CASE STUDY
LEAN FROM START TO FINISH

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In today's defense budget climate, contractors are required to provide innovative, superior performing products at a reasonable cost. Critical to achieving this goal is a start-to-finish approach to Lean that extends from early design through to manufacturing, management and administration

Traditionally, when industry refers to reducing waste and improving yields, the context is first assumed to be manufacturing-specific activity. Materials and how they are cut, cast, molded, shipped and assembled are a big element in the cost and productivity picture. Here at Boeing, Lean is really about everything that we do, not just manufacturing. It's top to bottom and lateral across every facet of our company. What happens in each department affects overall product performance and affordability.

Parts 3-D Renderings

Figure 1.0. Legacy Block III L/H Aft Avionics Bay Door – Looking Outboard

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Realizing this, we are focused on company-wide communication, measurement and continuous improvement. Integrated Product Teams (IPTs) systematically share the challenges and the solutions. This builds a culture of awareness about root efficiencies and how one action impacts the next.

Within Boeing Mesa, where the Apache Longbow AH-64D attack helicopter is designed and manufactured, we are working hard to expand the science of Lean so that we can account for subtle causes and effects that will serve to improve our quality, profitability and delivery of defense systems. To this end, Value Engineering (VE), Lean "Plus" and Design for Manufacture and Assembly (DFMA) are brought together in a structured, collaborative environment to not only guide design and production, but fully leverage procurement, customers, suppliers and all other stakeholders.

Product design impacts manufacturing, which then impacts planning, administration, supply chain management, service and profitability, concluding in a cycle where future contracts are either awarded or deemed too expensive. Knowing this dynamic, we increasingly concentrate on the role that conceptual design plays in improving everything that follows downstream in the Lean Plus culture. Let me give you an example.

Recently, a defense customer requested a new, specific electronics configuration that also meant creating a corresponding change in the layout of the Apache helicopter Avionics Bay Doors. The new doors were originally estimated in a metal-bond baseline configuration. Boeing airframe engineers, however, collaborated very early on with Army engineering to study and quantify the benefits of abandoning the older metal-bond bay doors in favor of a completely new composite door.

With upfront design as a driving business principle, the IPTs looked ahead at the full issues and implications of the Avionics Bay Door engineering change order to make an efficient and speedy decision that would benefit its customers. Our IPTs are self-directed and often co-located, so that process workflow moves forward with few reversals.

In this case, the team completed a current-state, value-stream map exposing existing areas of potential weakness, waste and opportunity where more modern designs, materials, processes and tooling could outperform past practices. The team also deployed advanced model-based 3D systems, simulations and benchmarking to find the highest value design.

Starting from concept designs, DFMA product simplification and cost estimating guided engineers toward the most desirable configuration by identifying areas for lower part count and fewer touch-labor hours in the assembly process. This effort, in turn, reduced the likelihood of non-value added scrap, rework and repair occurring downstream.

Boothroyd Dewhurst DFMA fits tightly into the Lean Plus and Value Engineering (VE) methodologies at Boeing because it quantifies trade-off decisions on structural efficiency that teams routinely debate. With fewer parts that incorporate greater functionality, DFMA-driven designs significantly cut down on the organizational overhead and trailing expenses that shadow every component an aerospace company produces and sends into service.

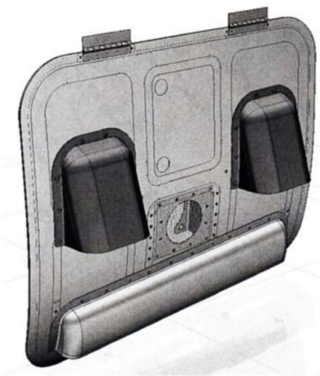

Figure 2.0. Legacy Block III L/H Aft Avionics Bay Door – Looking Inboard

Figure 3.0. New, Block III, 1-Piece SLS Screen Concept

RESULTS FOR THE AVIONICS BAY DOOR:

The new doors now have modular, reconfigurable components such as molded-in one-piece louvers (Figure 4.0), selective laser sintering (SLS) processed nylon materials, and common off-the-shelf hardware that allows for easy scaling, modification or expansion should future customers require different electronics packages.

The revisions are forecast to reduce detail manufacturing to approximately 86 percent of the metal-bond legacy doors (Figure 1.0). Total part count was reduced by 22 percent (calculated at component dash-number level, not composite ply-count). The new designs negate the requirement for legacy assembly methods requiring massive and costly “monument” facilities, assembly jigs and detail fabrication tooling.

Table 1.0. Lean Plus/DFMA/VE Project Results

	Legacy, Metal - **Before** DFMA	New, Composite - **After** DFMA	Percent Savings
Parts Count	90	78	13
Special Tooling	65	8	88
Processes	9	7	22
(Mesa) Touch Labor	27.5	20	27
Recurring Cost	Proprietary	Proprietary	~91.5%
Weight (lbs.)	9.23	7.88	15
Cost Avoidance	Proprietary	Proprietary	~75% current
CoRRS (Intangibles)	Proprietary	Proprietary	<1 defect/AC

With the advent of digital model definition and closely integrated numerical-control (NC) equipment, tooling strings for the new composite doors are roughly 13 percent that of the metal-bond units. Design, engineering and development resources are estimated at roughly 80 percent of legacy versions. And these estimates are conservative; the IPTs believe the numbers may be even better due to the independent research and development done up front, which integrate both initial analyses and conceptual layouts.

DOWNSTREAM SAVINGS FROM UNDERSTANDING CAUSE AND EFFECT:

Engineers developing the new composite doors also took into account the ability to readily service and replace parts or assemblies at aviation unit maintenance (AVUM) levels. In fact, today's engineers analyze the entire product lifecycle in order to create robust designs that meet the requirements of each discipline and community—from manufacturing to maintenance and field support.

The newer designs now lend themselves to lower field repairs and refurbishment costs. Subsystems install easily and have lower production cycle-times. The redesigned doors no longer require hand-layout and hinge-stock fastener patterns that are typically brought on at the assembly stage.

Switching to a more capable manufacturing process has brought added cost-avoidance benefits and other intangible savings. Aging special tooling previously required expensive, cyclic overhaul. Wear-type tooling such as sheet metal forming dies, drop-hammer dies, shearing and punching tools and facility assembly jigs were also expensive to maintain.

Figure 4.0. New, Block III L/H & R/H Composite Avionics Bay Doors

The new generation of tools, however, consists of non-wear type aluminum bond jigs as well as aluminum holding fixtures for subsequent NC trim and drill operations. Similarly, the current holistic approach toward lean manufacturing uses fast and efficient NC ply-cutting and laser ply-locating, as opposed to costly, cut and ply-application templates. This equates to fewer nonconformance activities, less material waste and better cost avoidance in cyclic tooling refurbishment—quite an improvement on historical manufacturing approaches!

Now, previously qualified, engineered materials such as plain-weave and 5-harness, pre-impregnated carbon-fiber/epoxy composite materials are employed in the primary structure. Composite sandwich panels use lightweight, foam-core stiffeners that are NC machined (shaped) using a highly capable ultrasonic knife cutter. Legacy intake screens—some with 10 subassembly parts—had been relatively complex sub-assemblies requiring special tooling and laborious assembly methods that included using paste adhesives and solid rivets. The redesigned SLS screen is all one piece (Figure 3.0).

Although SLS part repair procedures are in the infancy of their development, the ability to rapidly create parts, without tooling, allows original equipment manufacturers to maintain a min/max inventory. As a result, Aircraft on Ground (AOG) are no farther away than a purchase order and overnight shipment, to any global location. This means savings.

Design simplification has certainly been aided by evolving manufacturing technologies. Legacy aero thermal shields and ducting made of Kevlar™, fiberglass/epoxy and thermoplastics (note the three different materials) had required abundant labor and tooling-dependent processes. Now, nonstructural components use newer SLS technologies in lieu of the multiple materials and processes previously required. In addition to the cost benefits of fewer parts and tools, designers are able to reduce component flyaway weight, a major performance gain in our industry.

As we at Boeing seek to improve the cost and performance of each generation of products, we know that Lean, value-focused thinking must start early, involve everyone and include a deep understanding of the causes and effects that interweave engineering with business and customer satisfaction. Advanced tools—from Model-Based Definition (MBD) to DFMA best practices and Dimensional Management and Advanced Technology Assemblies (ATA) analysis—are helping make the journey to fully Lean product development fast, assured and rewarding.

Reference: http://www.pddnet.com/articles/2014/01/lean-start-finish