparison between the state described in this paper and the findings we see in 2003 reveals the significant progress made in the last two years by Boeing.

In the early 1990's, however, the St. Louis site was guided primarily by the thinking espoused in Jim Womack's "Lean Thinking" book with its emphasis on the factory floor and the Best Practices of the Toyota Production System. In general, the St. Louis site has used the LAI research and the LEM framework as a means of communicating and prioritizing its efforts to eliminate waste in all elements of its processes, *with outstanding results*.

In the end IDS St Louis developed a results driven Lean philosophy and integrates as much as possible into their culture. In an effort to deploy the Lean principles across the enterprise rather than simply applying it to manufacturing, IDS St Louis is currently integrating engineering, manufacturing and supply chain early in the product development cycle where 80% of the product cost is fixed. Information seems to be at the core of this practice, and impacts directly the engineering practices thanks to a supportive implementation structure and governance.

- The IDS Lean Engineering initiative is particularly impressive, with 12 Lean Engineering Best Practices (somewhat aligned to the LAI LEM Best Practices) representing the core of its engineering "Foundation for Change". The implementation details are considered to be Boeing proprietary, but key attributes of this system include Model Based Definition, Electronic 3D Simulation, Virtual

[23] Integrated Defense Systems
[24] Defense Advanced Research Projects Agency
[25] Lean Aircraft (now Aerospace) Initiative

Design Reviews/Collaborative Engineering and sophisticated use of IPT (Integrated Product Teams), among others.

As a result, Boeing IDS uses 3D Model Based Definition as its core tool/process, serving design reviews and changes, development of manufacturing process plans, resulting in full data-driven IPT decisions. In areas were Lean Engineering has been fully deployed, paper has been essentially eliminated as a communication medium for design definition and has eliminated the need for a hardware mockup with the resulting savings in cost and time.

The practices, centered around information management, problem solving and physical transformations induced impressive cost reductions. For example, cost reductions of over 50%, as compared to legacy practices, have been realized on the F-18E/F ECP 6038 Production Structures Design and on the X-32 Prototype Structures Design. Boeing St. Louis has clearly defined the Lean Best Practices for Engineering, developed a Lean Engineering Assessment tool and process to support deployment and is evolving the Lean Best Practices across all engineering disciplines... These engineering results have been emulated in the manufacturing domain, with equally impressive results for the re-designed C-17 FLE (Fixed Leading Edge) assembly with major reductions in parts and fasteners.

- In Manufacturing, the F-18E/F and C-17 assembly operations operate in both pulsed and moving lines modes depending upon the particular sub-assembly being manufactured. All parts tools and personnel (including appropriate engineering and manufacturing engineers) are located with the assembly stations. Suppliers stock commodity items in specific kanban carts, as required. For the C-17 program much of the gain in manufacturing performance is attributed to a new manufacturing facility laid out by teams of union floor personnel, IE's and Design Engineers.
- Boeing has engaged approximately 5% of IDS' suppliers in Lean activities. However, a significant percentage of the supply base has begun to embrace Lean concepts independently. Boeing wants to ensure Lean is a philosophy embraced by the supply chain since they are responsible for 70% of the product cost. Doing this requires establishing aligned goals, objectives and metrics, appropriate information sharing and common systems and tools. Although Boeing does not charge upfront for training/support or make suppliers commit to a specific cost reduction, they do anticipate (and have received) benefits in terms of lower prices (sometimes meeting cost reduction commitments already agreed to), better delivery performance, etc. This practice contributes not only to Boeing's cost improving effort, but also to the entire industry as competitors also have access to Boeing's suppliers.
- The Boeing IDS Operations Council has developed and deployed a Lean Manufacturing Assessment Tool (LMA), which provides roadmap for transitioning from traditional manufacturing to Lean factory environment. This tool was developed based on comprehensive benchmark of several world class

companies worldwide and refined several times over the past 6 years. This tool has a rating system where the Lean progress of organizations is rated on a scale of 1 to 5. This rating is taken very seriously and influences incentive compensation of managers, etc. in IDS Operations. The rating number represents a badge of honor and goals are set for yearly improvements. This metric has become part of the company's management culture and fiber and is one of the key reasons for continued success of the Lean program

The Boeing St. Louis site performance on cycle time (and resultant cost) is such that traditional cost estimating methods used by both Boeing as well as DoD and other government personnel appear to be obsolete and should be replaced by the results of effective implementation of the new Lean paradigms since this represents the benefit of companies pursuing an aggressive, effective Transformation to Lean initiative. *Government proposal evaluation personnel using the traditional cost estimating parameters and potentially penalizing Lean companies for "unrealistic" cost should not penalize such companies.* Such a recommendation will be submitted as part of the industry report on US A and D industry implementation of Lean and this as a "barrier" to achieving greater affordability through Lean principles and practices.

Little discussion of Boeing St. Louis system IT architecture and the role it plays in the gains realized to date or may be achieved in the future through true real time information flow, mostly due to time constraints.

Since IT has been shown to be a key enabler of Lean, the team would like a follow-up session or description of:

- ***the enterprise IT infrastructure, its extension to suppliers***
- ***the use of real time process information available through the MRP II systems and its interfaced application programs***
- ***Boeing's perspective on improvements in integrated ERP type systems that would significantly benefit this A and D industry.***

B.1.2. Discussion:

Key to Boeing St. Louis outstanding performance is it's commitment to the Boeing Company Lean Core Competency, one of only three stated company core competencies. This has been reflected in the several key mechanisms to both sustain and extend their utilization of Lean Principles and Practices as a key enabler of their competitive position.

- Strong, visible leadership of the Boeing IDS Engineering Council chaired by Thad Sanford and Boeing IDS Operations Council chaired by John Van Gels.
- A vital Boeing IDS Lean Enterprise Program managed by Jim Davis and Jan Martinson focuses on deploying Lean across all enterprise level processes We have seen significant evidence of inter-company communications and cooperation.
- An integrated Lean implementation staff involved in all IDS Boeing Lean activities and actively promotes Lean implementation across the company, both on the military and the commercial sides.
- A consistent set of methods and techniques across the IDS for implementing Lean and close coordination with BCA.
- Lean Engineering (LEAT) and Manufacturing Assessment (LMA) tools/processes, which promote aggressive goal setting and both self-assessment and independent assessment mechanisms.
- An extensive Supplier Development program including a Lean Transformation Template bolstered by Boeing's reputation as a Best Practice company.
- Use of AIW (Accelerated Improvement Work Teams), Value Stream Mapping, 3-P and other Lean techniques to focus specific resources on a priority need.
- We believe a goal setting and measurement process is the key to Boeing's sustained Lean performance and progress. The Boeing Lean Assessment Process (LMA and LEAT) are used to support assessment and goal setting process. It can probably be considered a standard for the industry. The Boeing process, like SEI software development assessment process, and the LESAT, is based on a maximum 5 rating with gradations from 1 to 5 levels based upon specific, demonstrable, metrics and measures. Management, teams and individual performance is assessed against these criteria. Further, it is a non-linear system with each new year's levels significantly more challenging than that of the previous year. The Lean leadership at Corporate, IDS and each Division or Business Area provides both coaching and independent assessment events to insure that the fidelity of the system is maintained. This process has become a part of the Boeing IDS management culture.

Engineering Approach to Lean: The Boeing St. Louis engineering organization approach to Lean emulates the engineering equivalent of manufacturing waste to dramatize ways of recognizing engineering waste and mitigating or eliminating this waste. For example, waste from errors occurring in engineering, scrap or rework of data, waiting for information or data (the value stream is not flowing at all), transport (time spent picking an item up, moving it and putting it down), inventories (warehousing of

data) among several wastes. Applying a familiar manufacturing view of waste helps capture the value of removing it and improving efficiency. In the context of engineering, the "product" is data and improved flow of data is the goal. Engineering influence can be measured across the entire value stream. Simulation and a comprehensive 3D design capability are the center piece of the design product. The complete technical data package, including notes and mall relevant manufacture, quality, test and related support data are contained in the engineering release. For current and future programs the data package is a single all electronic data base release. This includes the product definition to be used by suppliers. As noted in the Executive Summary major reductions in cycle time and cost have been achieved.

Manufacturing Approach to Lean: The manufacturing approach to Lean is that Lean should be part of the culture; i.e., Lean plus Employee Involvement equals success. There are 9 tactics to Lean Manufacturing. These include Value Mapping, Line Balance, Standardized Work, and Visuals in Place, Pulse and Moving lines, to note several. Investments in facility "choke" points such as complex structure drill and fasten processes are alleviated by capital acquisitions. Flexible tooling is stressed. Improvements in manufacturing cycle time such as the outer wing fabrication on the F-18 will be reduced by 50% in 2004 by transition to a pulse line.

Supply Chain Development: Across the Business units of IDS the suppliers make up 70 percent of the final product cost. 80 percent of this cost is paid to 175 suppliers. Boeing utilizes a Preferred Supplier Certification Process to characterize high-performing suppliers. Certified suppliers get additional "perks" including training opportunities, and preferential status in bidding new work depending on certification level – Gold, Silver or Bronze. Program teams identify critical suppliers, and with the Supplier Development function, identify additional investment that will enable improved supplier performance, development plans to reduce waste, participate with AIW teams as appropriate, educate and train in TPM, 5s, six sigma etc..

The Supplier Development organization coordinates Supplier Training Programs for Boeing suppliers in Illinois and Missouri. This training is provided by MEP organizations. Training programs are also being pursued for suppliers within the states of California, Washington and Ohio.

Boeing has set-up a Supplier Management Lean Integration Team (SMLIT) to coordinate tools, materials and approach to Lean deployment across the enterprise.

All activities are conducted to promote a more effective supply base and a more collaborative relationship. This Boeing involvement helps to develop an appropriate atmosphere for negotiated savings that are of benefit to both parties. The burden of the supplier is to show Boeing tangible benefits from this significant Boeing involvement.

Program Management: An innovative JDAM contract was developed for this urgently needed system; it was a "model Acquisition Reform" contract using commercial type contracting with only total contract price for a set number of deliveries on a specific monthly schedule. No/little additional contract data is provided to the government.

The Program Office has developed and applied assessment methodologies, BEST[26], trained suppliers, assessed a representative number of suppliers captured supply chain current status. Assessments are conducted once a moth.

- Results for JDAM:
  - Cycle Time Reduction – 60%
  - Set Up Reduction – 75%
  - Lead Time Reduction – 22%
  - Inventory Reduction – 45%
  - Floor Space Reduction – 27%

Business Systems Support: The business systems used were discussed but not in any depth. It appears that Boeing St. Louis follows a "best of breed" approach similar to that used in Boeing Rotorcraft, with the Manugistics MRP II system providing overall planning and requirements and developing demand systems for manufacturing operations. In a subsequent visit it would be very useful to delve into this area in more depth.

B.1.3. Conclusions:

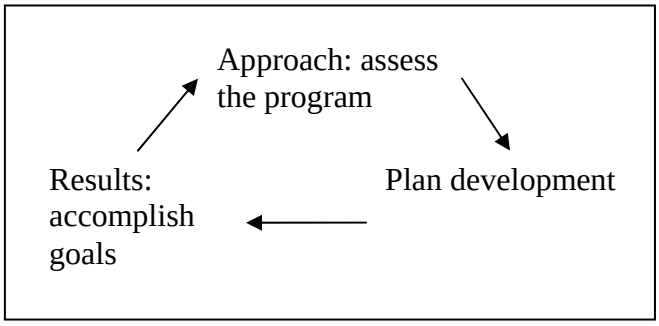
Boeing St. Louis has made impressive gains in cycle time, cost and quality of product as a result of employing the Lean actions noted above. Their approach is institutionalized and demands improving performance each year. The overlay of Lean staff, Lean Training and on the job Lean education is estimated to amount to 5 percent of work force payroll. This is a moderate amount compared to certain professional service and software development companies but still significant compared to many in discrete manufacture of complex products.

It is unclear how much improvement might still be gained from the utilization of real time information from ERP systems, particularly in manufacturing processes and associated engineering change processes. It would be very useful to this report to better understand the St. Louis enterprise architecture and the interfaced application programs and the degree to which they provide real time transaction data to accelerate the flow of data construed as key to their more effective operations.

[26] Boeing Enterprise Supply Tool

B.2. Lean Manufacturing Assessment Tool

The goal of the Lean Manufacturing Assessment (LMA) Tool is to transfer knowledge, provide criteria to assess Lean practices and means to disseminate internal best practices, help site prioritize improvement activities in transition to Lean production systems. To do that, they focus on the entire value stream.
Based on 9 tactics, 16 best practices and the LEM/LESAT tools, IDS Operations created a very detailed tool upgraded every year to assess the practices. The 5 point scale is absolute: you don't scale it down based on particularities.
Every month there is a report card (VSP and Best Practice Metrics) to keep track of the status of the ways things move on. Every year, you set new goals for your program, which you really need to accomplish. Every year it is more difficult since every year the tool is reevaluated and the criteria are hardened (that means if you get 3.5 3 years in a row, you really are improving, even though the number isn't!). Because the best practices rely on a new philosophy, legacy programs grade lower relatively to the newer for which there is a much greater expectation.
To assess the practices, we call upon experts. For example, if we want to assess the Lean inventory, we call expert people from Production Control and Supplier Management & Procurement. In terms of implementation, here is the model we think of:



What you want to do in the end is get Lean to be integrated in the culture, and you do that by forcing it from the advocates of the Lean office down to the disciplines, based on our specializations. Accordingly, the practice assessments are consensus based. It means you have to agree on the grade you will get, which is really valuable in terms of lessons learned and comprehension... Monthly status of progress to plans and yearly achievement results are openly shared within IDS Operations sites. This open environment fostered by the IDS Manufacturing Council, facilitates sites to request and offer support and assistance between sites.

Each year IDS Operations utilize non-advocate teams to assess each IDS Operations Site against the goals that were established at the beginning of each fiscal year. The goals are reviewed and approved by the IDS Operations Council. Because the LMA tool is revised every year, the scores obtained are re-base lined and the goal setting process starts again for the coming year. The Best Practices are integrated in the LMA

tool and reviewed at mid-year. The review by the non-advocate teams scores the Best Practices and the remaining LMA criteria to assess the site's performance against projected goals.

Teams evaluation:

They have a 4 level way of grading teams: a Level 4 team induces greater independence in decision making for the team, so the superintendents can focus on systemic issues and in developing teams that are in levels 1 through 3.

Supplier evaluation:

The Lean transformation model has been used by IDS for the last 4 years in its relationships with suppliers. First, define a program's value stream, and select suppliers. Then Supplier Development assesses whether the supplier is prepared to begin a Lean journey. If the supplier is ready, the process begins with educating the management... A Lean assessment is performed to provide a baseline of their Lean situation. A deployment plan is developed and Lean engagements are conducted and supported as the suppliers learn the use of Lean tools Boeing does not directly use LAI's tools but has been influenced by them.

IDS also developed a certification process, including performance in advanced quality, supplier performance (quality and delivery) and scoring of a supplier business processes assessment (here a bit inspired by LAI's tools). To be a preferred supplier to Boeing, you need to be good at the 3. Suppliers may achieve bronze, silver or gold status.

Lean Engineering Assessment Tool

The Boeing Lean Engineering Assessment Tool is comprised of 12 best practices that were developed over a number of years from incremental deployment of Lean principles in the engineering environment. The tool measures program efforts in 3 basic areas: process, implementation, and effectiveness for each best practice. Since execution of engineering processes and methods are tied to specific program requirements and other factors, Lean Engineering Assessments are conducted on a program-by-program basis.

Assessments are conducted by an independent team through examination of program evidence presented during the assessment period. Programs are given an assisted self-assessment to prepare for the formal review, which allows for more consistent evaluation. Each best practice is reviewed against clearly defined maturity criteria and a score from 1 to 5 is assigned. Additionally, strengths and opportunities are identified by the team for the program use in the development of their Lean improvement plans.

Lean Engineering Assessment scores are shared with program personnel to aid them in developing a Lean direction for the program. Because the scores and opportunities are identified for each best practice areas, the program has the flexibility to tailor their

improvement plans for maximum benefit. LEA scores are not shared across the enterprise because programs which need the visibility into their processes the most will likely be very low scorers and the sensitivity around being known as the “low scorer” would likely drive these programs away from the doing the assessments. LEAs are only done at the program’s request – they are not required.

N.B.:

- To do the team analysis better and almost instantaneously, they have been developing tools using Excel.
- Value stream mapping in the factory floor: We have modified the requirements for value stream mapping as defined in “Learning to See” by Rother and Shook. We have added dial charts (total cost, total material costs, defects, reworks), Cum Value Curves and Balance the Line charts that helps understanding where to concentrate your efforts. And they take into account information flow, in order to assess how IT impacts their processes.
- They also are implementing a demand flow system (JDAM program), not only a Toyota-like system and are investigating the theories of constraints philosophy.
- The process data sheets are electronically displayed on all of the shops floor systems. Process Data Sheets (PDS) are a form of “standard work” and is an IDS “Best Practice”. PDS are defined to assist the operator on the shop floor to address critical workmanship errors by defining process checklist and process documentation. It is a requirement that PDS are defined for the top 20% of workmanship errors experienced at a particular site and PDS deployment and usage are measured during the LMA review.

B.3. Notes from Boeing/IDS at St Louis (05-21-03).

B.3.1. Boeing IDS Lean Engineering Overview, by Tim Wilson.

Q: did you use LESAT?
Tim: No- the LESAT has not been used for engineering in St. Louis, there has been some attempts to use it in the West Coast, but there are mixed feelings about it. It is hard to determine if it is a problem of how the tool was implemented or if it is the way it was exposed to the community. But LEAT (the Boeing developed Lean Engineering Assessment Tool), covers in detail the topic, and is prior to LESAT.
Vinayak: LESAT is very high level, whereas LEAT is very much into the details.

Mapping Lean principles to Engineering.

Here we consider the value stream of manufacturing from a broader perspective and realize there is much to do at the engineering level when you develop a design your systems. Approximately 80% of the product cost is locked up in this first part. If you make a mistake in this part, you simply are wasting useful resources.
The Engineering value stream: in the context of engineering, the critical element is data. Therefore we look at the flow of data through our systems. When you look at this issue, you are thinking at three main things:

- Problem solving: an example is processing the proper requirements to create an acceptable configuration.
- Information management.
- Physical transformation.

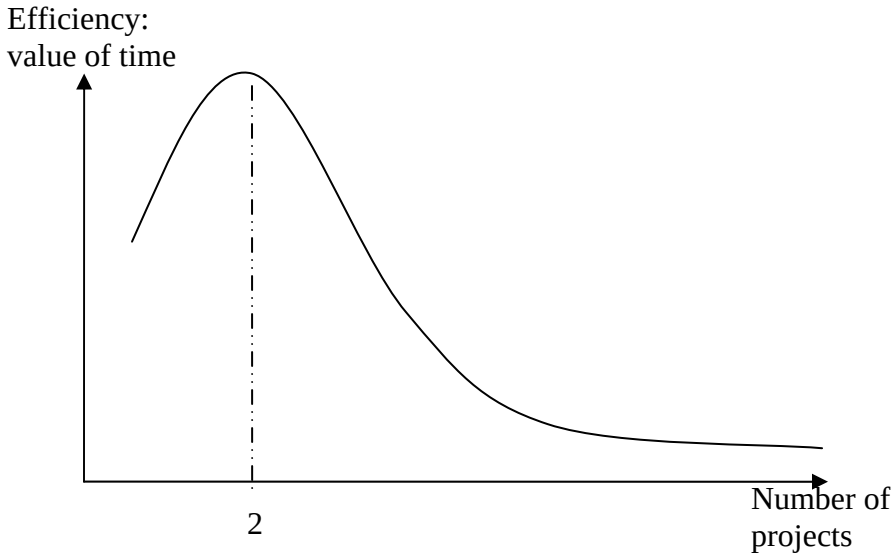
But our goal is to improve the throughput of the engineering system. A lot of times people will reproduce data because they can't find it or whatever. One of the fundamental foundations to enhance such a value stream is a single source of data, so that you create the data only once and whoever needs it can access it because he knows where it is. You need to have data management systems.

Q: do you use ANSI/EIA-632(Engineering System) for system engineering standard?
Tim: I don't know. But my guess is that they do.

So in that sense we try to find out what are the defects of data: scrap and rework. What we'd really like to is leave the design engineering as open as we can so that we can get the optimal solution. But the sooner the better. What are the sources of waste and defects?

- Errors:
    - manual transfers
    - lack of verification
- Inaccuracy/incomplete information:

  - Communication: are we communicating well enough? One of the ways we tried to answer this problem is with IPTs and virtual realities…see later in the best practice.
  - Lack of discipline: if you don't do the same things every time, you can't judge the way you're doing things.
- Timeliness:
  - The requirements change, and that has effects downstream. So the question would be whether it is better to wait to have good data and go downstream only once or regenerate it, which is what we do.
- Change.
- Waiting:
  - Queue times (in particular "canned" cycle times: in the community, there are standards, and it is difficult to convince the people that you've made improvements that is going to ameliorate that. We fall into the syndrome "if I am told the job is 100H long, then it is 100H long"! And it is tough to break the cycles.)
  - Engineering set-up tasks: locate and collect data.
  - Multi-tasking: Ref the IBM report. To a certain extent, multi-tasking can be linked to the theories of constraints. In particular, you can only deal efficiently with a certain number of tasks assigned at the same time. When you have various tasks, you have to choose which ones you'll do first, and it may not be the right ones! We are starting to develop the idea of looking at the tasks and ranking them by heir impact on the overall process, so you can process the right ones. This is an embryonic project.



Graph extracted from the IBM report

- Transport: if you are a manager and you don't sign a form somebody needs to resume working, then you are in a potential source of waste position.
- Inventory and excess processing.
- Complexity.
    - We have programs that generate data that aren't made for human reading but for machines, so you have to make sure another machine can access, read and process the data.
    - Excessive approval requirements, and "best guess" assumptions. If I need a piece of data to continue working, and I can't have it, I'll assume at best (best guess) what the information is and process it. But by the time I am done I do get the assumed data back, and so I have to reprocess everything.
- Monuments: systems (CATIA, Unigraph, etc, and communication issues between systems, in particular with suppliers), tradition (it has always been my job, so it will always be), organizations. When you talk about Lean, reducing time and costs, you also reduce jobs… in particular the solid 3D visualizations (see later) had a tremendous impact on the process.

Foundation for change.

Back in 92-93, we worked on a program introduced by DARPA. That program had the objective of reducing costs by 50%. IDS St Louis linked that project with DMAPS (Design Manufacturing and Simulation: internal project), and decided to go for it. The targets were to reduce cycle time by 1/3, cost by ½, and improve quality by 90%. To do that, we did not touch the entire value stream, but we started integrating from top down (from engineering design to manufacturing):

Configuration => conceptual layout => assembly layout => built/buy/support to packages.

However we also looked at the other way: get inputs from manufacture. To do that, we used 3D solid models, dimensional management, and supportability assessment. For example, the supportability people identified problems in a PDR (mainly communication problems with the clients), and they solved it using virtual reality simulations of assembly: the 43 problems spotted in the PDR went down to 3! From a Lean perspective, we eliminated the requirements for a hardware mockup and its cost, since the client trusted the virtual reality simulation!

Before, we used work with CATIA, and released the engineering in a data set that had along with it a 3D model and drawings. In the previous example, there were no drawings, since everything was in the virtual environment.

What we did with that project was touch to structure and subsystems installations, and solve a communication issue with the client.

At that time, we didn't know what we were doing. But the extension of that became the source of best practices.

Best Practices.

- 3D parametric solids: you build a solid 3D representation using algebraic expressions so that if a change occurs, you only change a number and it automatically changes the model. Now you don't have to redo the drawings at each change! The result is PD is reduced in cycle-time. This is the base of the entirety of what follows.
- Model based on definition (replaces the drawing).
- Electronic simulation (taking the solid models and linking them together, showing how they fit together at the assembly level: it's a how to assemble tool).
- Transaction new product and process technologies (how do you inject R&D in the production).
- Integrated data management (PDM essentially).
- Advanced Tech Assembly (self locating features and elimination of as many tools as possible).
- Trade studies (making sure that they account for cost at the design level).
- Dimensional management (remark: the suppliers are very much implicated into the process so everything works right for them too. This eliminates costs, waiting etc).
- Integrated Product Teams or IPTs: making sure that the team has a comprehensive view of the design (remark: socio-cultural issues like engineers vs. mechanics).
- Define Re-use
- Design for manufacturing and assembly
- Virtual design reviews/collaborative engineering (IPTs + tooling + suppliers + clients +…).

Key barriers:

- *Some customers want the drawings! Eventually they accepted our solution, but it is a slow process.*
- *Discipline (internal).*

Remark: 3D solids are a very supplier and customer oriented innovation, since it reduces the costs of transmitting the design and key assembly information to them. But it also enables to develop planning and to try out dynamic simulations. It is important to realize that the tooling is also a part of the 3D design!

Recommendation (Convince the DOD): no drawings. Make a standard out of such electronic representation to avoid drawings.

Remark:

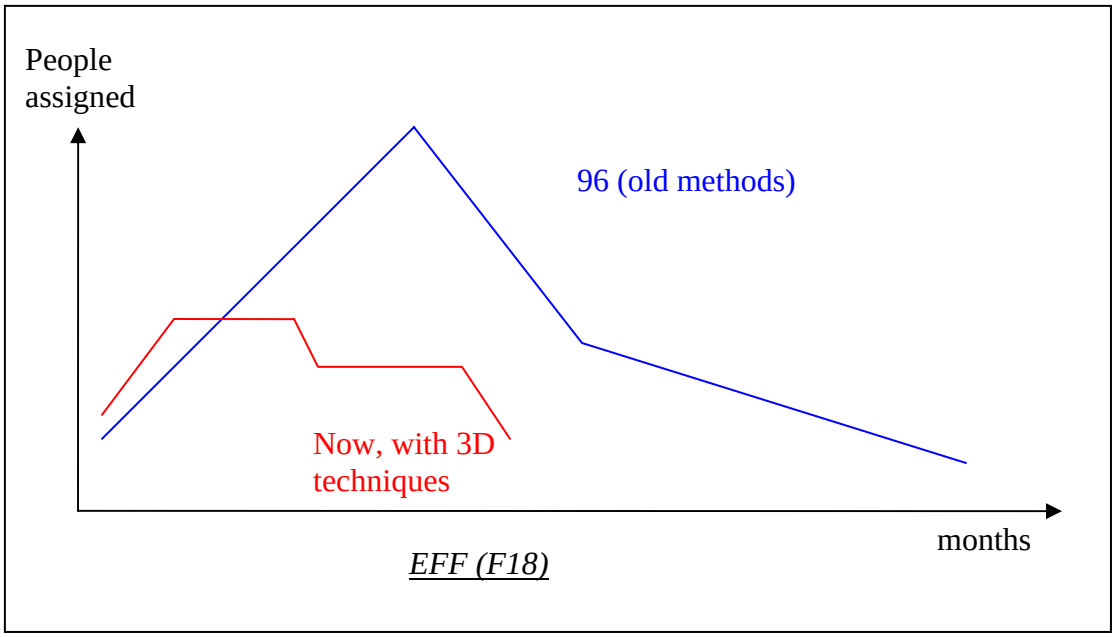
- *You do not capture the history of the design (failures, quality, etc) so you miss out on those experience. Plus you need to keep drawings for exceptions.*
- *This set of best practices has not gone through a true value-mapping process.*

Q: what has this got to do with lean? This is Best Practice.

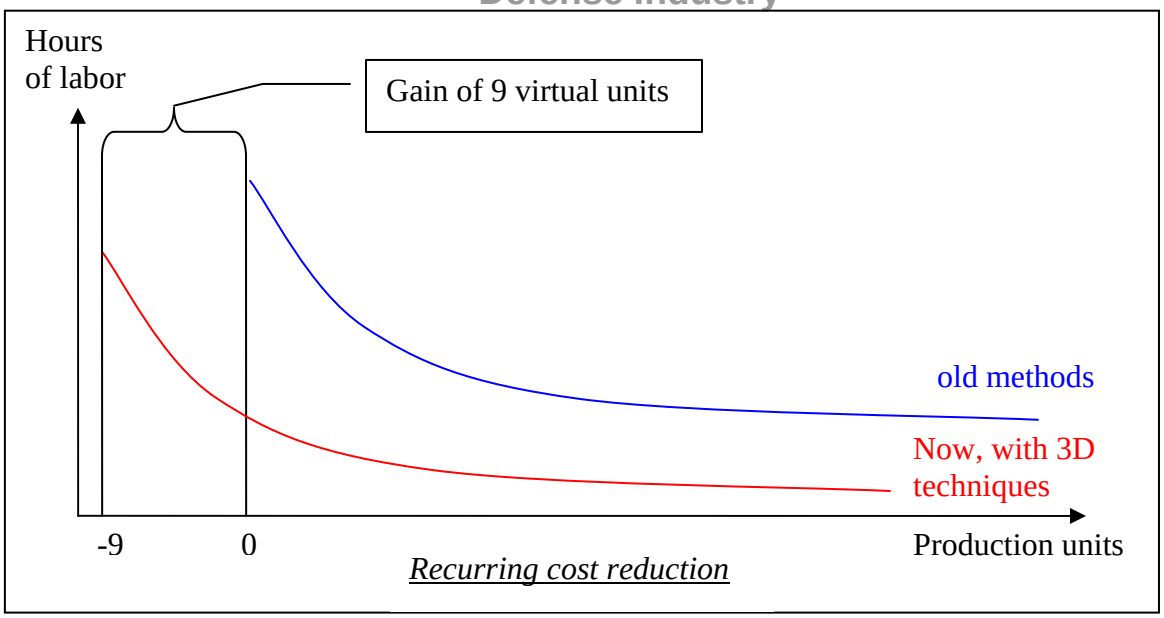
A: the results of doing this is you become Lean.

Degree of success with reuse of parts: medium (grade: 5/10).
Problem: I am a selfish program, since I don't share with the other future programs my information. Incentives are lacking: you are rewarded on the program not the integration with or reuse in the following program.

Examples of impact on the ECP (F18) and the C17 programs.



What is happening here is that you require more people upfront nowadays, but the program finishes earlier and requires less people. All the details and the information are available and exploited much more earlier in the cycle, thanks to virtual meetings, virtual manufacturing etc. The modern programs rely on 3D solid model master definition (no drawings), details available much earlier to support full data-driven IPT decision-making, regular disciplined virtual reality reviews and teamwork, virtual manufacturing, improved supplier coordination and concurrent procurement.
Another revealing graph is the following one, representing the labor in hours, function of the production units in a given project (EFF for F18):



We achieve a 48% savings (the goal was 50%). You reduce the T1 cost significantly and the learning curve is much more flat.
In terms of quality, we achieved a 65% improvement (goal: 90%).
You have less engineering changes now than before.

Q: how much of all that has to do with LAI?
A: Lean (LAI) is not essential to all that. But the Lean principles are essential and must be developed across in order to understand the big picture better. If LAI did not exist we would still be there doing this, but LAI gives the framework to organize ourselves with respects to our goals, in particular LAI is essential to expand across with suppliers and customers (tag time) and get them involved.

Another example was the Fixed Leading Edge of the C17. The purpose was to:

- align with design of C5
- reduce costs/parts…

The results were reductions of parts (13.9%) and fasteners (11.25%). There was an extensive use of the IPTs and ATAs, in a very tough business case environment, which makes this a wonderful success story (55% reduction in assembly hours and 36,715 hours saved).

Remark: the important thing to notice is that this is an engineering application of lean/best practice more than a manufacturing one.

Changing estimation thinking.

When they bid for proposals, the estimators have two techniques: the top/down and the bottom/up, and the weight of the product which they match up against an hours/weight

graph. This last one is a simple technique but has been proven over time and experience. By modifying the methods, you estimate as usual, and then you reduce the amount of hours necessary factoring in the Lean aspect!
Actual reductions experienced on recent programs:

- 50% on F 18 E ECP 6038 production structures design hrs
- 50% on X32 prototype structures
- 30% on F18 E/F ECP production subsystem design and installation
- 20% on X32 prototype subsystem installation

Spread the success.

To spread the success, we needed to develop and deploy Lean Assessment tools based on the best practices: focus on the entire value stream.
There are 3 parts to the assessment tool: approach, extent of deployment, results.
What we ended up with was a very detailed checklist we used to grade the programs with.
Because the best practices rely on new philosophy, legacy programs grade lower relatively to the newer for which there is a much greater expectation. The scale is absolute: you don't scale it down based on particularities.
You have a very clear score sheet that enables you to see if you are doing things right and to assess your goals for the next year (see Weapons).
However, when we score the programs, we do not publish the results. Why? Because the ones that need it the most would least want that to happen, hence would not use the tool and implement the best practice/Lean lessons. So we only publish the ranges, in order for the programs to realize where they are compared to others.
In terms of implementation, here is the model we think of:

Tom's recommendation to the government: everybody needs to have the same cost estimating baseline and model to make the industry less costly. There is an entire acquisition assessment and policy problem behind that.

B.3.2. Boeing Supplier Development, by Teri Hoenes.

The people at Boeing pride themselves in linking the organization, even though their journey is still not over...

Agenda:

- background
- vision
- Supplier development approach and processes
- Organization
- Business Unit coordination
- Integration
- Summary and next steps

The key element that we will examine here is “excellent supplier management”. IDS suppliers are responsible for 70% of product cost, with a total dollar spend in 2002 $20B (80% of which goes to only 175 suppliers). The number of suppliers to IDS is actually lower than in the past, and there is an active effort to continue on that track of reducing the number of suppliers.

The goal is to reduce the cost, lead time, and enhance the quality with an integrated approach of a Lean enterprise. Therefore you need an increase involvement of suppliers as partners. IDS should try to rely more on their suppliers and implicate them in the manufacturing process by creating a collaborative environment, increasing participation and involvement in IPTs. In addition to that and to facilitate it, there needs to be:

- Common systems and tools.
- Aligned goals, objectives and metrics.
- Information sharing

In order to do all that, IDS is helping its suppliers improve performance by providing training opportunities.

Supplier development approach:
Program value stream analysis => identify critical suppliers (quality, delivery, cost, lead time) => identify improvement opportunities (supplier value stream map, Lean assessment tool that is 6 or 7 yrs old and refined every year – not the LESAT tool) => define improvement tools to eliminate waste (AIW, 6 Sigma, 5S, 3P, TPM) => implement process improvements (single piece flow, set-up reduction, workplace org, sub-tier supplier integration) => validate results (cost reductions –not a goal per say-, lead time reduction, quality improvement, delivery improvement) => Negotiate with suppliers (operating procedure PRO 5598) => savings realized by program (higher quality, on time delivery, lower cost, lead time improvement)

Working with suppliers is very easy, once they realize that you come simply to help them.

Programs set goals, and Supplier Development provides suppliers tools to aid in achieving the goals.
We understand that we have to drive our costs down, but maintain their profit margins.

The Lean enterprise transformation model has been used by IDS for the last 4 years as a guideline for supplier development. Key suppliers are identified by value stream mapping at the program level.
Supplier Development assesses whether the supplier is prepared to begin a Lean journey. If the supplier is ready, the process begins with educating the management.. A Lean assessment is performed to provide a baseline of their Lean situation. A deployment plan is developed and Lean engagements are conducted and supported as

the suppliers learn the use of Lean tools Boeing does not directly use LAI's tools but has been influenced by them.
IDS also developed a certification process, including performance in advanced quality, supplier performance (quality and delivery) and scoring of a supplier business processes assessment.(here a bit inspired by LAI's tools). To be a preferred supplier to Boeing, you need to be good at the 3. Suppliers may achieve bronze, silver or gold status.,

Remark: the government has to recognize that this is an initiative that lowers costs, and that is beneficial to the entire industry.

There are various forms of trainings, since the suppliers differ.

Supplier readiness.
This is a new area to focus on for Boeing.

SM&P.
There are some Lean deployment needs within the Boeing company. To coordinate the approach across the enterprise, we created Supplier Management Lean Integration Team (SMLIT), to develop process for identification, prioritization and coordination across the entire enterprise.

Third party funding.
Boeing receives both state and federal government funding, although funding primarily comes from the federal level. IDS receives R&D dollars...

Current projects:
- Small/medium enterprise initiative (JDAM): quadruple the requirements for JDAM missile to the suppliers (in # of parts) with almost no impact on costs. In fact some suppliers even gave money back!
- Pathways I/II: we have done 3 different iterations. With this program, in addition to the Lean tools, we've incorporated a business development package.
- Supply chain practices for affordable navy systems (SPANS)

Project overview:
- Develop assessment methodology
- train suppliers
- assess a representative number of suppliers within a major component supply chain
- capture supply chain current state and opportunity
- macro-network analysis
- supplier summit to share findings and down-select supply chain project

- focused improvement activities
- develop process guidebook

About 5% of the suppliers are Lean engaged through Boeing.
Suppliers were surveyed, and answered that the most important lean-impacted aspect of their business was lead time, then delivery and inventory, quality and finally cost.

The e-commerce webpage (BEST: Boeing Enterprise Supplier Tool) enables suppliers to view an instantaneous description of their status and what has to be done, all that in a single place.

Success factors:

- Lean enterprise
- Top level commitment
- Lean champions
- Sustainment plan
- Integrated approach to Lean enterprise

(Boeing Enterprise Supplier Tool: one-stop shopping).

B.3.3. The Lean Manufacturing Tool (IDS), by Roy Graham III

The goal of the LMA assessment to is to transfer knowledge, provide criteria to assess Lean practices and means to disseminate internal best practices, help site prioritize improvement activities in transition in Lean production systems.
Every year the tool is upgraded based on internal and external benchmarks that are performed throughout the year.

The following approach enables us to link and coordinate all our efforts to make it happen (Lean, manufacturing/engineering, supplier development).

The following 9 tactics are the foundation for driving the manufacture in a Lean environment:

- value stream mapping
- balance the line
- standardize the work
- put visuals in place
- point of use staging
- establish feeders/supply chain
- break through processes

- convert to Pulse Line
- convert to Moving Line

Then we coordinate and link these tactics with the 16 best practices (standard work, balanced process data sheets, advanced craftsmanship, balanced metrics …). There is a section in the LMA tool that assesses maturity of Employee Involvement and this section with the yearly employee survey helps the site gauge the change in culture related to Lean. The way LAI fits in:

LEM/LESAT => Lean manufacturing <= 9 tactics + BP.

I want standard work, to have something that is repeated always the same, that is measurable, and we train different people on the same application so there is no unique specialty done by one man (to avoid stopping the entire process when he leaves on vacations). We always try to avoid a “one point of failure” case.

In the organizational structure, Boeing commercial and Boeing military link to better assess Lean. But in any case, there are two essential equations:

- Lean + employment involvement = success.
- If Lean doesn’t reduce cost, there is no need for it.

To assess the practices, we call upon experts. For example, if we want to assess the Lean inventory, we call expert people from Production Control and Supplier Management & Procurement.
What you want to do in the end is get Lean to be integrated in the culture, and you do that by forcing it from the advocates of the Lean office down to the disciplines, based on our specializations.

Remark: with our unions in St Louis, it was negotiated in the last contract that no worker would be laid off as a result of process improvement. So they make the business more efficient, and can only see results by augmenting production.
Q: and what about you, the Lean champions: how secure is your job?
A: first we look for other ways than layouts to achieve the same goals. Second, we try to transfer the knowledge to the people. And in the end we are rated by our bosses and clients, so if they don’t like what we do or don’t want to help me, I am not performing, and I am dealt with accordingly.

Every month there is a report card to keep track of the status of the ways things move on. Every year, you set goals, and you’d better reach them, which is every year more difficult since every year the tool is reevaluated and the criteria are hardened (that means if you get 3.5 3 years in a row, you really are improving, even though the number isn’t!).

The self-assessments are used by every program at the St. Louis site. The self-assessments are used to get a reading on were a program is related to their goals and to train program resources on the expectations of the LMA tool. In essence to assist the required change in the culture.. The review by the non-advocate team is a week long event. On the fourth day, the results of the non-advocate team review are shared with the site. This review is consensus based. It means you have to agree on the grade you will get, which is really valuable in terms of lessons learned and comprehension.

B.3.4. Examples of Lean at IDS, by Roy Graham III

Establish goals at program level, implementation plans developed by program to support LMA/BP goals, meet with assembly directors to formulate implementation strategy, coordinate with functional support groups to aid program's Lean development strategy, conduct weekly Lean meeting to assess performance to plans, run LMA/BP self-assessments and conduct Lean Project Reviews to share IDS best practices.

They don't do kitting for the C17: they supply directly to the point of use. But the production level is relatively low. They have their own final assembly planning. It takes about a few days, maybe a week to change the requirements on a final assembly and to adapt everything.

They have a 4 scale way of grading teams => a Level 4 team induces greater independence in decision making for the team, so the superintendents can focus on the lower grade teams…

To do the team analysis better and almost instantaneously, they have been developing tools using Excel.

We build a new building for the C17 major subassemblies (Cargo Ramp, Cargo Door and Nose assemblies), using the 3P techniques.

Value stream mapping: they modified the value stream mapping concepts by adding dial charts, cum value curve and balance the line charts that helps understanding where to concentrate your efforts. And they take into account information flow, in order to assess how IT impacts their processes.
They also are implementing a demand flow system (JDAM Program), not only a Toyota-like system. They are investigating the theories of constraints philosophy.
The process data sheets are electronically displayed on all of the shops (floor systems).
There are no individual logins: everything is controlled by the unique ID tags (cf tour).

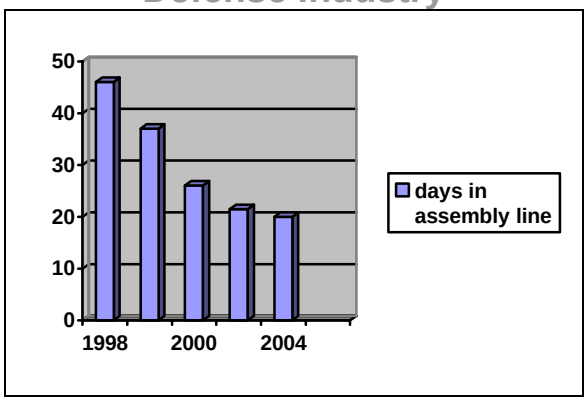
They rate their programs during each site's assessment, but once it is done, the programs decide what elements they want to improve for next year's goal setting process. You have to do what is best for your program, what makes good business

sense: it's up to the program to determine to stay at level 3 for a given element and not to go to 4! (These are the Lean levels 1 through 5).

Examples of these practices:

- Changing the display of the supplied boxes/feeder lines are there fore more efficiently supplied! Reduced by 11Mdays etc
- Elimination of Warehouses: 100% of planned part numbers are at line side for Weapons, F/A-18 E/F and C-17 programs. We are continuing to make progress on Point of Use deployment for the F-15 Korean program. The F-15K program is scheduled to be at a 60% level by the end of 2003.
- Value Stream Mapping: Current and Future State maps have been defined for the F/A-18 E/F, C-17 and Weapons programs. The F-15K program has completed its current state map and is projected to complete its Future State map by the end of 2003.
- We are continuing to implement Pulse moving lines at the St. Louis site. The C-17 program is anticipating a 10% reduction in assembly labor and a 20% reduction in assembly cycle time once the production system matures. The F/A-18 E/F program is projecting a reduction of cycle days by 50% when it complete installation of its pulse moving line in 2004.
- Breakthrough Process Re-Design: The F/A-18 E/F program replaced 5 spars, 8 ribs and 2 hinges with a single monolithic part. This reduced cost of detail parts, assembly cycle time and eliminated over 150 internal fasteners per A/C.
- 3-D Solid Modeling: The common use of 3-D solid models developed during ECP 6038 allowed the analysis of tooling concepts. Using the 3-D modeling concept the F/A-18 E/F program was able to convert the LRET tools to Splice tools. This led to the elimination of 4 LRET tools and the projected cycle time improvement is forecasted to be reduced by 50%.
- ATA process (Tim) => skinning process => skinning process reduced by 20%, cycle time reduced by 50%.
- Upper nose crown redesign, feeder line (cargo door subassembly), etc…more success stories.
- Tools:
    - common/reusable for other lines tools
    - designed by 3D tools designed for designing the planes

They managed to eliminate superfluous tools and superfluous elements on the plane => waste management overall, not just the plane!

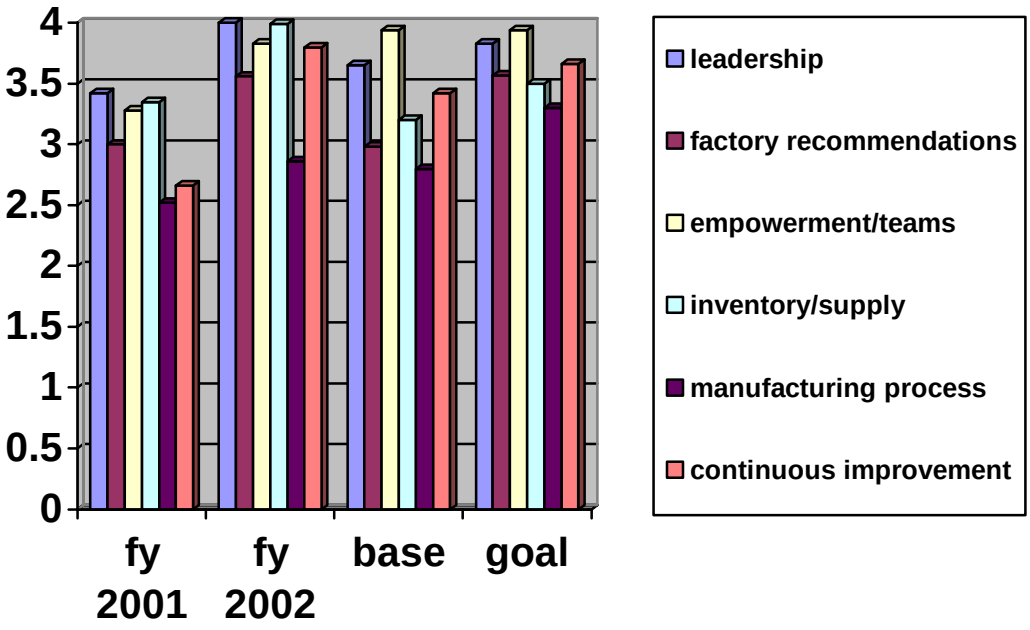


Based on the disciplined process established by the IDS Operations Council, the Lean Manufacturing Assessment (LMA) and Best Practices (BP) scores have constantly improved. The LMA/BP tool was revised each year making it more difficult:

- St. Louis site's LMA scores have matured from a 2.54 in 2000 to a score of 3.12 in 2002. The goal for the St. Louis site in 2003 is 3.36.
- St. Louis site's Best Practices scores have matured from a 2.78 in 2000 to a score of 3.1 in 2002. The goal for the St. Louis site in 2003 is 3.63

B.3.5. Weapons Systems Program, an example of the Lean institutionalization, by John Campbell.

There are 7 topics in the Lean manufacturing assessment tool graded on a 5 point scale, and here is how the weapons program manufacture rated on some of them. At least once a month John reviews progress to maintain control, in order not to be surprised…he sets up his own yearly goals, and the policy is to stick to the goals you set or else…



- *leadership*

The vision is to develop trust and so on. However, it is important to notice that they are not looking at Lean manufacturing; they are moving on to the concept of Lean enterprise.

They have a heavily integrated product and SMP, engineering and business, and think JDAM is almost a world class organization to benchmark.

The way they communicate this to their employees is through the following flow/framework:

[Vision => mission statement => strategy => objectives => focus (programs) => metrics => feedback]

They created a Vision Support Plan which is very similar to the balanced score card and has about 20 different metrics to update every month.

They have a lot of programs, each one having its own value stream. But they try to envision the future of every program in 5 years. They have a system architecture in mind for the future and are going for the best of breed solution, but in an integrating way and with off-the-shelf systems.

He wants no text-based work instructions: just like Sears! Picture based system…the 3D models is essential! They want bar codes, to have no more people entering numbers in the systems…

- *factory recommendations*

It's really about layout etc…

For example, they implemented reusable containers, low inventory levels, one touch inventory.

- *Empowerment/teams*

- *inventory/supply*

They use point of use and replenishment/min-max systems so that if a defect occurs then it stops the supply chain.

The results for JDAM are the following:

- cycle time reduction: 60%
- setup reduction: 70%
- lead time reduction : 22%
- product travel reduction: 71%
- inventory reduction: 45%
- floor space reduction: 27%

- *manufacturing process*

It's a cultural issue. The mechanic is the surgeon! What they did is implement very low quality inspection: 100% manufacturing is self-inspection based.

Manufacturing process improvement is the toughest area to make improvements because it requires engineering changes, and that cost a lot.

- *Continuous process improvement*

The real reason of this success is team, because he doesn't have the funding to do make design improvements. He cannot change the design – Government controls. What he can do is change the way to build it by improving the process.

C. APPENDICE C

C.1. Lockheed Martin Commercial Space Systems, July 28, 2003

Executive Summary:

The LMCSS Business Area is a state of the art space satellite facility and staff, formulated in 1995/1996 as a Greenfield design based on TBM principles similar to those of the Lean Aerospace Initiative. After the initial design of the facility, LMCSS implemented an integrated ERP system, which is now in place providing real time information to all that need it and providing systematic metrics to measure the progress of Lean activities. Design of the manufacturing approach and of the processes used for manufacturing payloads preceded the publication of the LAI methodology. However, as a member of the LAI consortium, Lockheed Martin had close relationships with LAI. Lockheed Martin Commercial Space Systems extensively used Kaizen events and methods to design the processes and a Master Kaizen was used as a value stream creator. . In addition LMCSS selected its suppliers carefully and helped their major suppliers use Kaizen and streamline their operations. Since 70% of the costs of LMCSS come from the supply chain, very careful attention was paid to develop reliable suppliers. LMCSS followed a principle of only ordering what they needed, demonstrating their commitment to the Lean principles. To drive prices down, they worked with the suppliers to eliminate waste in their transactions. . When the Market downturn hit, this approach minimized the impact across Lockheed Martin's supply chain, resulting in strengthened relationships as a result of the confidence suppliers had in their Lockheed Martin customer.

The journey of LMCSS to Lean is depicted in the included PowerPoint, demonstrating the similarities to the LAI roadmap.

Originally designed as a major satellite sub-system engineer-to-order facility, its performance excellence combined with the market downturn resulted in it being assigned full satellite design, manufacture and operation responsibility. Originally designed to design and produce sub-systems for 12 satellites per year, changes in the market have resulted in a sharp drop in orders in the late 1990's and early 2000's but the market is now beginning to recover.

Current Lean initiatives are integral part of the LM 21 program led by Mike Joyce of Lockheed' Martin's corporate office in Bethesda, MD. The Newtown enterprise value stream initially emphasized discipline in marketing, engineering tools in design and Kaizen for processes but has now been modified to shore up Lean Sustainment. It is

focused on the objective of 6 sigma in design and manufacture with discipline and Lean captured by an Operational Excellence program. All systems are produced on mixed manufacturing arrangement consisting of 7 product cells with standard manufacturing processes. The only differences are additions of tollgates for government inspection and validation.

Key to maintaining this momentum is metrics provided by the process performance and status data of the SAP A&D ERP system. The IT project is known locally as the IRIS project. The Kaizen methodology and process design preceded the SAP implementation, which followed a year later. The careful definition of processes helped achieve an excellent ERP implementation. The SAP ERP system has become the backbone of all Newtown operations systems and the data it provides is used by all levels of management as well as individuals. The enterprise features of the SAP A&D ERP system were a fundamental tool in the market induced staff reductions from 1700 to current staff levels. Particularly impressive of Newtown IT systems is the fully operational, wide-ranging functionality of the R/3 system and its interface with the Metaphase (Version 3.2) PDM system with a single BOM with date effectivity. All designs are electronic and both the PDM and ERP system are configured to allow suppliers to access the latest design or manufacturing information and reflect this in their design or production activity. This IT system configuration with a single BOM constitutes a Best Practice approach to efficient and high quality design and manufacture processes. The SAP version at Newtown is now the standard system for the LMCo $6 Billion Space Business area.

Newtown's supply network consists of 300 suppliers and 12 major sub-contractors. Supplier management consists of measuring suppliers on key parameters of cycle time, quality and adherence to delivery schedules. Newtown has established Sub-contract teams and commodity cells to oversee both areas of materials and services.

Discussion:

LMCSS employs 750 people for 565 million dollars in sales. Its headquarters and main manufacturing site are located in Newtown, PA where they were built in 1997 according to lean principles.

Setting up the facilities: bringing lean to life

The LMCSS Newtown facilities were thought through with an inter-industry benchmark (1995-1996) to get a sense of what was possible. The Lean Aerospace Initiative came in handy at that point as a means of communicating knowledge and contacts. However, LMCSS really relied on TBM[27] to set down the lean frameworks on which they would develop internally their lean principles and actions.

[27] Time Based Management

From 1996 to 1997, with the knowledge acquired, LMCSS developed a strategic thinking to ensure the adaptability of the facilities to future unthought-of problems. In the Kaizen spirit and with thorough value stream mapping, they focused on infrastructure.
In the 1997-1999 time frame, while implementing the facilities and the lines, LMCSS made sure it was taking value from the practices observed and principles set. Every means to achieve cost cutting and/or more efficiency is examined. In particular, LMCSS works tightly with its customers and the DCMA people. Involving them in the decision-making processes, Kaizen events, production groups etc… is a way of trying to ensure their support as well as a way of sharing knowledge to make things better. The results are impressive, as the following table shows:

	Method	***Lead Time reduction achieved***	***Cost reduction achieved***
Procurement System	25 Kaizens	40%	20%
Assembly and Test	75 Kaizens	78%	30%
Payload (spacecraft flow)	Standardized IT processes	70%	35%

Today LMCSS tries to find new tools to re-invigorate the processes and maintain continuous improvement, driving towards their quest of LM21 operational excellence.

However, during the 1996-2003 time frame, the market place took a tremendous hit and LMCSS production went down from 6 satellites produced a year to only 2.

Answering the manufacturing challenges

To answer both the challenges set by the market crisis and the quest for leaner/better practices, LMCSS Newtown had to move away from the multiple dedicated product cells to a single mixed model line. They implemented standard operations and Mixed Model Manufacturing (M^3).
The search for commonalties led to a new floor layout with three major common flows: Hermetically Sealed Devices/Microelectronics, Screened Packages Devices/RF Subassembly, and Integration and Test. Common standards allowed the operators to work on all products in a multi-model line. The end results of implementing common processes within common product flows were more flexibility, more time savings, more product efficiency, and less critical skills requirements. They got rid of 45% of the equipment, and had less people to manage on the floor. Parallel processing, standardization and discipline were developed to eliminate Work in Process (WIP). Everything was in place to use lean principles.

Supporting this effort was the SAP enterprise system. It gave data to support the change as well as the metrics to control the flow. It helped customize floor modules, and even gave color-coded visualizations to enhance the visual aspects in the shops.

Answering the supply chain challenges

LMCSS is reducing their supply chain base. In parallel the suppliers tend to consolidate or leave the space systems market because of the severe downturn and high rigor involved.
To be a LMCSS supplier, you have to be lean, and LMCSS help you with that by training you through a green belt program, by conducting value stream mapping and BPR in your facilities. LMCSS verifies your lean state through the analysis of your cycle times, product quality and costs. Again, SAP helps to make scheduling more effective.
LMCSS does not evaluate its suppliers' leanness with formal tools.

Answering the IT challenges

Although the people in Newtown had been hand picked for their adaptation qualities, the economic situation made it difficult to prove the value of the systems. Today, the system is trusted by all after a tremendous effort of communication (consensus-based decisions for enterprise-wide decisions) and implication of the different stakeholders including the government, the system is trusted by all today.

The IT architecture divides the main applications in two cores that went through the norm ISO 9001: engineering with Metaphase, and manufacturing with SAP/IRIS.

- Metaphase is a tool for managing product data, as well as an electronic workflow and data vault management tool. The goal is to eliminate paper, so everything is stored and managed electronically if possible

- SAP/IRIS is an integrated business system, fully integrated with the S&SM systems. It delivers real time information with a client/server structure, and has secured profiles. SAP is implemented in LMCSS versions (4.6C2),

The middleware developed for the interfaces is based on an in-house developed XML. It enables the entire architecture to work as one and execute the LMCSS primary functions: data revision, bill of materials etc…

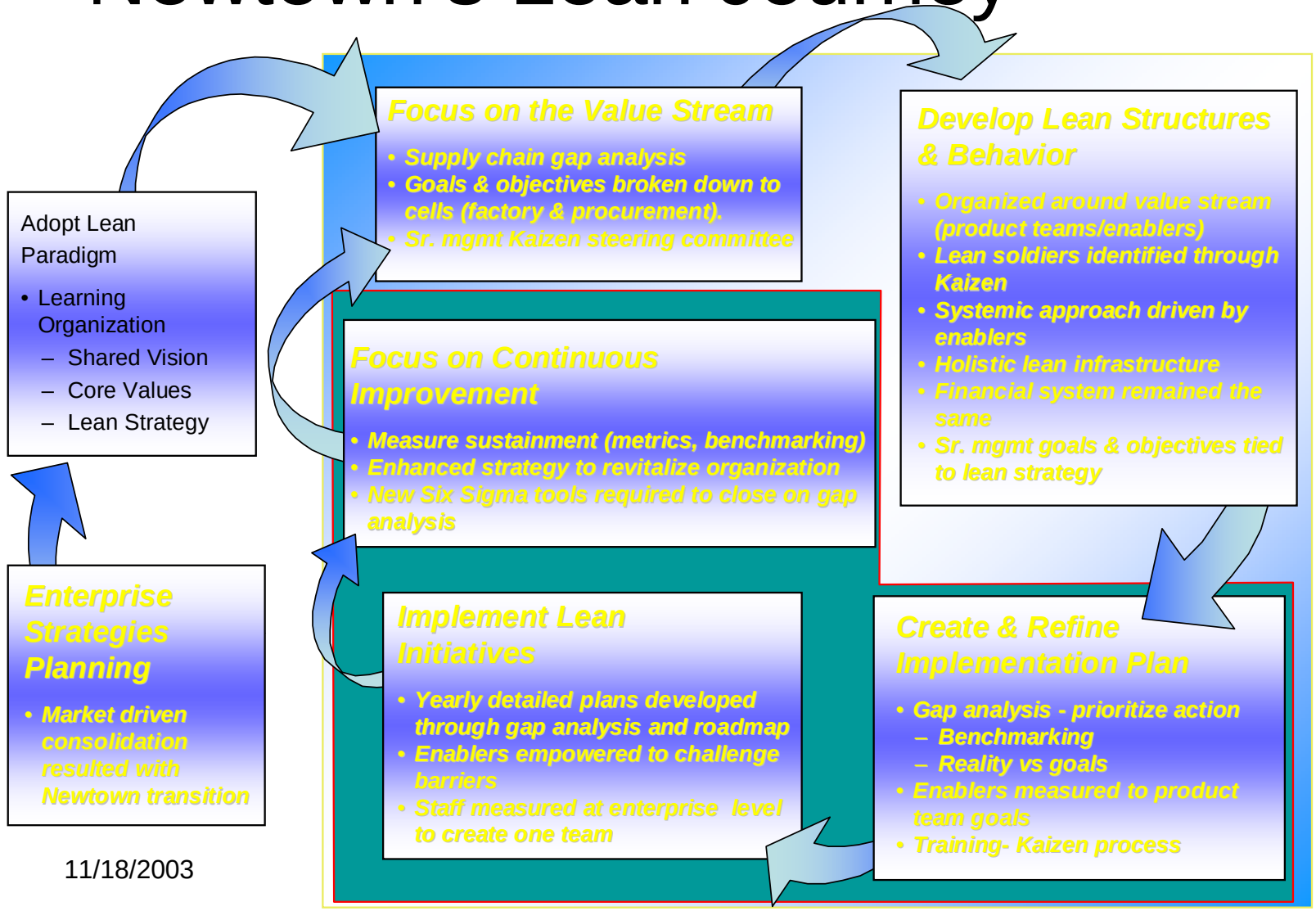
For select suppliers, there is a web interface allowing them to have the latest updates of the products to be delivered.

Conclusion, feedback comments and questions

Newtown is a great Lean "Greenfield" facility, with a very good ERP implementation and ingenious manufacturing multimode. The Engineering PDM is satisfactory, and the use of one bill of material laudable. The flexibility of the design of the processes and general management of the facility has allowed the company to weather successfully a severe market downturn and not be poised to take advantage of the coming recovery.

C.2. LMCSS Newton Lean Journey

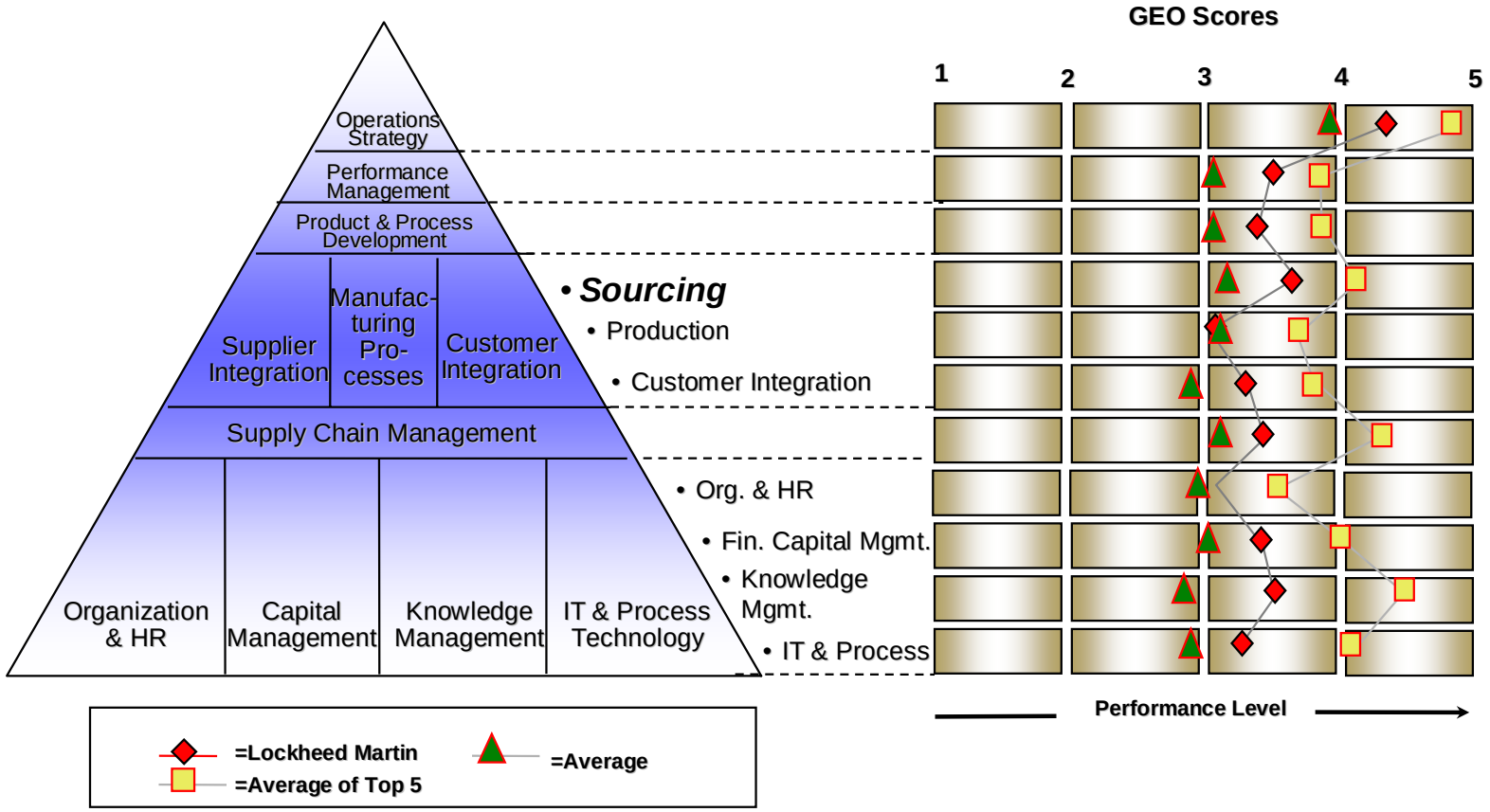
Newtown's Lean Journey



11/18/2003

External Benchmarking

A.T. Kearney GEO (global excellence in operations) results

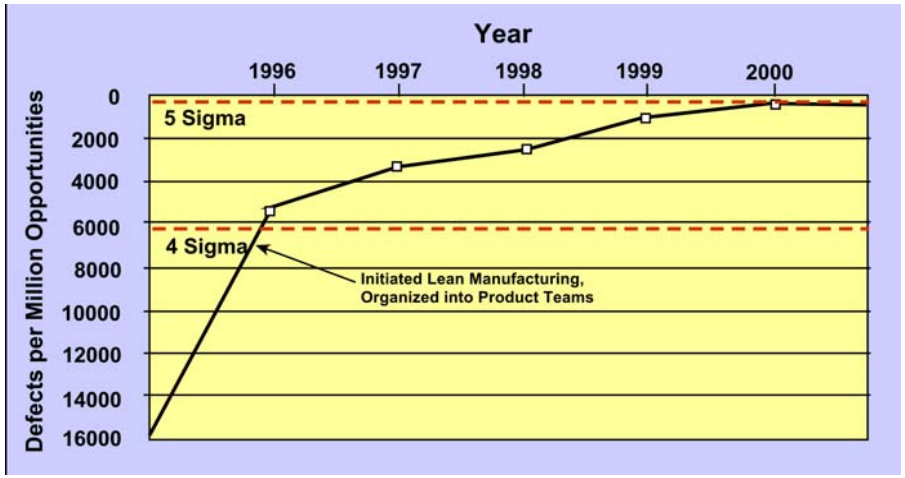


11/18/2003

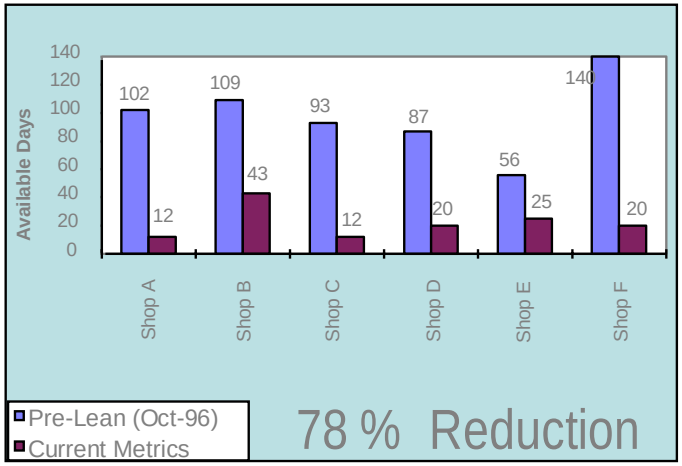
2

Bottom Line Results

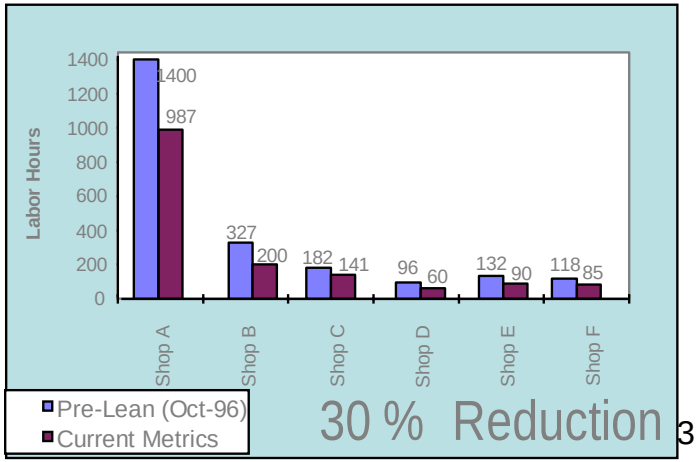
Quality



CycleTime



COST



Lessons Learned

- Reinforce the need for commitment from the top
  - Need to involve total business
  - Each program alone can not re-engineer the business
- Need short and long-term results
  - Attack long-term systemic issues while reaping cost savings from short-term solutions - eliminate the waste, then perfect the value
- Sustainment is the hardest part
  - Need to impact the culture while the energy is high
  - Long-term metrics and measured goals are necessary to sustain improvements from short-term results
- In parallel, re-engineer manufacturing and design processes
  - The long-term impact of design process changes requires a parallel effort with the short-term gains from manufacturing and business processes waste reduction
- New employees did not grow with the enterprise
  - Train, train, train - assimilate new employees into the culture

Summary

- Lean journey requires holistic systemic change
- The Newtown enterprise, by implementing lean principles, has joined in this transformation of the space industry
- Much done and more to do, the journey has uncharted ground
- Customer involvement is needed for a true lean partnership - e.g., requirements flowdown
- Export to the rest of the business - Stennis, etc.

Benchmarking against adjacent markets identifies continuous improvement opportunities towards excellence.

D. APPENDICE D

D.1. Boeing Rotorcraft Philadelphia, March 13, 2003

Summary

Boeing IDS has taken the LAI methodology and developed their own tools, which they are using very effectively. Boeing Philadelphia has an organization dedicated to implement the Lean program. This organization is headed by a Senior Manager and staffed by a competent staff. The lean organization works with the Program organization to make Lean happen and has precise tools for planning and measuring progress. It is an effective methodology producing measurable results; for example the new Osprey final assembly pulsed line.

On the IT side, Boeing has a "best of breed" approach which will use the Manugistics core applications as its primary requirements engine. The reviewers are not sure how much integration will be achieved, but at least there will be an interfaced system which can serve the company well and has the advantage that new "best of breed" applications can be interfaced in the future. Certain systems, mainly financials and Human Resources are corporate standards.

On the whole the programs reviewed at Rotorcraft are an intelligent and effective application of the principles developed by the LAI consortium.

Arrangements for and management of the meeting agenda and the participating Boeing personnel was outstanding and a tribute to the excellence of the motivation and skill of the Boeing team.

Boeing Philadelphia Rotorcraft Division View and Utilization of LAI Resources:

Overall, this Boeing facility views the LAI LEM (Lean Enterprise Model) Principles and Practices as a framework or structure to which the various Lean process actions, tool applications, and respective initiatives prioritization can be mapped or integrated. Without the LEM structure improvement projects were not necessarily prioritized or examined for real impact to operating efficiency and the bottom line. The LAI LEM has been translated to the Boeing LMA (Lean Manufacturing Assessment) with seven specific categories or Sections allocated to the Boeing Lean deployment, common to all Boeing IDS (Integrated Defense Systems) components. This includes factory organization, Work Force Empowerment, Manufacturing processes, Inventory and Supply Management, among others. The LMA process criteria were obtained from extensive benchmarking of 35 foreign companies, and US data from LAI research, Shingo Awards and internal benchmarking to supplement the external benchmarking noted earlier. The seven sections of the LMA/BP across the IDS provides a consistent set of criteria, processes and best practices which not only helps an individual site but provides data and input from all other IDS sites. Staff incentives are based upon

performance measured against LMA criteria, with specific levels of performance identified against specific objectives with metrics. An example of employee involvement in the LMA is the joint Boeing-Union teams. Both program management and functional personnel evaluate individual performance.

To quote Boeing:

"**Before LAI we were throwing darts**":

1. **LAI gave us structure. Now that we have the structure, we are more tied into the enterprise.**
2. **We knew we were doing good things, did not see improvements in the bottom line Now we see improvements in the bottom line.**
3. **We can see**
4. **Value stream mapping scan show improvement in the bottom line.**
5. **Unit costs, defects, cost of rework, inventory levels, turn rate, etc. have positive trends.**
6. **AIW scenarios. Good educational value.**

The LMA is structured with 5 levels of individual or team performance, with the 7 sections resulting in 65 elements**, similar across all IDS components.** The confidence of Boeing management in the PMA process is manifest in their willingness to take downstream program facility and process improvement funding, move it to the program front end and incorporate the projected savings into a reduced program cost.

Future State value stream: Boeing tracks head count reduction and/or material cost reduction. This is brought into forward pricing rates, i.e. **Boeing management is willing to have the government take the reduced cost in their forward pricing rates, primarily because Boeing is mainly interested in enhancing their market competitive position.**

At Boeing Philadelphia Rotorcraft manufacturing operations are based on "focused" factories, for example, Chinook, Osprey and Comanche manufacturing.

Manufacturing Operations Lean Staffing:

The Boeing Philadelphia site has assigned 7 staff to operations to initiate, oversee, manage, assess and coordinate internally all Lean Manufacturing initiatives and projects and integrate these at the IDS and BAC levels. This staff supports approximately 2000 operations personnel including the IAW union participation. Substantial effort is allocated to the once a year formal IDS assessment, applying the LMA criteria to all participants. **IDA and BAC treat this review as an assessment process vs. a traditional "IRS" type audit**. This approach encourages candor and realism on the

part of the participants. **BAC has used the LMA process for over five years during which the process has been enhanced, simplified and institutionalized.**

Supplier Management and Procurement:

Rotorcraft Philadelphia has outsourced all detail fabrication operations resulting in a focus toward final assembly, test and integration of its production programs. Consequently lean supplier and procurement initiatives have focused on a lean supplier community with value stream analysis the primary tool for streamlining procurement processes with business rules and use of IT technology. Prior to these lean activities some 70 to 80 percent of procurement activity was classified as non-value added. Results to date include 95 percent on time part availability and 30 percent reduction in SM & P costs. Drawings and specifications are now available to suppliers within 1 to 5 minutes of the request vs. previous cycle times of 2 to 10 days; CATIA, STEP, and IGES produced files are now available in 1 to 10 minutes, a major improvement over earlier metrics. The percent of electronic transactions may top out at or about 95 percent with a max/min inventory level ratio reduction from 4 to 2. It is believed that achieving 100 percent is not cost effective since this value does not generally reflect part shortages but suppliers not quite meeting the inventory ratio rules.
Specific lean supply initiatives include a 40 percent reduction in suppliers, expanded use of the electronic supply chain (noted above), CBO (Consumption Based Orders) reflecting the inventory max/min objective and reallocation of more available procurement personnel to focusing on high value and critical items. Additionally, Boeing has deployed Value Stream Mapping to suppliers free of charge in exchange for suppliers commitment to develop their own maps and use toward cost reductions. This has been very positive to date.

People involvement

Employee involvement teams. Led by the Unions, Staffed by the union and supported by management / support personnel.
“Lean = less employees are needed” is no longer the mindset at Boeing Philadelphia
They understand that 60% of something better than 100% of nothing.
Work packages slated to go out are explained to the Union and jointly staffed teams are put in place to work business case scenarios. The results have turned around original plans based on improved performance. LAI provided a means of explaining what we are doing.

“Plans are worthless, planning is everything”.

Rotorcraft Common Systems:

Rotorcraft Philadelphia IT infrastructure will be structured around a Manugistics core (including MRP II, Procurement, and MRO functionality); this Manugistics core and interfacing financials will become common throughout the Rotorcraft Division (Philadelphia and Mesa). A specific initiative to automate the IMAN PDM interface to the Manugistics MRP II functions has been approved by the IDS Process Council. This will provide a key enhancement for "Leaning" the engineering to operations technical data flow and would be a benchmark for this industry.

Fundamentally, Boeing IDS has decided on a "Best of Breed" approach to their enterprise IT infrastructure with the attendant support for application version and interface control. This approach has been approved by the IDS operations Council, chaired by John Van Gels. This type of system provides a lower level of functionality due to Boeings change in concept of operations, which will help to collapse existing interfaces and reduce maintenance cost. It is however easier to implement because it requires less cultural change, at the same time interfaces and integration always turn out to be more expensive to implement and maintain. It is a deliberate choice and it can be made to work.

Overall: This second visit completes our teams meetings with the Rotorcraft Division and their response to the team's survey questionnaire will add important data to the database. They have an ambitious but well managed Transformation to Lean program.