LEAN EFFECTS ON AEROSPACE PROGRAMS (LEAP) PROJECT

F-16 CASE STUDY REPORT

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1 INTRODUCTION AND OVERVIEW

1.1 Introduction

The F-16 Falcon project began production in 1977 under what is now the Lockheed Martin Aeronautics Company. Since its inception, it has been, and continues to be, the world's most popular fighter jet[1], used (or on order) by the United States Air Force (USAF) and numerous other countries, including Belgium, Denmark, the Netherlands, Norway, Israel, Egypt, Korea, Pakistan, Venezuela, Turkey, Greece, Singapore, Thailand, Indonesia, Bahrain, Portugal, Taiwan, Jordan, United Arab Emirates, Italy, and Chile. There are two sets of F-16 models, beginning with the F-16A/B: the single-seat A as the combat version, and the two-seat B version as a fully operational trainer. The F-16C/D models were upgrades to the A/B developed about six years after the originals. Although there are only two sets of model designations, there have been many improvement efforts incorporated in various productions groups of aircraft known as block upgrades. The first delivered A/B aircraft were block 01 which evolved to block 05, block 10, and block 15 over a period of three years. Almost three years later, in 1984, block 25 aircraft were introduced with the C/D designation. Since then, block 30/32 were introduced in 1986, block 40/42 were introduced in 1988, block 50/52 were introduced in 1991, and block 20 was introduced in 1996 for Taiwan. Most recently, advanced block 50/52 versions and block 60 aircraft are under development with scheduled first deliveries in 2002 and 2004 respectively. Although the F-16C/D model designation has remained the same throughout many block changes, the block 40/42 and 50/52 upgrades were more significant than the block 25 upgrade when the model names were changed. Likewise, the block 60 upgrade currently in development has virtually all new internal systems. This continuous, evolutionary development strategy has substantially increased the functionality of the system while the dimensions of the airframe has remained constant. The F-16 has been able to maintain the benefits of being a small fighter while improving the total system performance over the slow course of numerous upgrades. The F-16 is positioned as the "backbone of the worldwide fighter fleet well into the 21st century"[2]; specifically, it is projected to remain over 40 percent of the USAF fighter force in 2015, and in operation with the USAF and international air forces beyond 2030[3].

1.2 Main Findings

This report follows the F-16 journey of improvement over the last decade or so. Since an increase in focus on cost and quality in the early 1990s, there has been gradual but continuous progress along this journey. Most remarkable are some of the more recent changes, following the implementation of lean principles and practices across the program.

Some of the key results from improvement on the F-16 program have been identified. As shown in Figure 1.1, there has been less than three percent increase in the price of the Contractor Furnished Equipment (CFE) portion of the aircraft in the last ten years (using a USAF block 50 variant as a baseline).

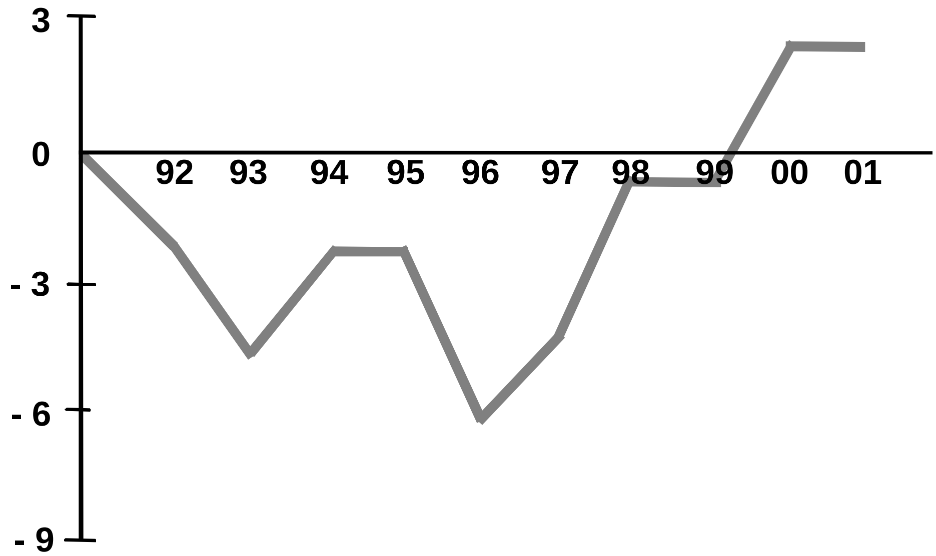

Figure 1.1 **Percent USAF CFE Price Difference of F-16 aircraft from 1990-2001 (block 50, constant year dollars)[4]**

Not only has Lockheed Martin been able to keep the price nearly constant, but they have a record of 100+ months of consecutive on-time deliveries. They have developed and produced over 100 different type versions of this aircraft (i.e. tailored configurations) for their various customers. At any given time, there are several different type versions in production in the same line. Because of this, each aircraft that goes down the production line is to some extent custom built, and the F-16 has shown that lean practices are effective whether you are producing one or one hundred. All of these achievements have been made despite fluctuating demand heavily contingent on international sales and a substantial drop in production rate from 200+ to 24 aircraft per year. At the same time, these improvements have been accomplished with minimal capital investment, while simultaneously increasing the capability of the aircraft system, and perhaps most impressively, on a well established, legacy airplane.

1.3 Approach

The Lean Effects in Aerospace Programs (LEAP) project, an exploratory study being undertaken in response to a request from members of the Lean Aerospace Initiative (LAI) Executive Board, seeks to answer the following questions:

- What has been the impact of "lean" on the US aerospace industry, as measured by key outcome metrics?
- What has been the degree of penetration of lean principles throughout the US aerospace enterprise?

To address these questions, a two-track approach was employed: (a) a questionnaire survey of US aerospace enterprises and (b) six focused case studies covering different industry sectors. Although a common approach was used for each study, this report covers only one of the case studies conducted.

The purpose of the case study was to investigate the impact and diffusion of lean concepts at the individual program level, providing a more fine-grained understanding of key outcomes, enablers, barriers and mitigation measures used. The case study also helped develop an understanding of the larger context in which lean implementation took place, specifically the dynamics of how the organization deployed and diffused lean ideas to improve their performance.

A structured interview methodology was used to gather information during the on-site case study. The site-visit was conducted on the 28-29 January 2002 by two researchers interviewing nine Lockheed Martin Aeronautics Company individuals. In addition, several additional sources were used for background information, such as *Jane's All the World's Aircraft*, and Lockheed Martin Aeronautics Company presentations and reports.

1.4 Organization of the Report

This report provides a profile of the program and product and an overview of the larger context – the extended enterprise. The implementation of lean, including some highlights and achievements, enablers and practices, as well as external factors and developments will be addressed. That is followed by a look at remaining challenges and future opportunities, and the paper is concluded with a section on lessons learned and concluding observations.

2 CASE STUDY PROFILE

2.1 Summary Case Study Profile

The F-16, shown in Figure 2.1, is a small, single engine, lightweight fighter originally intended for "high-performance day/visual air combat"[5]. Early in development it was "extended to include air-to-ground capability with radar and all-weather navigation"[6], becoming a multi-role aircraft.

Figure 2.1 **F-16 Block 60 Illustration**[7]

Prototype development began in 1972, with first flight in 1974. When it first entered service in 1979, it was considered "cutting-edge". In addition because of its design – an integrated system architecture with a modular avionics architecture – it has been possible to integrate new systems as technology has become available.[8] To date, there have been 11 block upgrades, two major modifications to bring older aircraft up to new standards, and a total production of over 4 000 aircraft, delivered to 19 countries.[9] In that time, "F-16s have been employed in combat operations by ten air forces and have accumulated more than 100,000 combat sorties and 300,000 combat hours…Only five F-16s have been lost to enemy ground action, and each of these cases the F-16 pilot ejected safely."[10]

2.2 Larger Organizational Context

The F-16 plays a major role in the Lockheed Martin Aeronautics Company, which is part of the Lockheed Martin Corporation. This business area is responsible for the design, development, production, test, sales, and support through upgrade design and development of the F-16 and numerous other military aircraft, as well as conceptual research and development activity. Within the Aeronautics Company, combat aircraft, including also the F-22 and JSF among others, represent 65 percent of business. The remaining 35 percent is split between air mobility (24 percent) and aeronautical research and development (11percent). [11] In the Corporation, the business mix is as follows: 50-55 percent U.S. defense, 25-30 percent civil government and commercial, and 20-25 percent international.[12] As a result, the company's partners, subcontractors and supplier base are widespread, including Northrop Grumman, BAE SYSTEMS, Boeing, Pratt & Whitney, and GE Aircraft Engines, as examples. The F-16 in particular is a program co-produced in five final assembly lines with manufacturing in 13 countries and over 3 900 multiple equipment and component manufacturers.[13] To remain competitive the Lockheed Martin Aeronautics Company has adopted many new principles to provide a consistently high quality product on-time and at low cost.

3 EVOLUTION OF LEAN IMPLEMENTATION

3.1 Highlights of Lean Transformation

To understand the significance of the achievements of the F-16 program, it is important to trace the story of how they were reached, identifying factors that enabled this performance along the way. In the early 1990s, the F-16 program was the vast majority of business for the Ft. Worth division of General Dynamics (since 1993 part of Lockheed, and since 1995 Lockheed Martin). At that time, when the program faced quality problems and cost over-runs, the entire company was affected. Pressure from the USAF customer forced changes in the organization. To maintain the lifeblood of the division, these changes were focused on the most significant program at the time, the F-16. It was important to reduce the number and cost of non-conformances. This is a *turning point* of the F-16 program, when lean principles and strategies were consciously implemented, whether or not they were explicitly identified as lean improvements.

In 1992 two new vice-presidents were brought in to operations and engineering, and a major shift in management attitude occurred to increase focus on both internal and external customers. Within engineering, this meant thinking of the production line as a customer. In operations, meetings were implemented between the new VP and the union employees, without intermediate management or supervision, to air concerns and to build trust within the organization. At this point, there was also a significant emphasis on metrics. Technical issues, schedule performance and cost began to be measured at the Work Breakdown Station (WBS) level.

The period between 1992 and 1995 was focused on identifying and pursuing core competencies. The division transitioned from the mentality of "we do everything" to the mentality that "we do what we're good at", specifically, design, systems engineering, test, integration and assembly. As part of this focus, supplier networks were consolidated into a central Materiel Management group.

This was followed in 1996 by an internal restructuring, and the implementation of a defined Integrated Product Team (IPT) environment. This clearly identified the focus of the program groups and the core functional groups. For example, the engineering core functional group, spanning all programs, allotted engineers to each program but also maintained a central group to be responsible for training and process development. On each program, IPTs were aligned with a system decomposition. Each IPT included both designers and the downstream functions: manufacturing planning, manufacturing engineering, and tool design.

F-16 Lean Transformation Timeline

Early 1990s:
- Poor quality and cost performance issues
- Customer dissatisfaction

1992 (*Turning Point*):
- New VPs of Operations and Engineering
- Emphasis on customer
- New policies to improve quality

1992-95:
- Focus on core competencies
- Supplier networks consolidated into central group

1996:
- Internal restructuring to separate programs and core functional groups
- Formal IPT implementation on programs

1998:
- Formalization of Lean group
- Pilot projects in lean production
- Interface between engineering and production improved

2000-01:
- Corporate focus on lean showing top-down commitment
- Focus on supplier networks and enterprise issues

By 1998, there had been significant improvement in many areas, spurred by efforts in the Continuous Improvement group. Between 1998 and 1999, a Lean office was created and improvement efforts across the company started to come together under the name of lean.

Implementation occurred on all fronts, from advancing technologies to improved flow. Pilot projects to create lean production cells were initiated, as well as a project to improve engineering response time to the production line. Since 1999, these pilot projects have been used as models for further implementation of lean improvements. The ALE-50 pylon (rigid externally mounted structure) has become the model lean production cell, and the Build To Package (BTP) Support Center[14] initially started to support the forward fuselage assembly now encompasses all of production except the flight line support. Most recently, in 2000 and 2001, the Lockheed Martin Corporation has decided that while the bottom-up improvement approach has yielded improvements, there is even greater opportunity when combined with a top-down commitment to improve the entire enterprise, across programs and across organizations with suppliers and customers.

3.2 Major Achievements

An initial overview of the F-16 shows how remarkable the aircraft itself is, but the nearly constant cost and the record of almost nine years of on-time delivery show how impressive the program has been. It also highlights some contributing factors to why over 4 000 aircraft have been delivered to 19 countries with 48 follow-on procurements (repeat customers) by 14 countries and over 300 new orders in the last two years.

As alluded to previously, these program accomplishments are the results of a transformative journey of improvement. A series of “smaller successes” have made major contributors to the program level results. For example, the ALE-50 pylon example mentioned in the previous section resulted in a baseline cycle time reduction of 92 percent (from 166 days to 14 days) and a labor time reduction of 82 percent, from 175 hours to 33 hours. This pilot project has led to reorganization in other areas of the F-16 production line. Implementing a pull system for inventory and parts in the forward fuselage section has resulted in a 50 percent reduction in WIP (Work In Progress) as well as a 58 percent reduction in inventory, equitable to approximately $350 million annually. Implementing standard work procedures and Electronic Work Instructions (EWI) in the production line has reduced cycle time 30-35 percent. Specifically in the wire harness installation in the forward fuselage area, EWI have resulted in a 200 hour per unit improvement. The BTP Support Center to improve engineering support of the production line has reduced cycle time by 85 percent and cost by 20 percent. What used to take two days to respond to now takes about ten minutes. While the quantification of these results is primarily focused in the manufacturing area, they have involved changes in many parts of the organization. It has taken a fundamental shift in thinking for each part of the F-16 program to realize that they are part of a larger process with upstream influences and downstream customers. There have been cultural changes in the organization affecting the way engineering interacts with manufacturing and suppliers to the way suppliers are managed and the way material, components, and sub-systems are procured. These differences are much harder to quantify with numerical results, but are equally, if not more important.

3.3 Key Enablers, Processes, and Practices

Along the transformation described, there were numerous enablers, processes, and practices that were important to the achievements reached. In detailing the timeline of the transformative journey, some of these were suggested, but it is appropriate to spend more time describing the factors that in fact led to the results described. It is important to realize that some of these enabling factors are localized to a specific group or project and others affect more holistic change at the program or company level.

With the introduction of new vice presidents in both operations and engineering, the change in leadership attitude to increase focus on both internal and external customers resulted in a cultural shift that started to build trust and respect between various levels of the program. “Skip level” meetings between the VP of operations and union employees on the production line were implemented as one way of increasing the communication in the program. No intermediate management or supervision were present at these meetings. In fact, they are named “skip level” for the idea of “skipping” levels of the organization. The goal of these meetings was to address issues openly for the ultimate purpose of improving the production line activity. Bi-weekly breakfast meetings including both union and salaried employees were also implemented for the same purpose. Another enabler was the creation of the Joint Workforce Employee Participation Program (JWEPP). This program is summarized in a one page document between Lockheed Martin and the union setting up the agreement that if a union employee improves their job so much that it goes away, they will not get laid off. The conscious focus on internal customers and employee stakeholders enabled the cultural change required to support significant organizational improvement.

Additionally, metrics became key in measuring performance at all levels. These metrics cover performance broadly, addressing performance with respect to technical requirements, schedules, and costs. The point of creating metrics was not only to measure performance but also to set goals and targets for each area measured. The metrics continue to be collected monthly.

Sometimes enablers come in the form of removing practices instead of implementing them. This was the case with the reduction of the number of Quality Anomaly Reports (QARs). At one point, there were a large number of unresolved QARs, which often took so long to return or reply to that the production line was delayed causing production schedules to slip and unfinished work to move between stations in the line. Although QARs are still in use today, the number of them has been significantly reduced, and the length of response time has also been reduced. This practice was removed as part of a program called Operation “Clean Sweep”, which literally cleaned-up the program by reducing waste, stored parts, and clutter on the manufacturing floor and throughout the organization. The alternative method that was implemented to more effectively handle quality issues was to place error codes on Engineering Change Notices, enabling root cause analysis. Combined with a special team from Operations to track root causes unfinished work was prevented from being moved from station to station in the production line. Everyone in operations became accountable for what they were producing, and engineering began to understand how, by considering Operations as their customer, they could be part of the solution to issues in the production line instead of being part of the problem. This longer-term solution to quality anomalies aligns nicely with the lean tenet to pursue perfection.

After initiating a significant cultural change through leadership and revamped processes, the foundation was laid for continuous improvement. During the mid 1990s at the division level, there was a focus on core competencies and an internal reorganization to form program IPTs and core functional groups. On the F-16 program, software quality was improved by standardizing processes in software engineering by pursuing the Software Engineering Institute certification. This is one program-level example of improvement enabled by the division level change to a more process oriented focus.

One of the biggest successes in lean has been IPTs. The key to IPT success in the F-16 program has been their proven profitability. They have been particularly effective in bringing a manufacturing interest into the engineering phase, reducing cost and increasing quality. Certainly not a unique phenomenon, but undoubtedly more visible on the F-16 program is learning. Due to the variety of modifications and customers, and the fact that several variations may be in development at the same time, it is necessary to learn and share between various development groups. The program cannot afford to invest money to "relearn lessons", and mistakes caught by one group must be flowed to all other groups. This is also important for configuration control and to ensure that each type variation can be produced on the same production line. Along the lines of software, data commonality has been essential in communication. Simple things, such as the use of the Microsoft Office suite and templates have helped to ease the difficulties encountered in multi-variant systems. An example of this is ICAS (Integrated Cost And Schedule), which is used for scheduling.

Following the formalization of a Lean office, several pilot projects were initiated within the F-16 program. In part due to the early focus of lean being on manufacturing, but also in large part because manufacturing is within the company, it is an obvious starting point for change. Two early pilot projects to create lean production cells were the vertical stabilizer and the ALE-50 pylon. These projects had a couple of common characteristics. Selection of projects was based on whether or not the project was likely to be successful; factors such as, was the construction simple and could the scope be well defined, were also considered. Careful selection of the project is tied to the effectiveness of process mapping to identify waste in the process (value stream analysis). The combination of project selection and using a structured tool like process mapping to help identify and implement improvements was an enabler for the early success of these pilot projects. Other enablers in manufacturing were the use of videotaping and photography to capture a process. To provide the appropriate tools at the point of use in a manufacturing process, the tools were taken out of individual employees' tool boxes, they were sequenced and color coded by operation, packaged in a shadow box, and set on a slide line that allowed the shadow box, and more importantly the tools, to move with the operator as they worked around the parts. Manufacturing improvement projects have been enabled by Blitz kaizen events including a multi-disciplinary team of mechanics, manufacturing planning, tooling, and at recent events, product development.   These pilot projects have shown that it is possible to achieve improvements using lean practices and tools. Since these successes, the program has been working on expanding lean concepts throughout the production line. The most recent opportunity has come as a result of

Lockheed Martin winning the JSF competition. It became necessary to reorganize the factory floor, and move the F-16 line. Though this was a disruption, the F-16 team took advantage of the situation to improve flow on the floor. As one employee stated, "moving the factory floor to make room for JSF started out as lemons, but has been turned into lemonade."

There are other examples of practices and enablers that have shown accomplishments in manufacturing, but have really resulted from changes and improvements in other parts of the enterprise. For example, in the supplier networks area, the program has worked with suppliers so products come from vendors ready to install for point-of-use. In the engineering area, achievements in supporting of the production line have been enabled by the BTP Support Center. Establishing this as a separate center, with its own resources, Lockheed was able to provide a single point of contact for shop floor support. This resulted in reduced dependence on Requests for Engineering Action (REAs). Piloted in 1999 and set on the factory floor, engineers are called to the center when necessary, and return to their posts when the task is complete. Other recent enablers have been making engineering responsible for the reduction of shortages of both make and buy parts. Implementing tools such as JEDI, Joint Electronic Development Initiative, an internal tool to integrate CAD systems with wire routing has also been an enabler. In this case, improving wire routing and the installation of wire harnesses is an opportunity for significant savings. New tools, new manufacturing layouts, and working with suppliers have all enabled improved performance on the F-16 program. This improvement, specifically in the area of quality, in addition to getting the government customer (Defense Contract Management Agency – DCMA) involved in the improvement process has enabled electronic buy-offs of some parts and sub-assemblies, with only periodic checks from DCMA. In this case, the pay-offs for implementing lean are replicating themselves where one improvement is leading to another, promoting a cycle of continuous improvement.

Most recently, sustaining change and improvement have been enabled by more broad factors such as leadership. Setting up expectations of success and then providing the management incentive, drive, and vision to make allow these expectations to become self-fulfilling prophecies is an important strategy. Without capital investment, having management that is willing to use indirect budget to implement improvements is another enabling factor. One practice the F-16 has found important is the creation of Collective Accountability Team Members (CATMs). These CATMs are related to objectives set at the vice-president level. CATMs get people out of their silos and tie them to the objectives as stakeholders. Each CATM is the owner for the objective who has the support of all the stakeholders. This is one way to focus the program on common goals.

3.4 External Factors and Developments

In every story of transformation within an organization, there are some factors that are internal and others that are external. Although it is nearly impossible to separate the effect of the various factors, it is important to identify as many as possible. This section is dedicated to naming the external factors that came into play in the F-16 improvement story. The most significant external factor was the imperative to change identified as the turning point. Cost performance and quality could have continued along a downward trend for longer than they did if not for the pressure from the Air Force customer which forced the realization that the company would not stay in business without significant change in the way they were running their programs. In addition, there was added pressure from international sales and competition on the open market.

The other major external development worth recognizing is the technology advancements in the computer and information technology areas. While it is not likely that a company that has gone untouched by this development, some of the improvements made on the F-16 program are directly attributable, at least in part, to technological advancements related to handling information. For example, substantial improvement is attributed to implementing standard work and Electronic Work Instructions on the production line. The magnitude of this improvement would have been different if not for the ability to implement an electronic, computer based system to illustrate the instructions. Another example in the engineering area is the JEDI system mentioned earlier to improve wire harness routing. This tool came out of the Virtual Product Development Initiative (VPDI) that relies heavily on new computer related, technology developments.

4 REMAINING CHALLENGES AND OPPORTUNITIES

4.1 Remaining Challenges

The journey of improvement is not always easy. Implementing principles of lean is a long-term and evolutionary process. Getting from the *turning point*, where change was consciously initiated, to the current state, there have been some barriers. Similarly, there are barriers that remain challenging future accomplishments. In some cases, the enablers that have allowed the F-16 to improve, sustaining it as a viable program, are related to the issues that remain as current challenges.

As stated in the previous section, the early transformation of the F-16 program was cultural in nature. New leadership was brought in, and a new mentality was established. The barriers faced in this instance were primarily those of tradition. While in some cases, tradition can have a positive impact by setting up expectations to succeed, at other times, business as usual is not productive.

During the mid 1990s focusing on the core competencies of the organization in fact created a challenge that is still being dealt with today. Off-loading work that is not aligned with a core competency has worked against supplier integration. There has been a strong cultural impact with the represented production line employees who may have "lost" the work that was off-loaded. It creates tension anytime there is an attempt to more closely integrate the supplier into the production line because the trust has been broken.

One challenge that the F-16 has faced for some time, and will continue to face in the future is the lack of certainty regarding the future size of the program. Relying primarily on new and follow-on procurements by international customers to increase the backlog of orders for the aircraft affects long-term program planning. It becomes difficult to justify the cost of change – of improvement. Compounding this is the fact that it can be very hard to determine the potential value of improvement, and in many cases people must rely on intuition. The example mentioned earlier about rearranging the factory floor substantiates this. The cost of moving the production line equipment and tools was unjustifiable. The value of moving the floor became apparent when space needed to be made for the JSF. This created an opportunity that the F-16 could leverage for improvement.

Another challenge that remains for the F-16 program is a difficult issue that faces any organization with a continuous improvement strategy. Specifically, a narrow focus and the big picture are by nature opposites. There is always a tension between short-term impact and long-term benefit. For many people it is difficult to see the benefits, and a question such as "how is this going to help me, right now, and what is the risk associated with taking it on?" often gets asked. It is hard to convince people that spending now will help lower costs later. Another facet to the "narrow focus vs. big picture" dilemma is trying to balance sacrificing part of an allocated budget for the benefit of the whole program. Individuals are not incentivized to voluntarily relinquish resources they control to improve the program as a whole.

4.2 Future Opportunities

Perhaps one of the biggest enablers of the journey of improvement for the F-16 program is the continuous improvement culture of the organization. During the case study site visit, the accomplishments already noted were captured, but numerous times, future opportunities for further advancement were identified.

Looking ahead, there is significant opportunity to learn from other programs. Within the F-16, it is possible and fairly easy to share between the various customer groups and development efforts. The boundaries within the program are relatively soft compared to those between the F-16 and other programs within Lockheed Martin Aeronautics. Sharing of knowledge and experience between programs is typically facilitated by the movement of people from one program to another. This has not proven to be a highly efficient way to learn as an organization. The JSF program has been the biggest example of learning from other programs, but as the JSF program gets underway, it will become even more important to continue the cycle of learning by reusing knowledge from the JSF program on others such as the F-16.

Another opportunity is the issue of incentive. The fact that government contracts are not flexible in allowing companies to offer incentives to their subcontractors and suppliers presents an opportunity for improvement. Considering that approximately 60 percent of the cost of the aircraft is procured from suppliers, this is a fertile opportunity to expand the focus of improvement from within the F-16 program at Lockheed Martin to the entire expanded enterprise, from customer to supplier network. Changing the contract and incentive structure would enable taking advantage of this opportunity.

4.3 Lessons Learned

By understanding the transformation that has taken place on the F-16 program – what has enabled change, what challenges remain, and where future opportunities lie – there are lessons learned from the experience that have been identified. The F-16 program at Lockheed Martin has benefited from high quality leadership that has continually appreciated and recognized the contributions of the employees working on the program. Getting the union on board and involved in improvements to the program has also proven to be very beneficial. It enabled early improvements and led to a bottom-up approach to implementing change. In trying to spread these improvements throughout the organization, it was determined that the bottom-up approach alone would be unsuccessful. Top-down commitment and support is also required. This has led to recent changes where strategies have been rolled down from the top and implemented with support from the lower tiers of the organization. Leadership has been a key role in both the impact and the diffusion of the improvement strategies on the F-16 program.

4.4 Concluding Observations

This case study report has traced a journey of improvement on the F-16 program beginning in the early 1990s through current day and into the future. The story began with identifying the *turning point* of the program when new management initiated practices to increase the focus on quality and cost performance. This set up the organizational culture to be receptive to changes down the road during the mid 1990s when there was a focus on core competencies and process development. The formalization of lean practices, originally in the production area, and now spreading throughout the entire enterprise is where the biggest accomplishments can be seen. It is important to realize that the journey itself enabled the transformation of the F-16 program. In the true spirit of lean, improvements have perpetuated themselves into bigger gains. Often an initial success is followed by a period of plateau, but each subsequent improvement leverages the new starting point that was set up by the previous accomplishment. In the case of the F-16, continuous improvement has become embedded in the organizational culture, and it will continue to help sustain the program into the future.

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