ENGINEERING MANAGEMENT FIELD PROJECT

UTILIZING INDUSTRIAL ENGINEERS TO IMPLEMENT "LEAN ENTERPRISE" AT COMPANY A

By Jean D'Ann Stein

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Linda Miller
Committee Chairperson

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John Bricklemyer
Committee Member

_____
Mike Kelly
Committee Member

Date accepted:_____

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Executive Summary

Industrial Engineers (IEs) have a wide breadth of knowledge that has proven to benefit organizations in a variety of ways. As process improvement experts with education in engineering, quality, and business, Industrial Engineers are skilled in the implementation of continuous improvement and lean thinking. This skillset has recently allowed IEs to work outside their normal realm of manufacturing, and focus on areas more closely related to service organizations.

At Company A, Industrial Engineers are employed within the manufacturing organization, focusing on process improvements and factory design. While Company A's core business is manufacturing, many other facets make up the entire business. With IEs only focusing on manufacturing, which encompasses only 23% of the enterprise's employees, Company A is drastically limiting the impact they can have on enterprise process improvements. By broadening the horizons for Industrial Engineers within the company, Company A can leverage the strengths of the IEs to help the entire enterprise "lean" out the process inefficiencies, cut costs, and better utilize its employees.

The scope of this project includes defining the breadth of influence Industrial Engineers can have within Company A. This includes background information which highlights the broad capabilities of IEs in process improvement and lean implementation, as well as supporting information on how lean thinking is applicable across the enterprise, particularly in service organizations. It also includes the business need for using lean thinking outside of manufacturing.

A study of how other manufacturing companies use their IEs and other employees in this expanded capacity is performed via personal interviews. These interviews are aimed at

understanding if their application of continuous improvement and lean thinking outside of manufacturing is successful, how IEs are involved in that effort, how the organization is structured, and how the company overcame any barriers in their implementation of lean across the enterprise. This information is intended to help Company A structure and deploy its own continuous improvement organization.

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Introduction

Industrial Engineers (IEs) have a wide breadth of knowledge that has proven to benefit organizations in a variety of ways. As process improvement experts with education in engineering, quality, and business, IEs have the ability to apply their skills and training to a vast range of businesses and situations. While traditionally employed in manufacturing roles, IEs have broadened their scope of influence to include not only manufacturing, but also health services, insurance, distribution and logistics, international trade, and entertainment. As a result of the broad applications in which Industrial Engineers can apply their skills, particularly in continuous improvements and the implementation of lean techniques, many IEs within the United States today work outside the realm of manufacturing, instead focusing on areas more closely related to service industries.

Given today's economy, businesses are focusing more on better utilizing their resources to stay competitive. David Brandt believes that "[t]he survival plan for these recent troubles lies in the very training and education [IEs] possess" (2009, 26-8). Given their skills in business and process improvements, it is intuitive that Industrial Engineers are the best-equipped personnel to lead the effort to improve the utilization of a company's resources.

Project Purpose

At Company A, Industrial Engineers are employed as a part of the manufacturing organization. While their work varies between different factories, they tend to focus on process improvements and factory design as their core scope of work. Recently, upper level management indicated that they were not fully aware of what the IEs are capable of

offering to the company, but that they would like to partner with the IE organization to better define their role.

As a part of the defense industry, Company A's core business is manufacturing, but many other facets make up the entire business. The company has a total of 11,900 employees, only 2,792 of whom are in the manufacturing organization. With IEs only focusing on an area that encompasses less than 25% of the enterprise's employees, Company A is drastically limiting the impact they can have on enterprise process improvements. By broadening the horizons for Industrial Engineers within the company, Company A can leverage the IE organization's ability to develop process improvements and use lean thinking across organizations such as Engineering, Business Development, Contracts, Supply Chain, Quality & Mission Assurance, Finance, and several others. This will help the entire enterprise "lean" out the process inefficiencies and cut costs across the board, in addition to improving the company's utilization of its most valuable resource: its people, which is needed to maintain a competitive advantage.

Project Scope

The overall scope of this project includes defining the breadth of influence Industrial Engineers can have within Company A. This includes background information which highlights the broad capabilities of Industrial Engineers in process improvement and lean implementation, as well as supporting information on how lean thinking is applicable across the enterprise, particularly in areas outside of manufacturing. It also includes the business need for using lean thinking outside of manufacturing.

A study of how companies with similar processes to those of Company A use their IEs and other employees in this expanded capacity is performed via personal interviews.

These interviews are aimed at understanding if their application of continuous improvement and lean thinking outside of manufacturing is successful, how IEs are involved in that effort, how the organizations are structured, and how the companies overcame any barriers in their implementation of lean across the enterprise.

Company A will be able to use this information as input in defining how to better utilize its current Industrial Engineering organization and in assessing the value of deploying lean thinking throughout the enterprise.

Literature Review

The field of Industrial Engineering has been continuously evolving since it was first recognized as a field of study. Over the past 125 years, IEs have gone from factory productivity experts to specialists in scientific process improvement and quality control. During that evolution, there have been societal influences that have caused shifts in the IE field as well. The literature review that follows includes a history of the Industrial Engineering field, with a focus on the integration of lean thinking into the IE scope of work. It also includes the more recent societal and economic influences that have broadened the IE field into service-related organizations. This section concludes with how universities have altered their IE curricula to reflect the new business needs of today.

The Evolution of Industrial Engineering

Industrial Engineering has been a very dynamic field since its inception. The field was founded in the late 1800s, based on Frederick Taylor's focus on "cutting factory waste and improving productivity" (Balasubramanian 2010, 35), in the post-industrial revolution era. This became the introduction of scientific management concepts to the factory floor. Within the next 50 years, Industrial Engineering evolved into "innovation in mass manufacturing, production control and management, and human-machine interface design" (Balasubramanian 2010, 36). In general, IEs became leaders of mass production, with a strong focus in quality, productivity, and human factors (Kuo 2003, 42). The focus in quality led to standardization, which heavily defined the work of many Industrial Engineers in time standards and work measurement (Role of the IE 1996, 18). During World War II, IEs expanded their scope to include Operations Research (OR), or the application of "sophisticated mathematical models and techniques to solve numerous

industrial problems relating to production, distribution, inventory management, forecasting, facilities design and resource allocation" (Balasubramanian 2010, 36). Later, in the 1970s, quality control circles became a part of the Industrial Engineering field, as engineers began learning about the strengths within Japanese manufacturing techniques (Bodek 2004, 58).

Expanding on that knowledge from the Japanese, IEs in the United States began using lean thinking techniques, a concept the Japanese had been refining since the 1930s (Bodek 2004, 58). Lean thinking is a term commonly used in the Industrial Engineering field to describe the focus on value as defined by the customer and the associated focus on value-creating tasks with the elimination of non-value-creating tasks. Lean thinking became so popular in the IE field that it has become a part of the core curriculum within IE departments at universities across the U.S.

There are five fundamental lean principles that can guide organizations:

1. Value – Identify value from the customer's perspective, whether internal or external
2. Value stream – Identify how value is delivered by mapping the value stream and understanding all activities
3. Flow – Ensure a simple, seamless, and standardized flow of information and minimize or eliminate all "wastes" that do not create value for the customer
4. Pull – Only deliver what is initiated by customer demand
5. Perfection – Eliminate all waste via continuous improvement (Abdi, Shavarini, and Hoseini 2006, 193-196; Ehrlich 2006, 41; Maleyeff 2006, 675-676; Piercy and Rich 2009, 55-56)

These lean principles have proven to be so successful in manufacturing that they are still used across the United States today.

In the late 1900s, when computers became staples in the workplace, globalization started to become more feasible. Businesses began moving manufacturing facilities and jobs overseas in an effort to lower the cost of doing business.

Finally, at the turn of the century, services began to overtake the manufacturing sector as the prime employment generator for many fields in the United States, with the Industrial Engineering field trending in the same direction (Balasubramanian 2010, 37). Today, many Industrial Engineers view service organizations as the new major area that can benefit from the types of process improvements they have been providing to the manufacturing world for over a century. In 2001, Erin O'Briant found that, "[w]hether it's applying industrial engineering to non-manufacturing parts of a company, figuring out supply chain logistics, or optimizing the enterprise, many IEs believe the next big thing for the profession is not a particular technology or program but lies in the bigger picture: systems overviews and the expansion of industrial engineering beyond traditional boundaries" (29). This transition into the service industry led Parasuram Balasubramanian to state that, "going forward, it would be apt to call the profession industrial and services engineering. In short, IEs need to become ISEs" (2010, 37).

The Need for IEs in Service Organizations

While the term "service" is frequently used in research discussing the expansion of the IE discipline, the word is so broad that it can easily be misinterpreted if not defined. Snee and Hoerl define service processes as "all nonmanufacturing operations and activities, either in nonmanufacturing industries or within organizations that manufacture" (2009,

38). Quinn and Gagnon expand on this definition, stating that "[s]ervices are actually all those economic activities in which the primary output is neither a product nor a construction. Value is added to this output by means that cannot be inventoried – means like convenience, security, comfort, and flexibility – and the output is consumed when produced" (1986, 95). This combined definition is the one that will be used for the purpose of this research project.

Using the above definition, it becomes apparent that "any organization…includes a number of internal professional service units that ultimately affect its long term performance. Each unit provides one or more services to internal customers, or to external customers, or to both" (Maleyeff 2006, 674). In 2005, Matthew May indicated that most of the corporate world was engaged in the primary task of managing information, as opposed to manufacturing hardware (33). The U.S. labor data in Figure 1 reinforces May's point. Although the majority of an organization's effort is in the service arena, it is still difficult to quantify performance in these service units and, in turn, evaluate and improve upon that performance. This is where Industrial Engineers are starting to provide extensive support.

In the aftermath of World War II, Japan was left with few resources so Toyota had to find a way to do more with less. Thus began the company's use of lean thinking outside of manufacturing (May 2005, 34). The application of lean thinking to the service organizations within the business, in part, helped make Toyota one of the top vehicle manufacturers in the world by the 1990s.

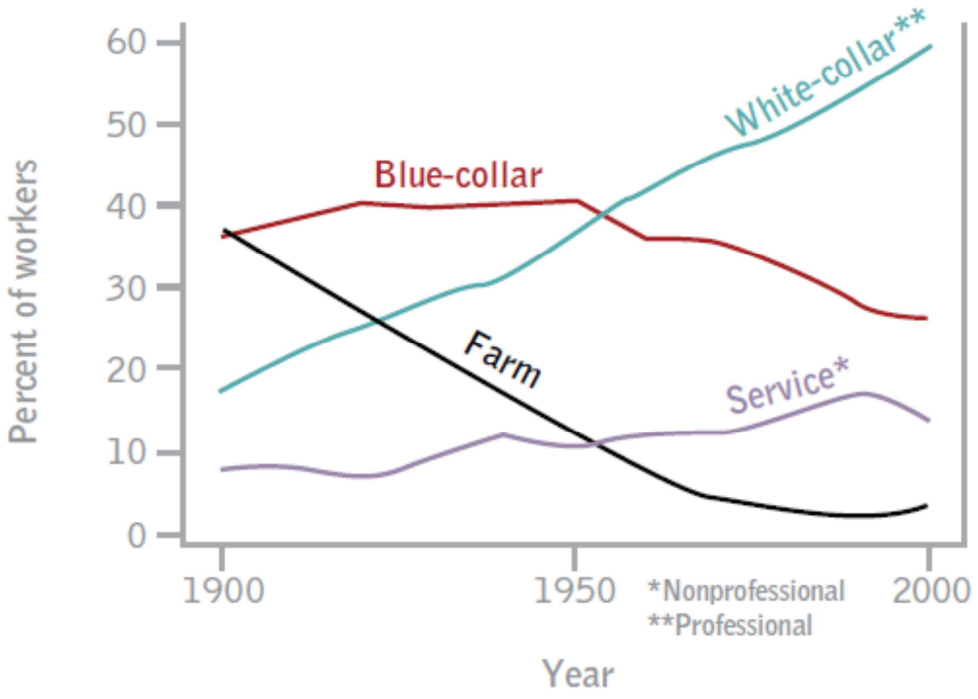

Figure 1: Occupational Distribution of the U.S. Labor Force (Snee and Hoerl 2009, 36)

Today, external pressures are driving businesses to "need to reduce costs, increase flexibility, raise quality, lessen variability and shorten lead times" (Abdi, Shavarini, and Hoseini 2006, 191). Piercy and Rich indicate that "[s]ervice research has highlighted a parallel between the increasing costs and declining quality seen in services" (2009, 55), as previously seen in manufacturing. The authors also indicate that the similarities are due to common operational and organizational designs, as service organizations have mimicked manufacturing structures over the years.

Philip Atkinson's research of over 200 work activities outside of manufacturing found that "as much as 40% of staff operating costs of businesses can be wasted" (2004, 20). As he explained, "[b]ecause these activities were never measured or assessed on a 'profit and loss account' they were viewed as normal or part of the inherent fire-fighting culture and never questioned prior to this project" (Atkinson 2004, 20). Atkinson's research also

found that many of the steps designed into the processes were there because management did not trust the staff performing the work, causing them to add unnecessary inspections and approvals (2004, 21).

John Maleyeff's research highlighted the typical weaknesses encountered in an internal service system, such as a service organization within a manufacturing firm. The top 10 weaknesses found in his surveys were:

1. There is a lack of standard procedures
2. The system takes too long
3. Communication breaks down with customer
4. The system is not well defined
5. Data and other information are inaccurate
6. There is poor personnel scheduling
7. Little or no flexibility exists
8. There is inadequate training
9. There is inadequate staffing, and
10. There is inadequate support from other functions (2006, 685).

Maleyeff's research also found that there were fewer communication breakdowns in systems that had a higher occurrence of duplicate efforts (2006, 686).

The above examples depict areas in need of significant improvement. Fortunately, Industrial Engineers are formally trained in continuous improvement and lean thinking, which can seamlessly translate to improvements in these problem areas.

How IEs Can Help Service Organizations

As Industrial Engineers become more involved in service-related organizations, more documentation has surfaced regarding their overall value to those organizations. Businesses such as GE, Bank of America, and Motorola have all seen irrefutable savings from using lean thinking in their non-manufacturing areas (Snee and Hoerl 2009, 37). However, no matter how apparent the savings are at these top companies, Snee and Hoerl's research suggested that "when people are faced with the need to improve service

processes, they assume that lean…does not apply" (2009, 38). This finding led the authors to define the similarities and differences between manufacturing and services, in an effort to determine why lean might not apply to services. The similarities between manufacturing and service organizations include:

- All work occurs through processes,
- Processes provide information and data that can be used for improvements,
- All processes have "hidden factories" that add cost and reduce output, such as a financial analyst having to rework the budget due to not having all of the pertinent information up front, and
- Undesired variation causes process problems (Snee and Hoerl 2009, 39-40).

The technical differences between manufacturing and service organizations include:

- Service organizations lack suitable measurement systems to gather data,
- Service organizations have processes that are not well-defined or standardized,
- Service organizations typically lack engineers, who provide the improvement ideas and expertise in manufacturing, and
- Service organizations have a greater human element than manufacturing, which is the largest source of variation (Snee and Hoerl 2009, 38).

The similarities identified demonstrate that there are processes everywhere, which is the foundation for lean thinking. The differences found indicate how service organizations have been ignored in regards to organizational process improvements over the years, but those differences can be changed with the use of more Industrial Engineers in service organizations. By implementing continuous improvement and lean techniques, IEs can influence how processes are defined, measured, and improved.

The research showing the strong similarities between manufacturing and service organizations suggests that the general lean strategies and principles that are used heavily in manufacturing can be successfully applied to service organizations. Betsi Harris Ehrlich reinforced this conclusion when she stated, "[t]hough the service sector has been slow to adopt lean, the principles of identifying value to the customer, simplifying flow to minimize waste, and pulling demand for greater profitability applies to all types of business environments" (2006, 41). These service organizations are not necessarily just organizations that formally interact with the end-of-the-line customer. They include human resources, finance, business development, contracts, engineering, supply chain, logistics, and many others.

The key to successful lean implementation in the service environment is that it is based on common principles, not tools. The lean tools used in manufacturing were developed for manufacturing, based on the core principles. For example, an andon lighting system is a tool that allows the factory floor to know where an issue exists, but it may not work in a service environment. However, the idea of easily identifying areas where issues exist can still be applied. It is the principles that should drive the continuous improvements, as opposed to the tools.

One of the most important aspects of lean implementation, no matter the type of organization, is the elimination of waste. Waste is "any human activity, which absorbs resources but creates no value" (Womack and Jones 1996, 15). Several researchers found that it is possible to transfer most of the major sources of waste in manufacturing to

services. These wastes, once identified, can be targeted for elimination. The sources of waste in service organizations are:

- Delays, such as queueing or waiting for information
- Mistakes, such as errors or omissions that can cause work to be redone and if found by the customer, can cause loss of reputation or customer defections
- Reviews, such as inspection of completed work for errors or omissions
- Movements, such as the unnecessary transportation of service information or the movement of resources to places where they are needed
- Duplication, such as activities that are or can be done elsewhere more efficiently, typically due to poor service process design
- Overproduction, such as performing activities before they are required
- Processing inefficiencies, such as the ineffective use of a resource in performing a specific task, like generating a report without a standard template
- Resource inefficiencies, such as underutilized people or misused talent (Buzby et al. 2002, 513; Maleyeff 2006, 683-684; StratForm n.d.).

These wastes typically result from significant task variability, processes flowing across functions, many handoffs of information, numerous management or technical reviews, no motivation for urgency, and a lack of focus on value as defined by the internal customer (Maleyeff 2006, 679-81). All of these wastes can be targeted for reduction or even elimination with a focused effort on applying the five lean principles to a service organization's processes.

The implementation of continuous improvement and lean in the service sector has countless proven benefits. It leads to better processes, better working conditions, and

better alignment with the organization's needs and purpose (Tischler 2006, 33). Furthermore, it helps increase the distribution of knowledge and power throughout the organization to where it is needed for improved flow. Although seemingly counterintuitive, standardized processes allow for more flexibility in that they allow individuals to apply the principles of what should happen under normal circumstances to the abnormal circumstances (Ehrlich 2006, 41; Maleyeff 2006, 687). The bottom line is that lean thinking is about achieving more with less; doing things better, quicker, at economical cost; generating minimal waste and rework; resulting in increased market share, revenue growth, and bottom line profits (Abdi, Shavarini, and Hoseini 2006, 192; Atkinson 2004, 18-20; Ehrlich 2006, 42; Tischler 2006, 32).

Examples of lean implementation within service organizations are extensive. Letens, Farris, and Van Aken found that using lean thinking in product development resulted in shorter lead times, lower costs, and higher quality (2011, 69). Over three years, they found that "project throughput doubled; project WIP decreased from 82 to 20; [and] the percentage of projects that were completed within the targeted lead time…increased from 25% to 80%" (2011, 82). Ismail and the Aberdeen Group studied over 300 companies to find that manufacturers who implemented lean across the enterprise had 21% more on time deliveries and 83% lower total inventory costs (2012, 2). Additional studies have shown continuous improvements leading to greater job satisfaction, shorter learning curves, less stress, smoother operations, and a reduction in wasted time and motion.

Having the formal education and background for implementing lean and continuous improvement makes Industrial Engineers the default experts in this area. As change advocates, they not only have the knowledge and ability to deploy such a concept across

an enterprise, but they also have the drive, passion, and desire for achieving the types of dramatic improvements that only come with a concerted focus on process improvement.

Service in IE Curriculum

As business needs for Industrial Engineers started to shift into more service-oriented organizations, university curricula also started to change. At the beginning of 2012, U.S. News ranked the best Industrial Engineering schools within the United States. Ranking was based on the following criteria:

- Quality assessment scored by Deans and recruiters
- Student selectivity
- Mean GRE quantitative scores
- Acceptance rate
- Faculty resources
- Student to faculty ratio
- Percent of faculty in the National Academy of Engineering
- Doctoral degrees awarded
- Research activity
- Total research expenditures
- Average research expenditures per faculty member (U.S. News 2012).

A review of the curricula at the top 10 Industrial Engineering schools listed on the U.S. News website provided some insight into how the IE curriculum has evolved to meet today's business needs. All schools showed similar focus in traditional IE tasks, including economics, statistics, modeling, queueing theory, finance, operations research, decision making, risk analysis, lean thinking, and manufacturing. In addition, the majority of the

universities reviewed had courses in supply chain modeling, logistics analysis, organizational behavior, and/or health care. Table 1 shows the service-related courses in the IE curriculum at these schools, making it apparent that IEs have already begun evolving well beyond the scope of the manufacturing floor.

This shift in the IE curricula is a direct reflection of societal and economic influences of the 21st century. The flexibility of this field allows Industrial Engineers to adjust to the business needs of today.

Table 1: Service-Related Courses in the College of Industrial Engineering at the Top 10 IE Schools in the United States

University	Associated Courses
Georgia Institute of Technology	-Stochastic Manufacturing and Service Systems -Advanced Stochastic Systems, with focus on customer contact centers, revenue management, and health care
University of Michigan – Ann Arbor	-Human Error and System Failure -Human Factors in Computer Systems
Northwestern University	-Systems Management -Systems Project Management
University of California – Berkeley	-Service Operations Design and Analysis
Virginia Tech	-Project Management & System Design -Logistics Engineering
Stanford University	-Organization Change and Information Systems -Issues in Technology and Work for a Postindustrial Economy -Management of New Product Development -Queueing and Scheduling in Processing Networks
University of Wisconsin	-Sociotechnical Systems in Industry -Engineering Management of Continuous Process Improvement
North Carolina State University	-Control of Production and Service Systems -Design of Production, Logistics, and Service Systems -Concurrent Engineering -Queues and Stochastic Service Systems
Pennsylvania State University	-Service Systems Engineering -Concurrent Engineering -Retail Services Engineering
Columbia University	-Design and Management of Production and Service Systems -Applied Systems Engineering -Service Engineering

Sources: Data from U.S. News & World Report LP; H. Milton Stewart School; University of Michigan; Northwestern University; University of California; Virginia Tech; Stanford University; University of Wisconsin; North Carolina State University; Pennsylvania State University; Columbia University.

How Large Corporations Implement Lean in Service Organizations

While there has been substantial research regarding the positive results of applying lean and continuous improvement in service environments, little has been documented regarding the burning platform for its implementation in large manufacturing corporations, how the organizations were defined, and the associated successes and obstacles involved in implementing lean across the enterprise. The remainder of this paper is devoted to answering those questions so that the leadership at Company A can structure the company's IE department accordingly.

Procedure and Methodology

In order to better understand how other companies have used Industrial Engineers when implementing lean thinking across the enterprise, interviews were conducted with select employees of five manufacturing corporations. Interviewees included managers from the associated Industrial Engineering and Continuous Improvement/Lean Team organizations within their respective companies. An interview method was chosen as the best means of conducting this research due to the flexibility it allows in adjusting questions slightly to account for how the interviewee answered the previous questions. Interviews also allowed an opportunity to ask for clarification or expansion on answers to confirm full understanding of the interviewee's response. While interviews do not allow for a large sample size, they do allow the opportunity to go more in-depth on the subject of interest.

The interviews were designed to highlight how lean thinking is deployed across the associated enterprises and how Industrial Engineers are involved in that deployment. The intent of this benchmarking activity was to understand the original justification for the deployment of lean thinking across the enterprise, how the organization was structured, and to learn what has been going well and what has not gone well. In the interest of company privacy, the companies that were involved in the interviews will be referred to as Companies B, C, D, E, and F throughout this paper.

Interview Questions

The interview questions were selected based on the information that could not be found in the literature review. The intent was to better understand the "how" part of lean enterprise deployment so that Company A can begin designing its path forward in spreading lean thinking throughout the company.

As the interview questions evolve, they move from understanding the basics of how the organization is structured, including how Industrial Engineers are involved in the deployment of continuous improvement and lean, on to learning the justification for having such an organization and how it has contributed to the company. Additionally, the questions cover the obstacles that the organization has encountered along the way and what the future looks like for the organization. Finally, the last question covers the impact the lean organization has had on the company's competitive advantage. The questions are also framed around the phrase "Continuous Improvement", instead of lean thinking, due to the different terminologies that companies use to describe such an organization. For more detail on the particular questions that were asked, the list of interview questions is included in Appendix A.

Selecting the Interview Candidates

Part of the overall goal for this project was to review organizations that had a primary purpose of manufacturing products, but also used lean thinking and continuous improvement principles outside of their core manufacturing environment. Basic preliminary information was gathered for each company involved to confirm these traits prior to the interviews taking place. The method of gathering this information for each company varied between two sources:

- Gathering information from the company's web page and
- Communicating with the interviewees before the interview.

Certain variables between companies were deemed acceptable, including size of the organization and where they were on their lean journey. The organizations involved in the interviews vary in size from 6,500 people to 170,000 people. The differences in size

allowed for different perspectives on lean enterprise deployment and adjustments made to accommodate the size of the organization. Additionally, one organization was fairly new to the deployment of lean thinking outside of manufacturing, having just started within the past six months. Meanwhile, the organization that had been using lean enterprise concepts the longest had been doing so for over six years.

Interview Method

A couple of different methods of interviewing were used, based on availability and comfort level of the interviewee. Most interviews were performed on the phone, as interviewees were located across the United States, from San Francisco to Cleveland. However, the interview for Company E was performed via electronic messaging, due to the interviewee's schedule constraints and preferences. For this reason, the interview notes from the telephone interviews appear as the author's interpretation of what was said during the interview, while the notes from the electronic messaging session appear as the interviewee's original words. All interview notes are attached in Appendix B.

As a courtesy, a copy of this document will be provided to all interviewees so they can view their contribution and the overall results and recommendations.

Results

The benchmarking interviews gave significant insight into the continuous improvement efforts at each of the five companies. It is important to note that while every effort was made to obtain a holistic view of the continuous improvement organizations within each company, the interviews were limited to the input of one person, so any bias that individual has may appear in their interview responses. The position each interviewee holds in their respective company is shown in Table 2.

Table 2: Interviewee Position within Their Company

Company	Interviewee Position
Company B	Lean Manager
Company C	VP Supply Chain & Manufacturing Operations
Company D	Lean Six Sigma Master Yellow Belt
Company E	Project Manager
Company F	Lean Leader

Results of the interviews are outlined below, detailing how each interviewee answered key sets of questions.

Industrial Engineering Department

Two out of the five companies interviewed indicated that there is a formal Industrial Engineering department within their company: Company B and Company F.

Company B indicated that their Industrial Engineering department supports the Manufacturing and Supply Chain departments, with primary duties involving expanding on their existing Enterprise Resource Planning (ERP) schedule system by using Just-In-Time lean manufacturing techniques to schedule work in their designated production cell. Secondary IE duties at Company B include the implementation and sustainment of lean systems and continuous improvement efforts within their work cell. Manufacturing and

Supply Chain IEs report to an IE manager who is responsible for all of the IEs within their designated facility. The facility IE managers report to their dedicated business unit, with weekly tie-in meetings to manage the IE skill set and set up standard processes for all IEs within the company.

Company F has a more segregated Industrial Engineering structure. All Industrial Engineers work within the manufacturing department and report directly to their factory floor manager. Company F's IEs are responsible for facility start-up and re-layout, as well as efficiency and bottleneck analysis. Production optimization and cost reduction are key goals for the company's IEs.

The other three companies, Companies C, D, and E, all indicated that they do not have a formal Industrial Engineering department or Industrial Engineering role within the company. However, all of them indicated that they do hire individuals with IE backgrounds for other roles within the company, as seen fit for those roles. For example, all three companies have hired Industrial Engineers to work within their respective continuous improvement departments due to their education and previous experience with lean and six sigma processes.

Continuous Improvement Department

All five companies interviewed indicated that they had some form of a continuous improvement department.

Company B has an overarching Lean organization, responsible for the corporate-wide deployment of lean thinking. Additionally, they have lean practitioners dedicated to every work cell on their production floors and within the supply chain organization. The lean practitioners are a part of a lean team dedicated to their respective commodities.

Company C has continuous improvement leaders who are dedicated to the deployment of lean thinking within Manufacturing, Supply Chain, Finance, and other areas. These leaders report to their respective organizations, but have started deploying to other areas, such as Human Resources, as requested to support further lean deployment throughout the company. Company C makes a concerted effort to eliminate the use of the terms "lean" and "six sigma" in their continuous improvement efforts because they believe those words have evolved to have a negative connotation in the workplace.

Company D has a Six Sigma department, which is a stand-alone department, separate from the laboratories and associated support departments. As a traditional Six Sigma organization, Company D supports the training and development of Yellow Belts all throughout the company. As Company D is focused on rapid prototype development and product innovation, the company's Six Sigma department specializes in process improvements related to all systems impacting product development, with a focus on the holistic perspective.

Company E has two organizations focused on continuous improvement: a Six Sigma organization and a Production System (PS) organization. While the Six Sigma organization uses Black Belts to deploy six sigma tools throughout the company, the dedicated PS organization is focused on safety, quality, and velocity across the enterprise. Both organizations are stand-alone departments, with their own management structure within the separate product organization.

Company F has a Lean Team, which began as an organization solely focused on manufacturing, but has evolved over the past decade to areas beyond the manufacturing floor. The Lean Team trains a primary lean coach for each area and that lean coach is

responsible for driving their organization in the right direction. As a full-time position, the lean coach for each area is in charge of setting up the infrastructure to grow their own organization, with as-needed help of the Lean Team.

Even though the structure of each company's continuous improvement organization differs slightly, each company has developed a method of driving the company's focus towards the efficient use of resources and elimination of waste.

Industrial Engineers in the Continuous Improvement Department

While the Literature Review highlights the extensive training Industrial Engineers receive in continuous improvement-related fields, both directly and indirectly, the interviews portrayed a broader range of individuals involved in the continuous improvement organizations within each company.

At Company B, IEs within the Industrial Engineering organization are involved in the implementation and sustainment of the improvements developed by the Lean organization. Also, while there are a few individuals within the Lean organization who have educational backgrounds in Industrial Engineering, there is a drastic pay difference between the Industrial Engineering department and the Lean organization, so most IEs would rather be a part of the Industrial Engineering department.

Company C hired individuals into the Continuous Improvement Leader role based on their previous experience with lean and continuous improvement deployment efforts. They do not have any requirements for individuals to have a background in Industrial Engineering directly.

Both Companies D and E have evolved their Six Sigma organizations the same way. The two companies developed their six sigma experts, black belts, and yellow belts from

other positions within the company. While there are a few Industrial Engineers working within these departments at each company, it is not a formal requirement for people within the organization to have an IE background.

Finally, at Company F, the lean organization was originally developed, and is run by, an Industrial Engineer. However, it is not a requirement for members of the Lean Team or for the lean coaches to have a background in IE. The lean coaches are selected by each respective organization and only 20-30% of the time is the area IE chosen to be a lean coach.

While IEs have the background and skill set to own the continuous improvement organizations within each of the companies interviewed, all of the interviewees indicated that their company's philosophy values either previous training and experience or the development of willing participants from within the company.

Justifying a Continuous Improvement Department

The main driving force behind the development of the continuous improvement organizations within each company was somewhat different, based on each company's situation.

At Company B, there was a somewhat small lean deployment effort, focused solely on manufacturing, prior to the Lean organization deployment in 2006. The main reason for the facelift was so that they could expand the organization to areas outside of manufacturing and so that they could include total employee engagement. Total employee engagement is a means of asking the people who do the work to be more involved in the improvements implemented in their area, including everything from the original improvement suggestion through to the final implementation and sustainment of

the improvement. Over time, though, the philosophy morphed into self-directed work teams, which allows for the teams to own the entire process from womb to tomb. Company B has also found this to provide a more cohesive team environment in the end.

At Company C, the justification was simple. The interviewee originally sold the idea of deploying continuous improvement experts to areas based on his previous experience at other companies. His justification included that the positions would pay for themselves in helping to solve problems and reduce costs. After just a month of deployment, the positions had paid for themselves and other areas started to pull for help from these experts. No one questions the value of these positions anymore and the company is even thinking about hiring more into their service organizations.

Company D had a slightly different justification for developing their continuous improvement organization in that they were required to implement six sigma as a part of a government contract. Over time, the organization has evolved and proven itself so that others within the company now see the value in the organization.

At Company E, the original justification was very simple: to reduce costs across the company. Now, the Six Sigma and Production System organizations have evolved to focus on people, quality, velocity, and cost, for a more holistic view and assessment of process improvements.

Similar to the justification at Company C, Company F's lean journey started with a presentation the interviewee made in 2003. He was given two factories in which to pilot the effort and those proved to be so successful that lean thinking became a directive for all factories to use to improve their metrics. After five years of lean deployment in the factories, the Supply Chain department asked for help and that evolved the organization's

area of influence into more service-related organization, such as Materials, Product Development, and Testing.

While each company's justification for having and maintaining a continuous improvement organization is different, it is clear that each company has tasted the value that such an organization has had to offer, which is why the organizations have evolved and expanded over time.

Barriers Encountered

As the overall focus of the continuous improvement organizations within each company interviewed share a general desire to make the company better at what it already does, the companies detail several key barriers in their continuous improvement journeys. Table 3 shows the barriers each interviewee described, how they compare with the other companies interviewed, and the individual resolutions each company developed to address those barriers.

While there is a range of barriers encountered by the interviewed companies, dealing with the culture change, resistance from middle management, and lack of engagement appear to be the biggest hurdles to overcome when implementing continuous improvements in service organizations.

Table 3: Barriers Encountered When Introducing Continuous Improvement in Service Organizations at Interviewed Companies and Associated Resolutions

Company	Barriers: Of employees tasked with actions outside of scope	Lack of bandwidth	Culture change	Resistance from individuals with transactional job functions	Resistance from middle management	Lack of engagement	Resolution
Company B	X						Focus organization's employees on continuous improvement goals
Company C		X	X	X			Prioritize, evolve at the pace of the organization's culture, and focus on helping people with their pain points
Company D					X	X	Show advancement in a few focal areas first, evolving into others pulling later
Company E						X	Tie improvements with personal goals and metrics and prove the value in the willing areas first
Company F			X		X		Focus on areas that want help, obtain support and engagement from leadership, demonstrate the business benefits, allow time for the culture change, and show middle management how valuable they are in helping the individual contributors

Value of a Continuous Improvement Department

Each company interviewed demonstrated a wide range of value added by the company's continuous improvement organization.

Company B indicated that the biggest value their Lean organization provided was two-fold:

1. As a large company, they were using different approaches to get similar results across the enterprise, so more focus was placed on leveraging the company's best practices across the entire company, and
2. Results were better when individuals worked on problems in a team environment.

With this information, Company B's largest continuous improvement efforts have been in streamlining their training system and eliminating wasted water and paperwork.

At Company C, the Continuous Improvement Leaders were able to justify their worth within the first month of being there. The biggest value they have experienced has been in helping people with what they have identified as their largest problems. They are focusing on streamlining their processes and eliminating waste. Employees are happy and eager to receive that kind of help.

Company D indicated that the largest value they have experienced on their six sigma journey came from when they shifted their focus from managing one thing at a time to a process management system. Focusing on the overarching process allowed them to experience unpredicted gains in their improvement projects.

Company E's improvements allowed the company to get back to the basics, regarding which process improvements to tackle. Instead of allowing each manager to decide how they wanted to evolve their area, Six Sigma and PS allowed them to base their priorities on metrics, such as cost and cycle time reduction, to become more objective in their evaluation methods.

Finally, Company F found the most value in releasing the focus on tools, and centering that energy on the cultural evolution of lean thinking. This helped them reach the point where lean and continuous improvement are no longer initiatives, but more of a way of life for them.

Successes and Lessons Learned

Most of the companies interviewed have very informal ways of tracking the success of their continuous improvement organizations. Companies B and F use the company's

dashboard metrics to gauge if their continuous improvement organization is having a positive impact within the company. Company C shows their successes in kaizen reports, which are written at the completion of a project. Kaizen is a lean thinking term taken from the Japanese word for "slow, continuous improvement" (Kelleher 2010). Company E tracks metrics for the Six Sigma and PS organizations, which also includes the value proposition for each project, and Company D does not formally monitor their Six Sigma organization's successes.

The documentation of successes and lessons learned is also informal and varied between the companies interviewed. Companies B and C document their successes and lessons learned in kaizen reports. Company D obtains validation of the success of their projects by having the Finance department validate and document the results of implemented improvement projects. However, they do not document their lessons learned. Company E does not document either their continuous improvement successes or lessons learned. Meanwhile, Company F seems to be the most advanced in their documentation methods. They use a learning forum to share and listen to project successes and also pose questions to other lean coaches and experts. Additionally, they have an extensive web page resource on their intranet, which displays project results for each area, including successes and lessons learned.

Areas for Improvement and the Future of the Continuous Improvement Department

The areas identified for improvement were linked by most interviewees to where they see the future of the organization headed.

The Company B interviewee indicated that the biggest areas for improvement were in replicating good ideas across the company, where appropriate, and maintaining the organization's focus on its core responsibilities, rather than getting caught up in helping teams fight fires. He indicated that both would be difficult to do, but he sees the organization focusing on their core responsibilities first, and then tackling the propagation of good ideas throughout the enterprise.

Sticking with their "keep it simple" philosophy, the Company C interviewee believed the Continuous Improvement Leaders needed to focus on biting off little pieces at a time, as opposed to trying to tackle all of the problems at once. He also indicated that since they are new to continuous improvement in service-related areas, they will continue to grow and expand their influence in organizations like Human Resources and Finance.

The interviewee for Company D was adamant about the need for a dramatic change within the company's Six Sigma department. He indicated that training people and then turning them back out into their original organizations has not been yielding the results they originally thought it would. They have contractual requirements to make improvements in certain areas, which they have not been able to yet. He believes that by focusing on improvements in one key organization, the company will be able to use them as the benchmark for improvements in all of the other organizations. This is where he sees the Six Sigma department headed in the future.

The Company E interviewee detailed several areas for improvement for the company's Six Sigma and PS organizations. First, she indicated that the current system of gathering and measuring data for metrics is too subjective and lends itself to massaging the data in the way that best suits the needs of the individual or team. The fact that this is happening

within the organization proves that the core focus is not where it needs to be, as implemented project benefits are over-exaggerated. Additionally, the interviewee indicated the cost/benefit analysis and justification for proposed projects should be changed to allow the opportunity to implement projects with a higher initial cost but also an associated long-term benefit. Currently, they are stuck in an endless cycle of short-term improvements that require revamping after only a few years. Finally, the interviewee believed that Company E would be best served if the Six Sigma and PS organizations had a more systemic view of the processes they are improving. They currently focus on projects within a single division, which does not lend itself to understanding the overall process and how changes made in one area could influence another. While the interviewee noted these three improvement areas as key to the success of the organizations, she does not believe the associated leadership agrees with making these improvements in the future. She indicated that they plan to continue leading the two organizations on their current paths.

At Company F, although the organization has evolved significantly over the past 10 years, the interviewee stated the greatest need for improvement is the sense of urgency. He does not believe the lean organization supports the sense of urgency experienced in the beginning, when a need for improvement is discovered. He believes that if lean coaches stop trying to control it so much and just let it take off, they will reap the rewards. As one of the key leaders within the Lean Team, the interviewee intends to lead the organization in this direction in the future.

Continuous Improvement in the Organization's Goals

Only three of the five companies interviewed had company goals tied to continuous improvement. Company B has Lean as one of four major company initiatives, with goals directly tied to the use of lean thinking across the enterprise. This set-up was designed by Company B's CEO, to ensure full leadership support and cooperation from the top, down. Company D has continuous improvement in the company's cost savings goals each year because it is a contractual requirement from the Department of Energy (DOE). The DOE even provides performance evaluation criteria for the company's continuous improvement projects. Company E managers use employee suggestions to create division performance goals, based on the value proposition of each suggestion. In contrast, Companies C and F do not have goals directly related to continuous improvement. However, both interviewees indicated that lean thinking is what the company uses to obtain their metric goals. As Company F evolves into lean as a way of life for all organizations within the company, the philosophy is that "lean" or "continuous improvement" does not have to be specifically called out as a goal because it is the normal way of doing business.

Impact on the Bottom Line

All five companies represented in the interviews indicated that their continuous improvement efforts were having a direct impact on their company's bottom line, particularly due to the cost savings efforts associated with their continuous improvement projects. Company B's focus on utilizing less resources, including people, water, paper, and training, to get the same amount of work done ultimately transfers to a reduction in the company's cost of doing business. Meanwhile, Company C has been surpassing their

metric goals to reduce costs by implementing continuous improvement and Company E has eliminated a significant amount of waste and improved profitability. Companies D and F have gone as far as to measure the impact their continuous improvement organizations have had on the company's bottom line. Company D calculated a return on investment of 3:1 with their improvement projects and Company F estimated that it saves an average of one billion dollars annually. With all companies unanimously agreeing, there is no doubt that concerted continuous improvement efforts are worth the investment.

Competitive Advantage

Finally, interviewees indicated whether or not they thought their continuous improvement efforts gave them a competitive advantage in their industry. Some were more positive than others.

The Company B interviewee was confident that they had an advantage over their competitors because their Lean organization is allowing them to maximize the utilization of the company's employees, which is their number one asset. He also indicated that, as the industry leader in the product it sells, Company B needs to maintain that industry leader position in all that it does, including continuous improvements.

The Company C interviewee had a bit of a different perspective when discussing the company's competition. He thought that they might be ahead of the continuous improvement curve in their industry but that the company was falling behind on product development and innovation. On that note, he indicated that maybe the company's Continuous Improvement Leads should look into helping the product development organization.

Company D competes for government contracts, which have become less generous with funding over the past few years. The Company D interviewee indicated that the company's continuous improvement efforts were helping get products to market faster, which is a key component of winning government contracts in their industry. He also indicated that the company is known for being expensive in comparison to its competitors, but that their six sigma efforts should pay off in the long run to make them more competitively priced.

Company E has used continuous improvements to decentralize decision-making and idea-generating and has become more objective and methodical during the design and implementation of its improvement projects. This has allowed for the company to evolve more rapidly than ever before, which the interviewee indicated, should be a wake-up call for the competition.

Like Company B, Company F is the industry leader, so when it comes to the competition, it strives to be at the top in all that it does. In addition to focusing on being the premier semiconductor provider, Company F's Lean Team aims to be the industry leader in lean thinking as well. From what the interviewee has seen from the competition, the company's continuous improvement efforts have led them to be above and beyond any other company in their industry.

Conclusion

Each interview added another level of understanding and reasoning for how companies choose to deploy their continuous improvement efforts. The key points gathered include:

- How involved IEs were in the continuous improvement efforts

- How the barriers depicted were characteristic of any type of change an organization may be experiencing
- How ad-hoc the monitoring and documentation of successes and lessons learned were, and
- How continuous improvement played into the overall company goals.

One of the most important findings was that Industrial Engineers do not have the primary responsibility for the continuous improvement efforts at any of the companies interviewed. The companies that have IE departments have separate continuous improvement departments, while the companies that do not have IE departments hire individuals into continuous improvement roles based on their desire to work in that role and their previous experience in continuous improvement, rather than their educational background. The cost of the associated labor seemed to have an impact on this decision at one company. Company B hired individuals into the company's continuous improvement organization at a much lower pay grade than that of IEs their IE department. Therefore, IEs are more inclined to work in the IE department, and get paid more, rather than work in the continuous improvement department. Accordingly, the Lean organization is more likely to contain individuals with non-engineering backgrounds, due to the lower pay grades. While not explicitly stated, salary may have had an impact on the decision to utilize non-engineers in the continuous improvement organizations at the other companies interviewed as well.

An additional interesting finding in the interviews is that two of the companies involved, Companies C and F, started their continuous improvement journey based on the strong recommendation of individuals with backgrounds in Industrial Engineering. It appears

certain that while Industrial Engineers may not own the continuous improvement efforts at any of the companies interviewed, individuals with an Industrial Engineering background still play an active role and have an interest in the success of the continuous improvement organization, even if indirectly.

A second key take-away from the interviews was that while there is no doubt about the benefits of having a formal continuous improvement organization, the barriers to progress are significant and must be addressed. Two of the key barriers found in the interviews involved resistance to change and the culture change involved in these improvements. While these are major hurdles to overcome, these are barriers typically associated with change in general, not just continuous improvement. Therefore, these barriers should not be solely attributed to how the continuous improvement efforts are being deployed, but rather they should be considered in regards to how the organization evolves and handles change over time. Each company overcame these barriers in different ways, based on what worked best for their work environment.

Another important finding was the overall lack of a formal way to monitor and document continuous improvement successes and lessons learned. While Company F had a seemingly robust system in place, the other companies appeared to have ad-hoc systems that are not intended for a larger organization. The idea of monitoring and documenting successes and lessons learned seems to have been an afterthought for most of the organizations. This finding begs the question that if Industrial Engineers, as process improvement experts with knowledge and experience in the scientific method, were more involved in these organizations, would this part of the system be better defined? Although these systems were not well defined, Company D had an innovative way of confirming

success by having a representative from the Finance department verify the savings of a project. Using that philosophy in more companies would solve issues like the one Company E has of overstating and massaging the true savings. Overall, it appears as though the organizations interviewed would benefit from strengthening the monitoring and documenting of their continuous improvement successes and lessons learned. This would allow them to use successes and techniques that work more broadly throughout the company and it would allow them to learn from mistakes so they do not keep happening in subsequent improvement efforts.

Finally, all of the interviewed companies appeared to use continuous improvement methods to reach certain company goals, whether or not continuous improvement itself was depicted as part of the goals. Generally, the companies seemed to use continuous improvement as a means of reaching their company's goals rather than pulling it out as a separate, stand-alone goal. While not explicitly questioned in the interviews, there appeared to be a positive correlation between having continuous improvement in the company goals and the level of management support for the continuous improvement efforts across the company. Again, Company F was slightly different in that they were so advanced in their continuous improvement journey that they were on the verge of eliminating the "lean thinking" terminology altogether, as it is becoming their normal way of doing business.

Overall, the interviews proved to be enlightening and useful from a benchmarking perspective. Information from the literature review and the interviews confirmed that companies are experiencing a positive impact on their bottom line and creating a competitive advantage by using continuous improvement and lean techniques outside of

the manufacturing world. Therefore, it would prove beneficial for Company A to pursue deploying continuous improvement and lean thinking efforts outside of manufacturing. Company A should be able to take the “how” information gathered in these interviews and apply and adjust the methods accordingly to suit the company’s needs. Additionally, Company A has the opportunity to focus on areas of weakness found in these interviews, such as the measurement and documentation of successes and lessons learned, and take measures to ensure a higher level of success than these companies experienced.

Suggestions for Additional Work

Broadening the area of influence for the Company A Industrial Engineering department to include applying lean thinking techniques outside of manufacturing would allow for Company A to have people trained in the scientific method and the application of continuous improvement in service-related areas positively influence the remaining 77% of the organization that is currently untouched by process improvement efforts. However, some additional work should be done prior to expanding the department's horizons.

First, no other company has been found to use the IE department to deploy continuous improvement across the company. Further investigation regarding why this is and if it would be more valuable to have individuals with different backgrounds included in the effort should be performed. Additionally, having a proposed organization structure, vision and mission statement, financial model, and plan of deployment for the new or modified organization is necessary prior to presenting to Company A leadership.

Finally, it would be valuable to understand how this change in organizational structure would play a role in the career development and desires of the Industrial Engineers at Company A. For example, it would be beneficial to understand what role this proposed change might play in IEs meeting their career goals and how their career paths might change.

Having the above information, combined with the information gathered in this project, would create a comprehensive review and path forward to present to Company A management as a proposal for broadening the scope of influence for the Industrial Engineering department.

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Appendix A: Interview Questions

1. What is your position within your company?
2. Does your company have a formal Industrial Engineering (IE) department?
3. What areas of the business does the IE department support (i.e. manufacturing, supply chain, engineering, etcetera)?
4. What does the organizational structure of the IE department look like? Who does the department work for?
5. Does your company have an organization that focuses on continuous improvement across the enterprise? What is that organization called?
6. How are your company's Industrial Engineers involved in the continuous improvement efforts within the company?
7. What does the organizational structure of the continuous improvement department look like?
8. What was the original justification for forming a continuous improvement organization?
9. How has that justification evolved over time?
10. What barriers did/do you encounter when implementing continuous improvements (particularly, if you have examples outside of manufacturing)?
11. How did/do you overcome those barriers?
12. Since forming, what value has been demonstrated by the continuous improvement organization?
13. How is the success of the continuous improvement organization monitored?
14. How are successes and lessons learned documented within the continuous improvement organization?
15. Do you think the continuous improvement deployment at your company needs improvement? In what areas?
16. How is continuous improvement tied to your company's goals?
17. Where is the continuous improvement organization headed in the future?

18. How do you think your continuous improvement organization has had an effect on your company's bottom line?

19. How do you think having a continuous improvement organization has helped your company succeed in your industry against your competitors?

Appendix B: Interview Notes

In the interest of company privacy, this section was removed.