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Integration Of Environmental Management Systems And Lean Concepts

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INTEGRATION OF ENVIRONMENTAL MANAGEMENT SYSTEMS AND LEAN CONCEPTS

by

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B.Eng, Mechanical Engineering

Ryerson University, Canada, 2005

A project report

presented to Ryerson University

In partial fulfillment of the
requirements for the degree of
Master of Engineering
in the Program of
Mechanical Engineering

Toronto, Ontario, Canada, 2008

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Abstract

Organizations around the world have been implementing environmental management systems (EMSs) as an effective means to manage environmental performance. However, successful deployment of EMSs requires the effective integration of EMS considerations into existing core business functions. This has typically been challenging for many firms, as many business functions are typically not well aligned with EMS objectives. Process improvement, namely Lean concepts, is an example. The objectives of Lean concepts are very different from the objectives of EMSs, and certain differences in both systems create the potential for conflict. This report further explores the potential to integrate EMSs with Lean concepts. This report summarizes EMSs and Lean concepts across several comparable aspects including objectives, drivers, benefits, and implementation. The standards for each system, ISO 14001 and the Shingo Prize Model respectively, are also presented. After careful analysis and comparison of Lean concepts and EMSs, eight strategies are proposed to effectively integrate the approaches and succeed against individual system weaknesses. An integrated toolset of Lean concepts and methods with EMS considerations are also provided. The integration strategies are lastly discussed with respect to ISO 14001 and Shingo Prize Model requirements.

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Chapter 1: Introduction

1.1 Current State of Climate Change

The most pressing issue of the 21st century is that of climate change. After decades of denial and disregard, the consequences of excessive global emissions are being realized with unprecedented influence. The evidence is clear:

“Canada's Inuit see it in disappearing Arctic ice and permafrost. The shantytown dwellers of Latin America and Southern Asia see it in lethal storms and floods. Europeans see it in disappearing glaciers, forest fires and fatal heat waves. Scientists see it in tree rings, ancient coral and bubbles trapped in ice cores. These reveal that the world has not been as warm as it is now for a millennium or more” (Pearce, 2006).

The study on climate change has been extensive over recent years and has been particular about the catastrophic consequences of continued environmental negligence.

1.1.1 Potential Outcomes of Climate Change

While climatic changes have been seemingly gradual over time, the effects of climate change are “...undeniably real, caused by human activities, and [with] serious consequences” (May, 2005). These consequences have been predicted by many scientists and are staggering claims of global proportion. Penny states:

“Climate change poses a long-term global threat, with significant human, national, and international security implications. Its projected consequences range from weather extremes to resource depletion and exacerbation of existing social conflicts, from compounding disease epidemics through to the complete disappearance of entire nation states, particularly low-lying island states in the South Pacific” (Penny, 2007).

The impacts described by Penny describe the broad array of expected outcomes from climate change. It is also of interest to note that the poorest populations, who have contributed least to greenhouse gas emissions, possess the greatest

vulnerability of being the most affected due to poor general health standards (Campbell-Lendrum and Corvalan, 2007). The threats to weather patterns, disease proliferation, natural resource contamination, and the food supply, have also been explored by a number of notable scientists. Frumkin et al. (2008) state:

"The potential health effects of climate change have been extensively reviewed. Principal concerns include injuries and fatalities related to severe weather events and heat waves; infectious diseases related to changes in vector biology, water, and food contamination; allergic symptoms related to increased allergen production; respiratory and cardiovascular disease related to worsening air pollution; and nutritional shortages related to changes in food production" (Frumkin et al., 2008)

Global wildlife is also not without severe impact. Fossil records over the past 520 million years have shown direct correlation between climate change and mass planetary extinctions (Biello, 2007). In turn, severe climatic impacts to global wildlife, including insect, plant, ocean, and animal life, threaten to upset the delicate equilibrium of natural ecosystems, and result in profound consequences for the human population. This same notion is stated by Frumkin et al. who declare that "...changes in the patterns of pests, parasites, and pathogens affecting wildlife, livestock, agriculture, forests, and coastal marine organisms can alter ecosystem composition and functions, and changes in these life-support systems carry implications for human health" (Frumkin et al., 2008). The long-term effects of mass extinctions and heavily disrupted ecosystems are largely unknown, due to the complex interrelationships of nature's systems. What is known is that mass extinctions have happened in the past. Geologic history has shown that planetary life recovers after 5 million years following a major extinction; however "...on the time scale of the human species, environmental disruption (or at least aspects of it) is permanent. Under these circumstances... the prospects for rediversification are limited" (Myers and Knoll, 2001).

1.1.2 Global Consensus on Climate Change

The frequent and numerous publications of doomsday scenarios prompted the establishment of a scientific body to provide consensus on the state of climate change. As such, the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) established the Intergovernmental Panel on Climate Change (IPCC) in 1988 to act as a trusted and reliable source of information on the subject. Ever since its first published report in 1990, the IPCC has confirmed that climate change is a verifiable ongoing phenomenon. The latest 2007 Synthesis Report published: "...warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level" (IPCC, 2007). Figure 1.1 demonstrates the rise in average surface temperatures and sea level, and fall of snow cover in the Northern Hemisphere. The IPCC drew the following observations about global warming from their 2007 assessment:

- Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases
- Many natural systems, on all continents and in some oceans, are being affected by regional climate changes. Observed changes in many physical and biological systems are consistent with warming. As a result of the uptake of anthropogenic CO₂ since 1750, the acidity of the surface ocean has increased
- Other effects of regional climate changes on natural and human environments are emerging, although many are difficult to discern due to adaptation and non-climatic drivers

The IPCC report also contains a key section on the impacts to future climate changes that provide specific details and expected likelihood of global impacts to natural ecosystems, food supply, coastlines and flooding, industry and society, public health, and water supply.

Figure 1.1: Changes in Temperature, Sea Level, and Northern Hemisphere Snow Cover (IPCC, 2007)

After controversy around whether human activity is the primary driver of global warming, the IPCC report explicitly tied the cause of these phenomena to increased greenhouse gas (GHG) emissions as a result of human activity. According to the 2007 report, the IPCC concluded that “there is very high confidence that the global average net effect of human activities since 1750 has been one of warming” (IPCC, 2007). In addition, the report states:

“Most of the global average warming over the past 50 years is very likely due to anthropogenic GHG increases and it is likely that there is a discernible human-induced warming averaged over each continent (except Antarctica). Anthropogenic warming over the last three decades has likely had a discernible influence at the global scale on observed changes in many physical and biological systems” (IPCC, 2007).

As general scientific consensus, climate change represents a clear and immediate danger to current and future generations, with the effects being accelerated by human activity.

1.1.3 International Action on Climate Change

These findings have prompted world governments to address the issue of climate change in efforts to halt the continued trend of environmental degradation. To achieve global stabilization of greenhouse gases, the Kyoto Protocol was adopted in 1997 as a consensus agreement to reduce emissions (Singer, 2004). The agreement outlined a pledge from major industrialized and developed nations to reduce all greenhouse gas emissions to an average 5% against 1990 levels between 2008 to 2012. Unfortunately, the fundamental approach of the Kyoto Protocol has been under intense scrutiny, and the agreement has not seen involvement from key parties. Opponents criticize that the agreement is impractical, unrealistic, inappropriate, and with negligible environmental impacts (Böhringer, 2003). The U.S., the world's largest creator of greenhouse gases, has also stated that it will not meet the terms of the agreement. Lastly, no global treaty has been agreed upon after Kyoto expires in 2012. As such, the Kyoto Protocol "...has not achieved a decisive breakthrough in international climate policy" and has even been dubbed a failure (Böhringer, 2003). Roughly referred to as 'post-2012' or 'post-Kyoto', international agreements after the Kyoto Protocol expires is currently indefinite. The Global Leadership for Climate Action (GLCA), an international task force of world leaders, has begun strong efforts to ratify the post-2012 scenario. Composed of former heads of state and leaders in business, government, and civil society from more than 20 countries, the GLCA has utilized its network influence to mobilize international negotiations as well as develop a framework for a consensus agreement (GLCA, 2008). The efforts of the GLCA represent a prominent prospect for an international agreement on climate change, post-2012.

The need to address climate change is clear. The means to avoid environmental collapse, however, is a complex and long-term undertaking that requires not only collaboration by world governments, but also support from businesses and citizens alike.

1.2 Personal and Corporate Environmental Responsibility

Environmental protection is a responsibility of more than just the world governments. Businesses and individuals also need to take action.

1.2.1 Personal Environmental Responsibility

The world population is expected to increase from current reports of approximately 5.6 billion to 8.3 billion by 2025 (Madu, 2007). However, natural resources such as fossil fuels, clean air, food, and fresh water supplies are in continual decline. Therefore, while the world population is growing, the resources needed to sustain the developing population are in decline. It is clear that this trend represents a severe imbalance and threat to future generations way of life. As such, current consumption patterns must change if current resources are to be able to support the rapidly growing demand. In turn, consumers have a strong responsibility to be environmentally conscious of the items they purchase, such that the materials and processes needed to create such items are mindful of the environment. For the average Canadian, it is apparent that environmental awareness has already become considerably influential. According to 2005 statistics by Pollara, it was revealed that 96% of Canadians stated they preferred purchasing products that were recyclable, while 92% preferred purchasing products manufactured through an environmentally conscious process (Sharp Electronics, 2005). In addition to purchase patterns, the expectation from government to be environmentally conscious was also notable. A 2007 Environics poll identified that 67% of Canadians wanted Canada to be a global leader for fighting climate change; with 44% stating that the most effective way to show that leadership is to be a model country, and 28% stating that developing and sharing technology is the best way (Savory, 2007). These results indicate the strong environmental conscience of Canadian consumers, and the extensive social awareness of environmental issues.

1.2.2 Corporate Environmental Responsibility

Corporations are also a critical element of environmental protection. Over the past 200 years of industrial development, businesses have enjoyed great wealth and prosperity at the unknowing cost of environmental degradation (Shrivastava, 1995). As recently confirmed by the IPCC, industrial activity is the main cause of the climate change problem. Since industrial activity is primarily centered within the private sector, businesses play a significant role with environmental protection. Businesses not only represent a large cause of the environmental issues at hand, but are also a critical element to the solution. Businesses "...have the knowledge, resources, and power to bring about enormous positive changes in the earth's ecosystems" (Shrivastava, 1995). As such, it is strongly regarded that by improving the environmental performance of corporations, the environmental standard of society improves as well (Yarnell, 1999). The problem of climate change cannot be solved without the direct and aggressive participation of global industry.

Historically seen as a secondary consideration to economic growth, environmental responsibility is rapidly becoming a primary business issue. In today's market, it is rare to find many businesses that do not have some kind of environmental program in place. The popular misconception that profitability and environmental protection are in conflict is quickly being realized to be false. Statistics Canada (2007) reports on the state of the environmental goods and services industry, and the findings are representative of a strong and fast growing market. According to the 2007 report, an increase of almost 17% in total sales of environmental goods and services was found between 2002 and 2004, from \$15.8 billion to \$18.5 billion respectively. Sales of goods increased by 14.8% between 2002 and 2004, from \$8.8 billion to \$10.1 billion. Service revenues increased by more than 20% over the same time frame, rising from \$7 billion to \$8.4 billion. Also, Statistics Canada (2005) reported that Canadian businesses in primary and manufacturing industries spent \$1.1 billion on technologies related to greenhouse gas reduction, in 2002. These are

overwhelming statistics in support of the growing market of environmental goods and services, and the increasing value that Canadian consumers and businesses are placing on environmental protection. However, development of corporate green initiatives and investment in environmental goods and services are only a start to the problem of climate change.

Having presented the grim consequences of continued environmental negligence, it is the responsibility of governments, businesses, and citizens alike to help avert climate change. For businesses, the problem of climate change requires strong participation and developing an environmental policy is an important first step. It is not enough, however, to simply create and advertise an environmental strategy. Companies must be able to successfully implement and manage that strategy to ensure effectiveness and true social benefit. As a result, Environmental Management Systems (EMSs) are often employed to execute and manage corporate environmental initiatives. A detailed account of EMSs is discussed in chapter two.

1.3 Objectives and Organization of the Report

The literature surrounding the integration of Lean concepts and EMSs is relatively thin. As a fairly new concept, the few contributions to this topic primarily discuss the incorporation of environmental considerations in Lean Manufacturing tools, rather than a more involved integration of the systems itself. An integration of Lean concepts and EMS systems would require more than combinatory tools, and have strong considerations to management objectives, the meshing of teams, and internal reporting structures. The objective of this report is to consider the existing work to integrated tools, and expand the scope of integration to management structures, team dynamics, and system objectives.

This report is divided into five chapters. The first chapter will provide a brief and current background on the problem of climate change, and discuss personal and corporate responsibility with respect to environmental protection. The second chapter will define EMSs, and discuss the history, drivers, benefits, and implementation of the system, as well as ISO 14001 requirements and implementation. The third chapter will present an overview of Lean Manufacturing and discuss the history, drivers, benefits, tools and concepts, and implementation. The chapter will conclude with a brief description of the Shingo Prize for Operational Excellence, the standard for businesses practicing Lean Manufacturing. The fourth chapter will discuss the integration of EMSs with Lean concepts by comparing the systems, identifying areas of synergy, and proposing strategies to integrate the systems. The fifth chapter will summarize the unique contributions and conclude the report.

Chapter 2: Environmental Management Systems (EMSs)

2.1 Environmental Management Systems (EMSs)

Proper execution and management of corporate environmental policies are crucial to warrant the objectives and intentions set forth by the organization. Environmental Management Systems (EMSs) are the typical framework to manage corporate environmental policies and have become an internationally adopted method for assessing, managing, and improving an organization's carbon footprint.

2.1.1 Definition and Objectives

The National Database on Environmental Management Systems (NDEMS), in conjunction with the Environmental Protection Agency (EPA), defines an EMS as "...a formal set of policies and procedures that define how an organization will manage its potential impacts on the natural environment and on the health and welfare of the people who depend on it" (National Database on Environmental Management Systems, 2003)

Baxter (2004) defines an EMS as "...a structured framework for managing an organization's significant environmental impacts... [and] part of an organization's management system used to develop and implement its environmental policy and manage its interaction(s) with the environment". According to Statistics Canada (2002), an EMS is "a management structure that allows an organization to assess and control the environmental impact of its activities, products or services", and is composed of six key elements:

- The statement of an environmental policy with goals and objectives
- A planning process to address potential environmental impacts
- The development of processes and practices to attain environmental objectives

- A monitoring and measurement system to determine if and how well environmental goals and objectives are being met
- A management review of the EMS processes and practices to evaluate effectiveness
- Continuous improvement of environmental performance

Baxter (2004) describes an EMS as the mechanism to execute corporate environmental policies and ensure that environmental impacts are assessed, managed, and continually minimized. As part of an EMS, corporate environmental policies are set and communicated to all stakeholders, as well as the individual responsibilities of each party. Environmental performance is frequently measured, monitored, and audited in order to provide the basis for determining EMS effectiveness, where changes are made appropriately. Continuous improvement is an important and ongoing component of EMSs, leading to improved environmental performance over time.

2.1.2 History of EMSs

Historically, environmental protection has been considered the responsibility of governments rather than businesses. Recently, however, there are multitudes of organizations that are now involved in voluntary environmental programs. To better understand the need for EMS, it is important to consider the sequence of events that lead to the sudden shift towards environmental protection from global industry.

Wolfe (1997) provides a detailed look at the international proceedings that lead to the drive for environmental protection. In his article, Wolfe argues that the most defining event that forged the connection between global business and the environment was the United Nations Conference on Human Environment, held in Stockholm in 1972. This conference acknowledged the conveniently ignored notion that industrial activity was a leading contributor to environmental pollution. A global action plan was put forth and The United Nations Environment Program (UNEP), responsible for generating environmental awareness and global stewardship, was established during this meeting. After the conference, the

World Commission on Environment and Development (WCED), an independent commission, was also created to reassess the environment from a developmental perspective and provide reports on progress. Gro Brundtland, who would later become the Prime Minister of Norway, lead the WCED to publish its historic report, *Our Common Future*, in 1987. This report was the first to mention the term 'sustainable development' and to appeal to global industry to develop and execute EMSs. As a result of global attention towards environmental protection in the 1970s, governments began enacting mandates to control pollution, and EMSs were a natural development by industry to manage these regulations.

NDEMS (2003) describes how EMSs were introduced into industry over the past 30 years. The group states that early models of EMSs were developed in the late 1970s and early 1980s by complex facilities or multi-site corporations as a response to maintain compliance with the extensive amount of environmental regulations that were being mandated. The abundance of environmental regulations in the 1970s captured the attention of businesses and government, generating vast concern with regulatory compliance. Compliance management, at the time, only required that pollution-control technologies affecting end-of-pipe were in place, and that permits and monitoring reports were submitted. However, the primary focus on environmental compliance produced "...a preoccupation with regulatory compliance rather than with integration of environmental considerations into businesses' core functions and management processes" (NDEMS, 2003). As such, environmental management by industry was perceived as a costly yet necessary inconvenience, rather than a new business opportunity. Regulations were deemed the responsibility of environmental engineers to implement pollution-control technologies, rather than a new dimension of corporate management.

During the 1980s, environmental auditing practices were introduced according to NDEMS (2003). As a result of increased regulations by government, auditing

was a natural development to ensure compliance assurance. In addition, the next phase for EMS development began to emerge. The prevention of pollution and the minimization of waste suddenly became promoted topics and recognized for potential economic benefits. The general perception of environmental management as a necessary inconvenience shifted to the notion that pollution and waste, in addition to being environmentally damaging, were ultimately a result of inefficient operations. By preventing pollution and minimizing waste, it was considered that an organization would realize economic savings, as well as save the environment. Therefore, pollution prevention and waste minimization programs were developed according to this new perspective on environmental management. In addition to waste reduction, the minimization of energy, water, chemicals, and other material inputs later became the next phase in EMS development. The strong motivation to manage resources more cost-effectively was driven by the potential opportunities to reduce costs, financial penalties of non-compliance with government mandates, and reputation damage by public disapproval of poor corporate environmental performance. Organizations also began to combine environmental responsibilities with health and safety under the jurisdiction of a single vice president, progressing beyond the simple compliance-technology approach of the 1970s and towards a more managerial model.

By the 1990s, many businesses began proposing voluntary environmental programs that met or exceeded regulations at lower costs. Leading advocates argued that environmental considerations had been well built into core business operations and strategies, and that they could achieve equal or better environmental performance at less cost. To do so, they argued that they would need more flexibility from the strict regulatory system. As such, self-regulation became the emerging concept. By 1996, the International Organization for Standardization (ISO) published the ISO 14000 series set of standards for environmental management. The history and development of ISO 14000 standards is thoroughly discussed in section 2.2.2. The ISO 14001 standard, a document outlining the management system elements needed to be in place to

comply with the ISO standard, offered a recommended framework that has become internationally recognized and consistent. Also, ISO 14001 adopting businesses could be audited and certified as ISO compliant. As of December 2001, it was estimated that 36,765 worldwide facilities were ISO 14001 certified, representing an annual increase well over 50% (NDEMS, 2003). ISO 14001 was widely adopted in the U.S., most notably by Honda, Ford, and General Motors. As such, certification of ISO 14001 compliant organizations continues to grow around the world.

2.1.3 Drivers and Benefits of EMS

Given the long series of international events that have popularized EMSs, the motivations behind organizations adopting environmental initiatives are important to identify. Thompson and Kirkland (2002a) have stated that the driving forces behind corporate EMS involvement are significant for understanding why it is useful, the possible benefits of an EMS, and for designing an EMS that addresses the driving forces to gain all potential benefits.

The motivations for EMSs have been studied globally. In July 2000, UN Secretary-General Kofi Annan appealed to international business owners to voluntarily participate in the UN Global Compact (UN GC), a 10 Principle framework of ethical business practices. Environmental issues were addressed in three of the ten principles, and companies worldwide were asked to join as participants. As a voluntary initiative, the willingness of participants to comply was uncertain. Cetindamar and Husoy (2007) studied the impact of the UN GC and found that by 2005, nearly 2300 participants in more than 80 countries had been gathered; with NGOs comprising seven percent, and labour organizations, universities, municipalities, foundations and associations constituting 13%. In addition, approximately 500 new member companies were joining each year. To explain the surge of participants, Cetindamar and Husoy identified a list of ethical and economic motivations for voluntary membership with the UN GC and ranked

importance according to results from company surveys. The reasons are presented in Table 2.1.

*Table 2.1: Reasons for becoming a GC participant
(Centindamar and Husoy, 2007)*

Reasons	Importance*	Origin (Ethical / Economic)
Legal procedures	2	Economic
To improve corporate image	4	Economic
To be able to enter foreign markets	2	Economic
To compete with firms in the global market	3	Economic
To distinguish your firm	4	Economic
To fulfill the environmental requirements of Total Quality Management (TQM)	3	Economic
To decrease unit production cost	2	Economic
To increase corporate efficiency	3	Economic
To increase customer satisfaction	3	Both
To increase employee satisfaction	2	Both
Pressure of stakeholders	2	Both
To be part of sustainable development efforts	5	Ethical
To be a good citizen	4	Ethical
To get access to UN's experience in Corporate Social Responsibility	3	Ethical
To get access to UN's network	3	Ethical

*Note: 1 = Lowest, 5 = Highest

From Cetindamar and Husoy's research, the widespread involvement in the UN GC was due to two primary types of reasons: ethical and economic. There are a few listed reasons that are a combination of the two, but the identification of the categories is important to consider. Even though the ethical reason, being "part of sustainable development efforts", ranked the single highest in terms of importance, the economic reasons for voluntary participation are notably more numerous. Therefore, it can be stated that, even though ethical practice is at the forefront of EMS driving forces, there are still many key considerations towards profitability.

Cetindamar and Husoy's research has provided a solid understanding of the main categories of EMS drivers but the results are primarily focused around internal factors. There are also many external motivations that contribute to an organization's decision to partake in EMSs. The need for EMSs may also be

driven by "...consumers, employees, suppliers, community groups, government, non-governmental organizations (NGOs), and institutional shareholders" (Paul and Siegel, 2006). Thompson and Kirkland (2002a) have developed the following generic list of internal and external driving forces for EMSs and improved environmental performance:

Policies, Laws, and Regulations (External)

- Laws (regulations, enforcement and penalties)
- Litigation (damages from accidents or discharges)
- Government Policies (what governments want to achieve without regulation)

Financial (Internal and External)

- Banks and Financial Institutions
- Investors
- Insurers
- Accounting Systems
- Reduced Costs
- Increased Benefits
- Purchasing Guidelines

Voluntary (Internal and External)

- Environmental Management Systems (EMSs)
- Voluntary Environmental Management Initiatives (VEMIs)
- Codes of Conduct
 - Industry Codes
 - National Codes
 - Environmental Non-Governmental Organization (ENGO) Codes
 - Issue-specific Codes
- Corporate ethics and social responsibility

External Stakeholders

- Unions
- ENGOS
- Professional Organizations
- International Agreements
- The Public
- Customers / Markets

Internal Stakeholders

- Board of Directors

- Legal Department
- Accounting
- Human Resources
- Employees

Motivations for a firm to adopt an EMS or improve its environmental performance are usually a complex combination of many, if not most, of the items in this list of driving forces. Given the range and variety of internal and external factors that drive the environmental performance of a firm, it is clear why an EMS can be useful to manage such requirements. In addition, environmental performance has become a critical business element, making the need for an EMS even greater.

The contributions from Cetindamar and Husoy (2007) and Thompson and Kirkland (2002a) have provided comprehensive understanding of the driving forces behind EMS adoption. Typically, however, the motivations behind EMSs have been described by the range of potential benefits that a firm stands to gain. As evident, many of the discussed driving forces and reasons can be described as benefits to the organization. Yarnell (1999) has provided a list of potential benefits from implementing an EMS, adapted from several notable sources:

- Demonstrating standard of care and due diligence
- Savings from reduced penalties due to non-compliances with regulations
- Fulfilling environmental requirements from regulators, investors, the public, and environmental groups
- Increasing employee satisfaction and morale
- Demonstrating corporate environmental ethics
- Facilitating access to capital and insurance
- Improving environmental assessments and audits
- Increasing operational efficiency and productivity
- Accessing markets that require responsible environmental conduct for business relationships
- Increasing preparedness for future national and international legislation

The EPA (2002) has defined six main advantages of adopting an EMS that best capture the contributions from all of the cited authors:

- *Improved Environmental Performance*

Proactive planning and management can enable a firm to find opportunities for environmental performance improvement that would otherwise go unnoticed, and avoid surprise crises or non-compliances.

- *Better Organizational Competitiveness*

In the global marketplace where environmental protection is becoming increasingly valued, firms that embrace EMSs will not only improve operational efficiency and generate savings, they will be able to gain access to secure or exclusive markets that demand environmental codes of conduct from their business partners.

- *Reduced Costs*

EMSs can determine many areas for operational improvement. By reducing waste, pollution, and energy and resource consumption, organizations can generate substantial savings.

- *Improved Public Image*

As stated, the social value and need for environmental protection is quite high. In turn, potential investors, customers, regulatory agencies, and the public in general demand responsible environmental practices. By boosting a firm's corporate environmental image, external perceptions are kept positive for future business growth while securing public trust and credibility.

- *Better Retention of Valuable Employees*

Environmental, health, and safety issues are common topics of interest to many employees. Adopting an EMS will demonstrate the company's commitment to environmental protection and boost employee pride, morale and overall job satisfaction. Retention of current employees and the ability to attract new talent is heightened.

- *Improved Management of Environmental Legal Obligations*

By employing an EMS, legal and regulatory requirements can be effectively managed. Non-compliances, violations and their ensuing consequences can be avoided, and preparedness for future regulations can be improved.

The driving forces behind EMS implementation are a complex combination of internal and external factors, comprised of ethical, economic, and other various kinds of reasons. The benefits of EMSs are attractive and real, and are quickly overturning the notion that environmental protection and profitability are not positively aligned.

Having identified both internal and external factors as motivation for EMSs, it is important to note that environmental management is quickly becoming a requirement rather than an option. The social value of environmental protection is high; activists protest that companies are not doing enough to save the environment, governments impose legislation against polluting practices, and employees, consumers, and investors demand environmentally responsible products and services. The consequences of ignoring these factors and *not* using an EMS are quite severe and can severely damage the corporate image and profitability of even the most prestigious firm. Penalties for regulatory non-compliances, increased operating costs, lost clients and investors, and poor corporate image are a few of the plausible outcomes of overlooking the need for an EMS. While the costs of implementation may be used as an excuse for small or medium sized enterprises not to adopt, the investment to "...implement environmental practices is minuscule compared to the overall detrimental outcome of not doing so" (Smith, 2007). In the global marketplace where corporate policies are under increasing scrutiny and quickly being reported through the media and Internet, businesses can no longer afford to neglect their own environmental impacts or face a public backlash with financial repercussions. In turn, the pressure for organization's to adopt EMSs and other environmental programs is being felt quite heavily both internally and externally, from a risk management perspective, and ultimately on a firm's bottom line. EMSs can no longer be considered an option, but rather a necessary condition for business success.

2.1.4 EMS Implementation

The common approach for implementing EMSs is the *Deming Cycle*. Popularized by Dr. W. Edwards Deming, the Deming cycle is a popular approach to quality management and also widely known as the *Plan-Do-Check-Act* (PDCA) cycle after the four basic steps of the process. Figure 2.1 illustrates the cyclical nature of the four basic steps in the Deming or PDCA cycle.

Figure 2.1: Deming Cycle or PDCA Cycle

The Plan phase involves identifying the problems and establishing objectives and processes needed to improve performance. The Do stage involves implementing the processes set forth in the previous phase. The Check phase includes close monitoring and measurement of the system to compare and verify performance improvements. Lastly, the Act stage analyzes and reviews the results of the Check phase and initiates corrective actions and continuous improvement activities. The cycle is then repeated and any new objectives and processes learned from the previous cycle become the new elements in the Plan stage.

Madu (2007) provides a generalized application of the Deming cycle's four steps to EMS implementation:

Plan

The Plan stage involves the establishment of an environmental policy, entailing the goals, objectives, and vision for environmental performance. The prerequisite to effective planning, however, is information. An organization is not able to develop an achievable and realistic plan without knowledge of the nature of its business, the interactions with the environment, its history, the legal and regulatory conditions, the internal and external consequences of non-compliance, and the like. With a strong knowledge base and management commitment, attainable targets can be set and planned.

Do

The Do phase involves the actual execution or implementation of the EMS policy as previously defined. The tasks, activities, and actions required to attain the policy objectives are broken down, distributed, and communicated among the organization. Training is provided and all activities are documented. Emphasis is placed on operational controls and emergency preparedness and response.

Check - Act

Monitoring the process, gaining feedback, and correcting the system are critical to EMS success. Through frequent monitoring of actual environmental performance, an organization can compare actual results to the objectives and targets set forth by the policy. In turn, environmental performance can be tracked and necessary action can be taken to correct any deviations to ensure compliance.

Management review is also an additional phase taken to critically analyze the effectiveness and suitability of an EMS policy. Given certain organizational changes, the environmental policy may need to be revised, or redeveloped. The

environmental policy drives the entire cycle and a firm's environmental performance. It is essential that management direct the development of this task.

2.2 The ISO 14001 Standard

2.2.1 Definition and Objectives

ISO 14001 is the international standard for EMSs worldwide. As part of the ISO 14000 series of standards, ISO 14001 is the main document that outlines general management system elements required to be in place to be compliant with ISO environmental standards. The ISO 14001 standard is designed to be applicable to any organization, regardless of size or business sector, and must be appropriate to the scope, scale, and nature of the activities of the company (Thompson and Kirkland, 2002b). ISO 14001 is also fully auditable and an organization can be officially certified or registered as compliant with ISO environmental standards.

2.2.2 History of ISO 14001

As described by Wolfe (1997), an independent commission, named the World Commission on Environment and Development (WCED), was established after the historic success of the UN Conference on Human Environment held in Stockholm in 1972. The commission reassessed the environment from a developmental perspective and provided progress reports to its head, Gro Brundtland. The WCED published its famous report, *Our Common Future*, in 1987 and was the first to mention the term 'sustainable development' and appeal to global industry to develop and execute EMSs. International reception to the report was very positive. Wolfe (1997) describes that by the end of 1988, over 50 world leaders had publicly expressed support for the WCED report and prompted for an international event to discuss action plans. The Earth Summit, held in Rio de Janeiro in 1992, was organized to heed this call by the UN. Maurice Strong, Secretary General to the Earth Summit, wanted to ensure direct involvement from the business sector and hired a Swiss industrialist, Stephan Schmidheiny, as principal advisor to business issues. Schmidheiny founded the Business Council for Sustainable Development (BCSD) shortly thereafter and encouraged international standards organizations to be involved. As a result, the

International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) became key supporters in the time leading up to the summit. Between the ISO and IEC, the Strategic Advisory Group on the Environment (SAGE) was created in 1991 to assess the current state and provide recommendations for environmental management. As a result of SAGE's analysis, two key outcomes were produced: a set of ISO/IEC recommendations on environmental management, and a recommendation to develop standards for environmental management with a new ISO committee for this task. Both of these deliverables were influential for future developments. During the Earth Summit in 1992, the need for improved environmental management was the major issue in two key documents that emerged from the conference, namely, Agenda 21 (the overarching environmental policy from the summit) and the Rio Declaration (a document featuring a set of principles for sustainable development), which proposed the need for better environmental management at the forefront. By 1993, the ISO acted upon SAGE's second recommendation and established TC 207, a new technical committee charged with the development of environmental management standards. The TC 207 distributed the task among 20 sub-committees and invoked the support of the world. By the third plenary meeting in 1995, over 500 people from nearly 50 countries gathered in Oslo for meetings and intense development work. As a result of the strong efforts from Oslo, significant progress was gained. The TC 207 drafted six defining EMS documents during the third plenary meeting:

- *ISO 14001: Environmental Management Systems* – a document outlining the management system elements that must be in place for an organization to be officially certified or registered as compliant.
- *ISO 14004: Environmental Management Systems* – a broad document that provides general guidelines, background information, examples, techniques and tips.
- *ISO 14010: Guidelines for Environmental Auditing* – a guide that provides general principles for environmental auditing.
- *ISO 14011.1: Guidelines for Environmental Auditing* – a document detailing the procedures for auditing environmental management systems.

- *ISO 14012: Guidelines for Environmental Auditing* – the guidelines around qualifying criteria for environmental auditors
- *ISO 14060: Guide for the Inclusion of Environmental Aspects in Product Standards* – a guide for standards writers outside of environmental management.

These documents were officially published in 1996 and many revisions and additions were made to the ISO 14000 family of standards over the ensuing years. By 2008, several ISO 14000 series documents were published and released. Table 2.2 highlights the ISO 14000 family of standards and each document's most recent date. ISO 14001 is the main specification document that describes the ISO requirements for EMSs, while the other standards are supporting documents that provide additional information, tools, examples, and guidelines. The ISO 14000 series of standards represent the internationally recognized model for EMSs.

Table 2.2: ISO 14000 Series of Standards
(Adapted from <http://www.tc207.org/pdf/documentdevelopment.pdf>)

ISO Standard and Date	Title
ISO 14001:2004	Environmental management systems - Requirements with guidance for use
ISO 14004:2004	Environmental management systems - General guidelines on principles, systems and support techniques
ISO 14005	Environmental management systems - Guidelines for a staged implementation of an environmental management system, including the use of environmental performance evaluation
ISO 14015:2001	Environmental management - Environmental management assessment of sites and organizations (EASO)
ISO 14020:2000	Environmental labels and declarations - General principles
ISO 14021:1999	Environmental labels and declarations - Self-declared environmental claims (Type II environmental labeling)
ISO 14024:1999	Environmental labels and declarations - Type I environmental labeling - Principles and procedures
ISO 14025:2006	Environmental labels and declarations - Type III environmental declarations - Principles and procedures
ISO 14031:1999	Environmental Management - Environmental performance evaluation - Guidelines
ISO/TR 14032:1999	Environmental management - Examples of environmental performance evaluation (EPE)
ISO 14040:2006	Environmental management - Life cycle assessment - Principles and framework
ISO 14044:2006	Environmental management - Life cycle assessment - Requirements and guidelines
ISO/TR 14047:2003	Environmental management - Life cycle impact assessment - Examples of application of ISO14042
ISO/PWI 14048	Environmental management - Life cycle assessment - Data documentation format
ISO/TS 14048:2002	Environmental management - Life cycle assessment - Data documentation format
ISO/TR 14049:2000	Environmental management - Life cycle assessment - Examples of application of ISO 14041 to goal and scope definition and inventory analysis
ISO/DIS 14050	Environmental management - Vocabulary
ISO 14050:2002	Environmental management - Vocabulary

2.2.3 ISO 14001 Requirements

Due to the intensive international collaboration in the development of the ISO 14001 standard, specific details of the document were difficult to agree upon due to the cultural, legal, and economic differences between nations. As such, the intent of the standard (which is emphasized several times) is not to provide a rigid, output-focused system, but rather a consensus agreement to recognize and reconcile national and regional differences and provide general requirements for managing environmental performance (Dodds, 1997). Therefore, the standard provides only general requirements and “deals only with environmental management standards and does not consider performance issues” (Madu, 2007). The ISO 14001 standard is comprised of eighteen EMS requirements and Dodds (1997) lists the requirements:

- *Establish and maintain an EMS*
- *Develop an environmental policy*
- *Planning*
 - Environmental aspects
 - Legal and other requirements
 - Objectives and targets
 - Environmental management program(s)
- *Implementation and Operation*
 - Structure and responsibility
 - Training, awareness and competence
 - Communication
 - Environmental management system documentation
 - Document control
 - Operational control
 - Emergency preparedness and response
- *Checking and Corrective Action*
 - Monitoring and measurement
 - Non-conformance and corrective and preventive action
 - Records
 - Environmental management system audit
- *Management Review*

Madu (2007) provides an excellent description of each of the ISO requirements:

Establish and maintain an EMS

Companies must be committed to developing and maintaining an environmental management program with strong continuous improvement of the system.

Develop an environmental policy

Organizations must establish a solid environmental policy. Top management must be involved with the development of this policy.

Planning

The Planning requirements involve critical elements of the environmental policy. Elements of the policy must include:

- *Environmental aspects* – the procedures that an organization carries out to identify the environmental aspects of its activities, products or services. This information is analyzed with respect to environmental impacts and company controls to set objectives and targets. This information is also continually monitored and updated over time.
- *Objectives and targets* – the environmental goals set by a firm that should be consistent with the policy and committed to pollution prevention. Objectives should include consideration of legal and other requirements, environmental aspects, technological options, and other internal and external drivers and influences. Targets should be specific, measurable, and achievable within set time frames.
- *Legal and other requirements* – Any legal and regulatory requirements the company should comply with.
- *Management programs* – operational procedures to attain the policy objectives and targets. These procedures include the time frame, and the breakdown of responsibilities, activities, tasks, and resources.

Implementation and Operation

Organizations must possess the necessary support functions and capabilities to effectively implement and maintain an EMS. These functions must contain:

- *Structure and responsibility* – clearly defined job responsibilities and authorities that are fully documented and well communicated. Necessary resources must be provided and management available to assess system performance and viability.

- *Training, awareness and competence* – employees should be well informed, trained and competent for EMS deployment. Education, training and awareness is a major element.
- *Communication* – procedures that manage communication between the firm and internal and external interest groups should be available and in practice.
- *Environmental management system documentation* – consistent with other ISO standards, extensive documentation (paper or electronic) is required.
- *Document control* – all documentation must be subject to strong document control procedures.
- *Operational control* – Business activities should be performed under controlled, specified conditions. Suppliers, contractors, and other business partners should be made aware of the company's environmental procedures.
- *Emergency preparedness and response* – Procedures and plans for emergency situations or accidents must be developed and in effect. These plans should be up to date and tested periodically.

Checking and Corrective Actions

These requirements involve the necessary activities to measure, monitor, and evaluate a firm's activities. The following functions must be in place according to the ISO 14001 standard:

- *Monitoring and measurement* – organizations must be able to track operational performance, controls, objectives, targets and also monitor and measure key areas of environmental performance. All monitoring should also comply with all regulations and legal requirements.
- *Non-conformance and corrective and preventive action* – Any non-conformances must involve procedures around corrective and preventive actions.
- *Records* – All monitoring, measurement, corrective and preventive action reports must be archived for future reference.
- *Environmental management system audit* – auditing is frequently performed to ensure compliance and proper execution of procedures and policy objectives. Reports are made available to management for review.

Management Review

Management review of an EMS is the final requirement of the ISO 14001 standard. This requirement states that an organization must periodically review

and continually improve its system in efforts to improve its environmental performance. Management should also review the suitability and effectiveness of the system, and make necessary changes to policy or operations as necessary.

The ISO 14001 standard features eighteen internationally recognized requirements and is fully auditable whereby an organization can be certified as compliant with ISO standards. While ISO 14001 offers a recommended framework with the possibility of certification, many businesses have opted to create their own EMSs. The framework of existing standards and newly developed EMSs, however, is largely similar (Baxter, 2004).

2.2.4 ISO 14001 Implementation

Implementing the ISO 14001 standard is best achieved through the Deming cycle, as the requirements of the standard fit well into the basic steps of the methodology. By following the cycle's steps of Plan, Do, Check and Act, firms can ensure correct EMS implementation through an established and accepted approach. To properly implement ISO 14001, however, it is important to understand precisely how the ISO 14001 requirements fit into the Deming framework, and incorporate them into the implementation plan. While the generalized approach has already been described in previous sections, Table 2.3 illustrates how the ISO 14001 requirements correspond to each step of the Deming cycle.

Table 2.3: Deming Cycle Steps and ISO 14001 Requirements

Deming Cycle Step	ISO 14001 Requirements Satisfied at this Step
Plan	Developing an environmental policy and all Planning requirements
Do	All Implementation and Operation requirements
Check - Act	All Checking and Corrective Actions requirements
Management Review	All Management Review requirements

Kinsella (1997) presents three basic steps on how to get started on developing an EMS, and preparing for ISO 14001. Kinsella recommends:

1. *Perform a Gap Analysis* – measure the difference between current business practices and ISO 14001 requirements, to identify areas that need attention. A third party is usually helpful in this task for objectivity.
2. *Implement an Internal Program* – using the results of the gap analysis, implement an EMS development and improvement program under a set schedule. Business efficiency, as is the objective of an EMS, can only be set by the organization.
3. *Consider Self-Declaration / Registration* – self-declaring conformance and seeking third party registration against the standard is recommended to be separate processes in order to effectively implement change into the organization. Third party registration is an option driven by market advantage and customer demand.

The true value in EMSs and ISO 14001, however, is the effective integration of the programs into an organization's core business functions. This task is complicated, as it is clear that the objectives and requirements of EMSs and ISO 14001 are quite different from traditional business thinking.

Chapter 3: Lean Manufacturing

3.1 Lean Manufacturing

In order to remain competitive, businesses have strived to improve quality, cut costs, optimize operations, and continuously improve. Since the 1950s, one methodology has seen notable success. Lean Manufacturing is a process improvement model that has been found to be applicable to a wide array of industries with remarkable results. Originally developed for automotive production in the 1950s, Lean Manufacturing has seen usefulness in many other manufacturing and service environments, from metal ore mining to hospital emergency rooms.

3.1.1 Definition and Objectives

Lean Manufacturing employs a number of tactical methods to improve process efficiency and customer satisfaction by focusing on value-added tasks, and minimizing or eliminating activities that do not add value. Lean Manufacturing is a customer-focused approach, and defines value as customer needs and wants. Activities that do not add value are dubbed *waste*, and there are several types of waste that are specifically targeted by Lean Manufacturing. Lean Manufacturing focuses on value in the process, eliminates waste through a collection of tools and methods, and then continually optimizes the system. Lean Manufacturing is a business practice as well as a culture of continuous improvement. Table 3.1 lists seven types of waste, and provides examples within the manufacturing and service sectors.

*Table 3.1: Seven Types of Waste
(Adapted from <http://www.epa.gov/lean/thinking/types.htm>)*

Waste	Manufacturing Wastes	Service Wastes
Defects	Production of products that require scrap, rework, replacement production, inspection	Order entry, design, or engineering errors
Waiting	Delays from stock-outs, lot processing delays, equipment downtime, capacity bottlenecks	System downtime, response time, approvals
Overproduction	Production of items for which there are no orders	Printing paperwork, purchasing items before they are needed; processing paperwork before the next person is ready for it
Transportation	Excessive transporting of work-in-process (WIP) long distances, trucking to and from an off-site storage facility	Multiple sites outside of walking distance, Off-site training
Inventory	Storage of excess raw material, WIP, or finished goods	Office supplies, sales literature, and reports
Complexity	Excessive parts, process steps, or time than necessary to meet customer requirements	Re-entry of data, extra copies, excessive reporting, etc.
Unused creativity	Failure to capture ideas, skills, improvements, and suggestions from employees	Limited tools or authority available to employees to carry-out basic tasks

Many Lean Manufacturing practitioners have adapted the types of waste over time and it is not uncommon to see differing number of wastes and elements between sources. Some practitioners have opted to identify only seven types of waste, while others have included more. The types of waste also vary between sources. Complexity waste is commonly called processing waste in other lists, implying unnecessary process steps to create the desired product or produce the service. Motion waste is also another type of waste that is not mentioned in Table 3.1 but is commonly seen in other Lean Manufacturing resources. Motion waste implies unnecessary walking or moving during processing, awkward operator positioning, or poor ergonomics. Nonetheless, the same concepts are being applied and the objectives of Lean Manufacturing are the same among variations around waste. It is important to note for later discussion that environmental waste is not considered an objective of Lean Manufacturing.

3.1.2 History of Lean Manufacturing

The Lean Enterprise Institute (2008), founded by Jim Womack, provides a brief history of the foundations of Lean Manufacturing. The first developments towards Lean Manufacturing started with Henry Ford. In 1913, Ford was the first to integrate a production process, and introduced a new type of manufacturing he called 'flow production'. By integrating interchangeable parts with standardized work and moving conveyance, the moving assembly line was born. However, the implications of such a revolutionary process yielded much greater breakthroughs. Ford decided to align fabrication steps in sequence wherever possible using special-purpose machines and go/no-go gauges. This allowed components going into vehicle to be fabricated and assembled in only a few minutes, with perfectly fitting components being delivered directly to line-side. Compared to the common shop practices of the American system at the time, this was revolutionary thinking. Typical American shop practices involved grouping general-purpose machines by process to fabricate parts that were eventually assembled into finished goods. The parts were not perfectly fitting and required some subassembly before final assembly. Ford's system was much more efficient. Ford's model, however, was not perfect. The flow of his production system was excellent, allowing a full turn of company inventories every few days. Ford's problem was with the limited variety in product that the system was designed to produce. Only one colour and one specification could be produced under the flow production model. Variety was the main downfall of flow production. Therefore, up until the end of production in 1926, all produced Model T chassis were essentially identical. In essence, there were no changeovers and only a single part number was being made on each machine. Over time, the market demanded variety.

Womack et al. (1990), in their landmark publication *The Machine that Changed the World*, describe the inclusion of product variety into the automotive industry. Alfred Sloan introduced innovative management and marketing techniques by offering a range of products with standardized parts and features. By coupling

Sloan's techniques with Ford's flow production, the system became known as *mass production*. With Ford, Chrysler, and General Motors (GM) employing mass production, the model led the United States to dominate the automotive industry around the world, with the United States holding the largest market. By 1955, the height of the American automakers reached its peak. Ford, GM and Chrysler comprised 95% of all sales with six models representing 80% of all cars sold. Ironically, market share and competitive advantage for American manufacturers began to decline immediately after 1955. European automakers began converting to mass production and making products that were quite different from traditional American designs. Volkswagen, Renault, Fiat, and Mercedes began producing at scales similar to Ford's major facilities, offering a variety of foreign products with new features to the market. Unfortunately, however, European production models were basically copies of American mass production but with less accuracy and efficiency. Mass production techniques would likely be still in practice if not for the revolutionary work being done in Japan.

The Lean Institute (2008) describes how Kiichiro Toyoda and Taiichi Ohno studied the American system, and improved it. Toyoda was the founder of the famous Toyota Motor Corporation, and Ohno was Toyoda's production genius. By studying Ford's original flow production model, Toyoda and Ohno experimented with a number of techniques at Toyota and reasoned that, through some modification, it would be possible to maintain Ford's strong production flow and offer product variety. While mass production excelled at speed and throughput, product variety was extremely difficult. Ohno and Toyoda shifted the focus of their system at Toyota towards the flow of the product and the overall process, rather than the traditional attention to machines and their utilizations. Toyota discovered that by using machines that matched actual needed volume, using self-monitoring devices to ensure quality, aligning the equipment in process sequence, enabling fast set ups and changeovers so that each machine can produce multiple products, and communicating the needs at each work station to

the previous station, it was possible to achieve some dramatic results, namely, lower costs, higher varieties, higher quality; and rapid throughputs able to adjust to consumer demands were the outcome. Information management was also much simpler. This new system was known as the *Toyota Production System* (TPS), and is the original Lean Manufacturing production model. Lean Manufacturing, as it is known now, is a Westernized adaptation of the TPS.

Lean Manufacturing production was not known in North America before the definitive publication, *The Machine that Changed the World* by Womack, Jones and Roos was released in 1990. This book clearly explains the entire Lean Manufacturing system, and is the result of a five-year study by MIT across fourteen countries. Since then, Lean Manufacturing concepts have been applied around the world and across multiple industries, from health care to retail to distribution and supply chain.

3.1.3 Drivers and Benefits of Lean Manufacturing

Lean Manufacturing methods employ a radically different way of thinking from traditional production models. The typical focus of mass production is centered on reducing product costs and increasing efficiency through economies of scale. Lean Manufacturing, on the other hand, is centered on reducing cost and increasing efficiency through streamlining the manufacturing processes, and incorporating quality and flexibility into the processes. Table 3.2 highlights some of the differing elements of each approach.

Table 3.2: Mass Production and Lean Manufacturing Comparison
(Adapted from Ross and Associates, 2004)

	Mass Production	Lean Manufacturing
Focus	Product	Customer
Overall Aim	Reduce cost and increase efficiency	Eliminate waste and add value
Quality	Inspection (stage after production)	Prevention (built into design and methods)
Business Strategy	Economies of scale and automation	Flexibility and adaptability
Improvement	Expert-driven periodic improvement	Workforce-driven continuous improvement

To illustrate the success of Lean Manufacturing thinking over mass production, Womack et al. (1990) describe a survey they performed in 1986 that compared the performance between a General Motors (GM) facility and a Toyota plant. The GM assembly plant, situated in Framingham, Massachusetts, represented all the traditional elements of American mass production. The Toyota assembly plant located in Takaoka, Toyota City, was utilizing Lean Manufacturing methods. After visiting the Framingham assembly plant, the team of Womack, Jones and Roos noted that the facility featured:

- Many indirect workers, idle along the assembly line waiting to relieve employees, repair a machine, housekeep, etc.
- Piles of inventory next to each station.
- Only senior managers were able to stop the line. The line was stopped frequently.
- Discarded boxes and temporary wrapping material littered among the floor.
- Uneven work distribution, where some workers are scrambling to keep up while others are idle.
- An enormous work area filled with defective products awaiting rework.
- Large buffers between processes.
- Large inventories of parts.
- Low worker morale.

On the other hand, the Takaoka assembly plant was quite opposite. The Toyota facility was noted to feature:

- Hardly any indirect workers, or people standing in the aisle. Narrower aisles.
- Small amounts of inventory next to each station.
- Any worker was able to stop the line with a pull cord above each station. The line was rarely stopped.
- Smoother work distribution, where workers operated at about the same pace.
- Almost no rework area.
- Practically no buffers between processes.
- No parts warehouses.

- High worker morale.

After their visit, Womack, Jones and Roos, constructed a simple box score to compare the performance between Framingham and Takaoka. The differences between the facilities were remarkable. Table 3.3 depicts the box scores of both facilities across a number of simple measures.

*Table 3.3: GM Framingham Assembly Plant versus Toyota Takaoka Assembly Plant, 1986
(Adapted from Womack et al., 1990)*

	GM Framingham	Toyota Takaoka
Adjusted Assembly Hours per Car*	31	16
Assembly Defects per 100 Cars	130	45
Assembly Space per Car	8.1	4.8
Inventories of Parts (Average)	2 weeks	2 hours

**Adjusted Assembly Hours per Car includes adjustments in standard activities and product attributes*

The team's findings remarked that Takaoka was almost twice as productive and three times as accurate as Framingham when performing the same activities. Takaoka also used 40% less assembly space and stored only a fraction of the parts that Framingham was keeping. In addition, Takaoka had the flexibility to be able to change over its operations from one model to the next generation within a number of days. Mass production facilities at the time normally take months to do the same. Framingham was eventually closed in the summer of 1989.

From the results of Framingham and Takaoka, it is clear that Lean Manufacturing presents some obvious benefits that are undoubtedly attractive. Also, the overall competitive advantage for firms employing Lean Manufacturing is exceptional. The growth of Japanese auto exports in the United States is strong proof of Lean Manufacturing's success. Between 1965 and 1975, Japanese car exports experienced tremendous growth. The Japan Automobile Manufacturers Association (JAMA) reports by 1970, Japanese auto exports exceeded "...Italy, the United States and the United Kingdom making Japan the world's third largest automobile exporter" (Japan Automobile Manufacturers Association, 2008). By 1980, Japan surpassed the United States as the world's largest motor vehicle producer (Fieleke, 1982). By 2007, Toyota ousted General Motors as the world's

largest automaker outselling the American car giant in the first quarter (BBC News, 2007). The success of Japanese autos has been largely due to the high quality, low fuel consumption, and fair pricing of their products. It was noted: "both U.S. consumers and engineers have indicated in surveys that they consider foreign cars to be of higher quality than U.S. cars... [and] consumers buying foreign cars are more likely to be satisfied with their purchase and to report a low frequency of repairs than [of] those buying U.S. cars" (Fieleke, 1982). These elements have only been made possible by Lean Manufacturing processes and management techniques.

By today's standards, the need is clear for organizations to be increasingly competitive to survive in the face of intense competition from both domestic and global sources. In the new business environment, competition is fiercer and businesses are forced to innovate, adapt, and reinvent themselves incessantly. As the demands of the market become more challenging, operational efficiency is more crucial than ever to survival. Lean Manufacturing provides the mechanisms for firms to survive within the business environment that is becoming more dynamic than ever. An organizations decision to pursue Lean Manufacturing is usually driven by these strong business drivers as a fundamental need to improve business competitiveness. Business needs for increased competitiveness are attributed to direct global competition but can also stem from evolving customer or supply chain expectations, and Lean Manufacturing practitioners often cite that a real or perceived business crisis is required to justify the substantial transformation for a successful Lean implementation (Ross and Associates, 2004).

Many companies who have successfully recently implemented Lean Manufacturing have realized some substantial benefits. Martin (2007) explains that typical benefits from Lean Manufacturing include significant improvements to production errors, labour, floor space, delivery time, and many other categories.

Table 3.4 depicts the general improvements expected from implementing Lean Manufacturing.

*Table 3.4: Typical Lean Manufacturing Benefits
(Martin, James W., 2007)*

Category	Improvement
Process Development	25% to 75%
Labour	15% to 50%
Floor Space	25% to 50%
Errors	25% to 90%
Excess Capacity	25% to 75%
Throughput Time	25% to 95%
Delivery Time	25% to 80%

Ross and Associates (2003), in their research for the EPA, identified other manufacturing and organizational benefits that they found consistent among Lean Manufacturing practicing firms:

Manufacturing Benefits from Lean Manufacturing

- Reduced inventory levels and associated carrying costs
- Decreased material usage by reducing material requirements and creating less waste
- Optimized equipment using lower capital and resource-intensive machines
- Reduced need for facilities and production space
- Increased production velocity from streamlining processes
- Enhanced production flexibility from a “pull”, Just-In-Time production system
- Reduced complexity from simplifying product designs and simplifying manufacturing processes.

Organizational Benefits from Lean Manufacturing

- A culture of continuous improvement focused on eliminating wasteful production activities
- Employee engagement in continuous improvement and problem solving.
- Operations-based focus of activity and involvement

- A metrics-driven environment that stresses rapid performance feedback and leading indicators
- A holistic systems view and understanding of optimizing performance.

In essence, Lean Manufacturing provides the delivery of high quality products or services at minimum cost and waste. The benefits are highly desirable, and Lean Manufacturing is driven by strong business motivations to do more with less.

3.1.4 Lean Manufacturing Concepts and Tools

Lean Manufacturing employs several tools and concepts to implement the system. There are numerous Lean Manufacturing tools that exceed the scope of this report, but some of the principal elements include:

- Kaizen
- Visual Workplace and 5S
- Just-In-Time (JIT) Production
- Value Stream Mapping (VSM)
- Six Sigma

Kaizen

Ross and Associates (2003) state that Lean Manufacturing is founded on the concept of kaizen, or continuous improvement. It is a simple philosophy that asserts that small, incremental changes to a system that are rapidly applied and sustained over time result in significant improvements. A kaizen event is typically a short-term venture that aims to quickly implement improvements to targeted systems using Lean Manufacturing methods. It is a team-based activity that actively involves employees from multiple functions and levels of an organization. Lean Manufacturing methods are first used to identify areas for improvement, and then the team works to rapidly implement the improvements usually within 72 hours. It is an intensive undertaking but the results are often impressive. The EPA (2007) has identified a few of the reasons why kaizen events are so successful:

- Kaizen is focused on moving rapidly from planning to implementation;

- Kaizen is focused on making continued progress rather than waiting to find the perfect solution;
- Kaizen is focused on worker involvement and teamwork;
- Kaizen is focused on addressing the root causes of problems; and
- Kaizen is focused on process improvement from a systems perspective.

Plenert (2006) identifies three basic steps to performing a kaizen event, and provides an example of its success at the Marine Corps in the United States. Plenert states that kaizen events firstly involve observing the situation, then defining the changes that need to be made, and finally implementing those changes. Plenert describes that at the Repair Division of the Marine Corps Logistics Base in Barstow, California a pilot project was run utilizing kaizen thinking. The following results were determined:

- 63% reduction in final assembly lead time
- 50% reduction in work-in-progress (WIP) inventory
- 83% reduction in distance material traveled
- 70% reduction in workshop space requirements

Kaizen events are considered the building blocks to all other Lean Manufacturing methods, and a primary activity for developing an organizational culture of continuous improvement and waste elimination.

Visual Workplace and 5S

Martin (2007) explains that the visual workplace is a Lean Manufacturing concept implying that the status and the problems of a process should be visually recognizable. This concept reduces waste because anyone can quickly identify any areas that need attention, resulting in time and money being saved. In order to achieve the visual workplace, implementing the 5S system is the first step. 5S is the acronym for *Sort, Set in Order, Standardize, Shine, and Sustain*, and represents the five key elements of the system. 5S consists of sorting what items should and shouldn't be present in the work area, well organizing and arranging the items in the work area, standardizing all work methods, cleaning and tidying the area, and sustaining any improvements over time. 5S is a prerequisite to the

visual workplace since improvements cannot be sustained in work areas deficient in operational standardization. Visual displays to convey status information between work areas are also to be set up, and visual controls are to be installed throughout the workplace. Visual controls can include simple alarms to alert of process changes, or actual prevention of errors and defects through mistake proofing. Once all phases have been implemented, the status of work areas and processes should be visual and in real-time, allowing key metrics to be seen on a timely basis. By expanding 5S to include visual displays and visual controls, the workplace becomes a true visual workplace where local work teams can easily view the status of processes and work areas. The overall complexity of managing the workplace is reduced and abnormal conditions are easily visible, resulting in lower costs, shorter lead-times, and higher quality. A common addition to the 5S methodology is a sixth 'S' for Safety. This process is commonly referred to as 6S (not to be confused with Six Sigma) in the United States, particularly in the military, and refers to incorporating ergonomics, environment, fire protection, machine and tool guarding, preventive maintenance, and safety training into the framework (Plenert, 2006).

Just-In-Time (JIT) Production

Ross and Associates (2003) describe Just-In-Time (JIT) as a critical Lean Manufacturing method enabling firms to produce products that its customers want, when they want them, in the correct amount they want. JIT works to significantly reduce inventory and work-in-progress (WIP) by leveling production over time to ensure smooth flows between processes, varying the product mix on a single line, using physical signals (called kanban) to initiate movement of raw materials or components through the production process, and ensuring suppliers deliver smaller quantities of raw materials or components "just-in-time". Plenert (2006) describes JIT as the objective of only bringing to work area what is necessary, when it is needed, and only in the amount that is needed. By only providing workers with one piece at a time with nothing before or after their process, inventory, parts, space and labour are minimized. The next pieces are

not introduced into the production system until they are requested. In other words, nothing is produced until the customer requests it, and nothing is purchased until production begins and materials are requested from the vendor. This is considered a 'pull' system, whereby the production process is driven by feedback from the customer, rather than automatically 'pushed' into production through a set schedule. Martin (2007) mentions the strong customer focus of JIT and adds that the major characteristic of JIT is the continuous flow of product, information, and demand-pull starting from the customer in efforts to match production schedules with actual customer demand patterns. This type of Lean Manufacturing system significantly reduces waste associated with inventory, WIP, packaging and overproduction.

Value Stream Mapping (VSM)

Womack (2006) expresses that value produced by an organization is the final deliverable resulting from a complex process or series of activities known as a *value stream*. By analyzing and optimizing value streams, organizations are able to not only improve the internal process, but the external value to the customer as well. Value stream mapping is the "...process mapping method used to document the current and future states of the information and material flows in a value stream from customer to supplier" (EPA, 2007). VSM is typically a first step in Lean Manufacturing ventures and kaizen events. The EPA (2007) describes VSM as the technique to map business processes utilizing visual representations of material and information flows. VSM is a simple three-step process: a current state map is first developed and the entire value stream analyzed for waste; a future state map incorporating improvements is then developed; and finally the improvements are implemented throughout the workplace. Wedgwood (2006) remarks that VSM is similar to traditional flow-charting but differs according to three key features:

- VSM maps are centered on a Primary Entity in the process. For example, if the Primary Entity is an order, then the main horizontal center flow of the map is for the order and what occurs to it.

- The activities on a VSM map are analyzed for the value they bring to the end customer.
- VSM integrates measures of performance for the process.

VSM aims to ultimately create a leaner system and the key element is the big picture view of the production system as a sum of parts. Instead of improving single steps or subparts in the process, the relationship between that step and the entire value stream or production process is understood. This knowledge enables a holistic understanding of the production process, and how different types and combinations of changes can affect the whole system. In turn, the most optimal types and combinations of changes for the system can be determined.

Six Sigma

Six Sigma was developed in the 1990s by Motorola Inc. from well-established statistical quality control methods and data analysis techniques, and can be defined as "...a set of structured, data-driven methods for systemically analyzing processes to reduce process variation, which are sometimes used to support and guide organizational continual improvement activities" (Ross and Associates, 2003). Six Sigma has also been described as a "...measurement-based strategy that focuses on reducing variations through monitoring and measurement tools" (Plenert, 2006). As the originators of the system, Motorola provides the best definition of Six Sigma. Motorola (2008) defines Six Sigma having literal, conceptual, and practical definitions. Six Sigma can be understood at three levels: as a metric, a methodology, and a management system. In essence, Six Sigma is all three elements concurrently. As a metric, Six Sigma refers to the statistical understanding of sigma, or standard deviation. After six standard deviations from the mean, an outcome is considered a failure, hence the name Six Sigma. The objective metric is to achieve 3.4 defects per million opportunities (DPMO), or only 3.4 measurements outside of six standard deviations from the mean every one million opportunities. Six Sigma began as an effort to reduce defects in manufacturing, but has greatly expanded beyond

that into a wide array of business processes. As a methodology, Six Sigma has evolved into a general business improvement approach that utilizes two main models: DMAIC and DMADV. DMAIC, is an acronym for *Define-Measure-Analyze-Improve-Control*, representing the five basic steps of the model. DMAIC is the most common approach, and is widely used for improvement to existing processes. DMADV stands for *Define-Measure-Analyze-Design-Verify*, and is the less common approach used for designing new processes. Six Sigma also features its own set of statistical and analytical tools to assess process quality and waste. As a management system, Six Sigma "...drives clarity around the business strategy and the metrics that most reflect success with that strategy. It provides the framework to prioritize resources for projects that will improve the metrics, and it leverages leaders who will manage the efforts for rapid, sustainable, and improved business results" (Motorola, 2008).

Six Sigma is not an original element of the Lean Manufacturing framework, but often employed in conjunction with Lean Manufacturing tools. While Six Sigma provides statistical measurement and analysis tools, Lean Manufacturing supplies the practical techniques and methods to improve business operations. Lean Manufacturing and Six Sigma are an excellent combination of tools and thinking to execute real process improvement within an organization. The term Lean Six Sigma is common to describe the combination of the methods in business practice.

Six Sigma is a large and complex topic, and a comprehensive explanation of the system is beyond the scope of this report. It has been briefly summarized in this section.

3.1.5 Lean Manufacturing Implementation

Womack and Jones (2003), two of the original writers who brought Lean Manufacturing management to the international stage, have defined a five-step

process for organizations pursuing a Lean Manufacturing enterprise. These basic steps are:

1. Specify Value
2. Identify the Value Stream
3. Improve Flow
4. Initiate Pull
5. Pursue Perfection

Specify Value

The starting point for Lean Manufacturing thinking is identifying value according to the customer. Value must be expressed in terms of a good or service, which meets customer needs at a specified price and at a specified time. This concept must be kept in the forefront at all times, as it is common mistake for organizations to focus their strategies inwardly towards their own financial needs or operational requirements, rather than externally to what customers really want. Womack and Jones recommend ignoring existing assets and reevaluating according to product-lines with strong, dedicated product teams. This is essential to establishing a clear idea of what is really needed to create true value. Otherwise, providing unwanted goods or services the right way is waste.

Identify the Value Stream

Once value has been defined, clearly specifying the entire value stream is the next step. It is important to identify the entire process. The likely outcome is that three main types of activities will be found to occur, namely, activities that create value, activities that do not create value and are not avoidable, and activities that do not create value but are avoidable. This type of activity exposes waste in the value stream and provides a holistic perspective and understanding of the entire process, as well as where value is being created.

Improve Flow

Once value has been defined, the value stream mapped, and obvious waste activities have been removed, the flow of the interconnecting activities in the value stream can be improved. This is achieved through shifting one's focus from the traditional departmentalized, batch-and-queue production model, to the flow production model of small lot-sizes in continuous flow. This is a counterintuitive notion to traditional thinking, as it is more commonly reasoned that work should be grouped in departments and produced in batches. The Lean Manufacturing alternative is to shift focus from traditional thinking in terms of functions and departments to value creating activities for specific products and services.

Initiate Pull

After the execution of the first three steps, dramatic reductions to lead times should have occurred. At this point, it is possible to initiate a revolutionary phase: allow customers to dictate what is produced rather than producing to forecast. That is, let the customer 'pull' the products through the system where production is not initiated until a customer request is generated. In turn, customer demand tends to stabilize when they know that orders can be satisfied immediately, and manufacturers can avoid discounting of excess inventory.

Perfection

Once the first four principles have been embraced, it is possible to continually improve the system. Identifying value, specifying streams, enhancing flow, and creating pull tend to interact with each other cyclically to expose waste and improve the overall system. By enhancing flow, process waste can be identified. The harder the pull, the obstacles to better flow are visible. Finally, discussion with the customer redefines value and often leads to improvements to flow and pull. Once an organization has defined value, mapped the value stream, created flow, and initiated pull, it "...dawns on those involved that there is no end to the process of reducing effort, time, space, cost, and mistakes while offering a

product which is ever more nearly what the customer actually wants...suddenly perfection, the fifth and final principle, doesn't seem like a crazy idea" (Womack and Jones, 2003).

Success with Lean Manufacturing requires more than knowing the tools, concepts, and methodologies. In order to effectively implement and sustain Lean Manufacturing initiatives, people are the critical element. People utilize Lean Manufacturing tools and thinking, and are the real drivers of change in an organization. Lean Manufacturing not only requires a different set of tools and thinking, it requires a different management style and organizational culture. Arguably, this is the most difficult part of Lean Manufacturing implementation. Plenert (2006) reports that acceptance of Lean Manufacturing represents 80% of the efforts in an implementation, with technical tools comprising the remaining 20%. Figure 3.1 displays the relationship between the technical and acceptance tools for Lean Manufacturing sustainability. It is interesting to note that for Lean Manufacturing to be sustainable, both technical and acceptance aspects are required.

Figure 3.1: Technical and Acceptance Tools
(Adapted from Plenert, 2006)

Plenert (2006) has provided a set of guidelines for Lean Manufacturing implementation, particularly relating to initiating change in an organization and

some common pitfalls. Plenert states that common pitfalls to implementing Lean Manufacturing include:

- Thinking of Lean Manufacturing as an event rather than a new business model
- Failing to seek expertise regarding cultural change and development
- Attempting broad transformations while maintaining a “business as usual” attitude
- Avoiding passive or active resistance within leadership ranks
- Including only staffers in the implementation and failing to include key process owners

Alternatively, in order to achieve Lean Manufacturing success, organizations need to:

- Create a clear vision and direction
- Establish top down support (for dealing with resistance)
- Employ bottom up implementation
- Manage complex change
- Eliminate or reduce barriers
- Continuously train and create momentum

Lean Manufacturing requires major change. One of the most effective methods to implement change in an organization has been the famous model developed by professor John Kotter of the Harvard Business School. Kotter defined an eight-step process to create major change in any organization, which is exactly the type of change that Lean Manufacturing requires. Kotter (1995) summarizes his eight-step model:

1. Create a sense of urgency

- Examine the market and competitive realities
- Identify and discuss crises, potential crises, or other major opportunities

2. Form a guiding coalition

- Assemble a group with the power to lead change

- Encourage teamwork
3. *Develop a vision and a strategy*
 - Create a vision that directs the change effort
 - Develop strategies to achieve that vision
 4. *Communicate the vision*
 - Use all channels and vehicles to communicate the new vision and strategies
 - Ensure the guiding coalition role models the new expected behaviour
 5. *Empower broad-based action*
 - Remove obstacles to change
 - Change systems or structures that undermine the new vision
 - Encourage nontraditional ideas, activities, actions and risk taking
 6. *Plan and produce short-term wins*
 - Plan for visible performance improvements or 'wins'
 - Create wins
 - Visibly recognize and reward employees supporting the improvements
 7. *Consolidate improvements and generate more change*
 - Build on increased credibility to change all systems, structures and policies that do not fit the vision
 - Hire, promote, and develop people who can implement the vision
 - Reinvigorate the process with new projects, themes, and change agents
 8. *Implant new approaches into the culture*
 - Articulate the relationships between new behaviours, changes, and corporate success
 - Create the means to ensure leadership development and succession

One of the interrelated and critical themes among implementing Lean Manufacturing and organizational change is leadership. Successfully initiating,

implementing, guiding, and sustaining Lean Manufacturing is heavily dependent on leadership and commitment from top management. Without solid leadership, effectively implementing the type of transformation that Lean Manufacturing requires is extremely difficult, if not impossible.

3.2 The Shingo Prize for Operational Excellence

Lean Manufacturing has developed its own award process, the Shingo Prize for Operational Excellence. The Shingo Prize was established in 1988 "...to promote awareness of Lean Manufacturing concepts [to] recognize companies in the United States, Canada, and Mexico [who] achieve world-class manufacturing status" (Shingo Prize for Operational Excellence, 2008) and has "...become the international standard for what Lean [Manufacturing] should like" (Plenert, 2006).

The prize is named after the famous Japanese industrial engineer, Shigeo Shingo. Shingo, albeit less famous than Ohno, also helped to develop some of the Lean Manufacturing tools core to the Toyota Production System. He has authored numerous books on production management, quality control, and continuous improvement. In particular, he is most renown for his development of *Single-Minute-Exchange-of-Dies (SMED)* and *Poka-Yoke*. SMED is a methodology to reduce equipment setup and changeover times from days and hours to mere minutes. Poka-Yoke, or mistake proofing, is another of Shingo's techniques aimed at eliminating defects or errors before they occur. An example of mistake proofing would be designing machine guides or templates to only allow parts to be assembled in the correct way, eliminating the opportunity to assemble incorrectly (Martin, 2007). Due to his remarkable lifetime contributions to improving manufacturing practices, the Shingo Prize was named in his honour.

3.2.1 The Shingo Prize Model

The Shingo Prize Model is comprehensive and awards points to an organization under four main categories:

1. Cultural Enablers
2. Continuous Process Improvement
3. Lean Enterprise Thinking
4. Business Results

Figure 3.2 illustrates the Shingo Prize Model.

Figure 3.2: The Shingo Prize Model
(Shingo Prize for Operational Excellence, 2008)

Cultural Enablers

The Cultural Enabler category is divided into four subsections which organizations are graded:

- Leadership and ethics
- Education and training
- Empowerment and involvement
- Environmental and safety systems

Top-down directives and piecemeal implementation of tools is not enough to accomplish a Lean Manufacturing transformation. Widespread commitment throughout the organization is required. Cultural enablers are the basis for Lean Manufacturing transformations as they provide the right environment for Lean cultures to grow. Leadership, people development, and safety systems are the primary elements of an enabling culture.

Continuous Process Improvement

The Continuous Process Improvement category features two subsections:

- Lean principles
- Value stream and support processes

This category grades an organization according to its deployment and understanding of Lean Manufacturing tools and techniques across its operations. Tools and concepts such as process focus, flow and pull, waste, kaizen, 5S, visual workplace, value stream mapping, SMED, and the like are evaluated for integration with current operations. In addition, continuous improvement principles applied to value streams and administration processes are also assessed.

Lean Enterprise Culture

There are two subsections for this category:

- Enterprise thinking
- Policy development

Applying Lean Manufacturing concepts to all business processes throughout all levels of the organizations is the core of a Lean Manufacturing enterprise. Initially, Lean Manufacturing tends to focus on the utilization of the tools and how they contribute to the overall system. Once the principles and concepts are truly appreciated, businesses tend to think systemically and gain a holistic understanding of all the relationships within the entire system. A common Lean Manufacturing platform must govern all the critical aspects of a Lean Manufacturing enterprise, including financial reporting, capacity planning, information management, leadership development, and policy deployment.

Business Results

The final category focuses on six subsections:

- People Development
- Quality
- Delivery
- Cost
- Financial Impact
- Competitive Impact

The value created by Lean Manufacturing must be visible to customers and the organization. Metrics tied to employee safety and morale, product quality, responsiveness and service, cost savings, growth, revenue and profit, and overall competitiveness are evaluated.

The Shingo Prize Model not only awards businesses for Lean Manufacturing success, but also serves as a general roadmap for organizations looking to make the transition.

Lean Manufacturing has gradually evolved over the course of its implementation around the world to be applicable to more than just automotive production. By extending the concepts and tools of waste elimination beyond production, Lean Manufacturing concepts are applicable to virtually any kind of operations system. As an example, Lean Manufacturing concepts are seeing application in pharmaceutical laboratory practices, building construction and design, and even software development. Lean Manufacturing concepts now represent the set of thinking, tools, and mindset from Lean Manufacturing that is now being applied to systems beyond automotive manufacturing. This report will now simply refer to the process improvement system of applied Lean Manufacturing concepts as 'Lean'.

Chapter 4: Integrating EMSs and Lean Concepts

4.1 Comparison of EMSs and Lean

EMSs and Lean represent different systems for business improvement. While EMSs are focused on pollution prevention, Lean is centered on process and operational efficiency. ISO 14001 states the EMS framework and elements that need to be in place, but does not specify the operational means to implement them efficiently into existing processes. Lean, on the other hand, does not consider environmental waste as a primary objective, nor does it incorporate environmental considerations into its set of techniques. The two systems host different objectives and are not typically integrated in business practice. Businesses are usually running both systems in parallel, and do not "...necessarily integrate environmental management into their implementation of Lean methods. Instead, environmental managers may operate separately from the workforce-driven, continual improvement efforts of Lean production on the shop floor" (Tice et al., 2005). This division between EMSs and Lean is problematic to workplaces looking to implement both systems. By operating in parallel, there is potential for conflicting management objectives, redundant activities, and the danger of implementing initiatives beneficial to one system but detrimental to the other. In turn, overall organizational performance and efficiency is reduced. As such, integrating the two systems of thought is a valuable notion for organizations looking to effectively sustain both initiatives. Creating a synergy between Lean and EMSs, where the effectiveness of both systems are enhanced, is highly desired and highly possible.

4.1.1 Lean and EMS Objectives

The objectives of an EMS are to minimize environmental impacts, in other words, pollution prevention. Lean looks to improve efficiency by eliminating waste out of the organization. The objectives of both systems are fundamentally different. As

defined, Lean focuses on eliminating seven specific types of waste. Environmental waste, however, is not one of them. Ross and Associates (2003) have tabulated the potential environmental impacts of Lean waste, which are seen in Table 4.1. It is clear from Table 4.1 that the relationship between environmental impacts and Lean methods are all positive, and quite extensive. Therefore, implementing Lean inadvertently improves environmental performance. This relationship has been empirically studied, and strong evidence has been found that Lean production is complementary to pollution prevention (King and Lenox, 2001). The systems, however, are still quite distinct.

*Table 4.1: Environmental Impacts of Lean Waste
(Ross and Associates, 2003)*

Waste	Examples	Environmental Impacts
Defects	Production of products that require scrap, rework, replacement production, inspection	<ul style="list-style-type: none"> • Raw materials consumed in making defective products • Defective components require recycling or disposal • More space required for rework, repair • Increasing energy use for heating, cooling, and lighting
Waiting	Delays from stock-outs, lot processing delays, equipment downtime, capacity bottlenecks	<ul style="list-style-type: none"> • Potential material spoilage or component damage causing waste • Wasted energy from heating, cooling, and lighting during production downtime
Overproduction	Production of items for which there are no orders	<ul style="list-style-type: none"> • More raw materials consumed in making the unneeded products • Extra products may spoil or become obsolete requiring disposal
Transportation	Excessive transporting of work-in-process (WIP) long distances, trucking to and from an off-site storage facility	<ul style="list-style-type: none"> • More energy use for transport • Emissions from transport • More space required for WIP movement, increasing lighting, heating, and cooling demand and energy consumption • More packaging required to protect components during movement
Inventory	Storage of excess raw material, WIP, or finished goods	<ul style="list-style-type: none"> • More packaging to store work-in-process • Waste from deterioration or damage to stored WIP • More materials needed to replace damaged WIP • More energy used to heat, cool, and light inventory space
Complexity	Excessive parts, process steps, or time than necessary to meet customer requirements	<ul style="list-style-type: none"> • More parts and raw materials consumed per unit of production • Unnecessary processing increases wastes, energy use, and emissions
Unused creativity	Failure to capture ideas, skills, improvements, and suggestions from employees	<ul style="list-style-type: none"> • Fewer suggestions of pollution prevention and waste minimization opportunities

4.1.2 Key Similarities

Table 4.2 exhibits some of the key similarities and differences between Lean and EMSs. Although they are different systems designed for different purposes, there are some common elements. Particularly, Lean and EMSs both aim to eliminate waste; where environmental waste can be defined as business activities that produce environmental pollution. Secondly, Lean and EMSs operate within an organizational culture that promotes employee-driven problem solving. Lean is heavily focused on empowering production operators, and EMS implementation requires involvement from all parties. Lastly, both systems work under a philosophy of continuous improvement. By continually improving the system and sustaining those improvements over time, Lean and EMS both operate under the premise that better performance ultimately ensues. These similarities are the foundation to developing an integrated system of Lean and EMS.

4.1.3 Key Differences

Despite being similar on these fronts, there are also a number of differences. Lean provides a set of tactical methods and tools to improve operational efficiency. It is a collection of philosophies strongly rooted in business competitiveness and customer satisfaction. EMSs, on the other hand, only provide a framework for environmental management, rather than a set of tactical tools. The benefits of Lean are dramatic, quick, and rapidly visible to employees and to the bottom line. In turn, the drivers for Lean are heavily tied to operational strategy and efficiency, and overall market competitiveness. Ultimately, Lean is internally driven by an organization. The benefits to EMSs, on the other hand, are often very strong as well but do not guarantee quick and substantial financial savings. Pollution prevention, not quick financial savings, is the primary goal of EMSs. EMS drivers are more strongly tied to risk management, regulatory compliance, social responsibility, and corporate image. EMSs are also internally driven, but feature many motivators that are external. Therefore, the benefits of Lean often present a much stronger business case, but EMSs are a requirement

driven by more than just internal management looking to gain a competitive advantage, where financial savings may not be as rapidly realized as Lean.

*Table 4.2: Comparison of Lean and EMS
(Tice et al., 2005)*

	Lean	EMS
Overall Type	Production philosophy with operationally oriented tactics and practical tools	Management system framework
Objectives	Eliminate non-value-added activity	Eliminate environmental impacts and risk
Primary Participants	Operations, with involvement of all employees where appropriate employees	Environmental professionals, with involvement of all where appropriate
Drivers / Motivation	Fundamental business competitiveness and customer expectations; need for improvements in cost, time/responsiveness, and quality	Need to better or more cost-effectively manage environmental compliance, risk, and performance; need to demonstrate this to external customers/stakeholders
Methods / Tools	Defined toolbox of tactical methods for eliminating different types of waste	Programs, processes, and procedures designed by organization to support management system framework and to meet objectives and targets
Culture	Employee-involved problem solving culture; empowerment of decision making to address needs where they occur	Same
Improvement	Continual improvement, based on Plan-Do-Check-Act model	Same

4.1.4 Environmental Weaknesses of Lean

While it has been noted that Lean waste yields environmental benefits, Lean does not specifically examine environmental risks. As such, it is important to assess any potential environmental drawbacks from Lean methods. Larson and Greenwood (2004) discuss three limitations of Lean's environmental impacts.

Firstly, Lean does not directly target environmental waste as part of its primary waste objectives, and so its methods do not capture all environmental aspects. It has been noted that environmental benefits do result from Lean, but without explicit and direct consideration of environmental aspects within Lean, there exists a possibility of Lean methods producing improvements that increase risk of emissions or material waste. Waste is often thought about differently between

environmental managers and Lean practitioners. Case studies conducted by the EPA have indicated that a Lean business will focus efforts on value-added, product transformation processes. While this is entirely what Lean is designed to do, it tends to miss the very early and very late stages of material flow that have environmental implications. For example, the environmental costs needed to obtain and supply resources for manufacture, and any non-product waste or disposal are not considered in the Lean approach. Lean also tends to overlook the environmental risks of materials and transformation processes used to manufacture products, as well as the ultimate usage and disposal of final products. All these elements bring strong environmental concerns around emissions and material waste. Since Lean is not designed to include the entire gamut of product impacts and processes, the capacity and effectiveness of Lean for fully optimizing processes is limited from the viewpoint of full product life cycle and sustainability.

Secondly, environmental personnel are typically operating in parallel to operations-based functions and Lean efforts. This division has been previously discussed. As a limitation of Lean, environmental personnel are usually not familiar with Lean tactics, nor are Lean practitioners familiar with environmental requirements. This lack of coordination between functions leads to isolated efforts by both teams, and the risk of implementing misaligned improvements that benefit one system and upset the other.

Thirdly, the information and expertise of pollution prevention and waste minimization from environmental agencies is not always effectively transferred to Lean practitioners. Public environmental agencies and non-profit organizations promoting pollution prevention have already developed many specific types of improvements that can be implemented to improve environmental performance and resource productivity. Many of these recommendations are the result of decades of industry study. By not effectively providing the information to Lean practitioners, improvements to environmentally sensitive processes (which have

already been previously studied by environmental agencies and non-profit organizations) are reinvented by local teams, or neglected altogether. Transferring this wealth of knowledge from environmental agencies and non-profit organizations is an important step to enhancing Lean implementation efforts.

4.1.5 Lean Weaknesses of EMSs

Despite the many drivers and benefits of EMSs, reluctance to implementation still exists. Kirkland and Thompson (2002) have documented thirty different types of barriers to EMS implementation. While this list is extensive, the barriers related to return on investment and process efficiency are most notable in comparison to Lean. An EMS's primary objective is pollution prevention, rather than financial reward or operational efficiency. Therefore, practical execution of suggested improvements by EMSs may encounter resistance when at odds with these factors.

As discussed, the financial benefits of EMSs are significant. However, pollution prevention initiatives often require a longer time frame to realize cost savings, as opposed to Lean activities that generate immediate benefits. In addition, the return on investment for environmental initiatives is often in question when in comparison to other investment options. Financial savings from EMSs often "...draw on cost savings generated through material efficiency and avoided regulatory and liability costs [and]... questions about the relative magnitude of their financial benefits and whether, from the standpoint of the opportunity cost of capital, they represent a good investment, sometimes appear to limit their attractiveness" (Larson and Greenwood, 2004).

EMS assessments of operations may produce large lists of suggested improvements. From a practical standpoint, the business case may not be attractive enough to warrant some changes. Even though improved environmental performance is highly sought, suggested improvements from

EMSs encounter inertia when implementation is cost, labour, or time intensive, or economic benefits are unknown. Recommendations related to major product redesigns, operations overhauls, culture changes, and process restructures can be difficult to justify without a considerable and persuasive business case, especially in the face of ongoing Lean initiatives under stronger business drivers. EMS recommendations and requirements may also be at the expense of adding waste to processes, the very thing Lean works to eliminate. As such, conflicts between Lean and EMS can exist under these circumstances.

4.2 Areas of Potential Synergy

Even though Lean and EMSs are rather distinct, the potential for synergy is promising. By effectively marrying the systems, the ultimate result is an enhanced system that achieves more than either paradigm alone. There are a number of specific areas between Lean and EMSs that can form potential synergies. These areas are further explored in this section.

4.2.1 Existing Environmental Benefits of Lean

As discussed, the pursuit of eliminating Lean waste can generate positive environmental outcomes, albeit somewhat unintentional. By eliminating production waste, many environmental improvements are a natural consequence. Case study research has found improvements of 30% to 70% in resource productivity as a result of Lean implementation, significantly reducing energy, water, raw materials, and non-product output (Larson and Greenwood, 2004). However, there are also a number of weaknesses, previously discussed, with respect to environmental risks of processing and materials and product lifecycle management. Nonetheless, this relationship represents a promising starting point for synergy between Lean and EMSs. Having proven that the relationship has already yielded environmental benefits, further investigation into the details of Lean methods may not only maximize these benefits, but also make them deliberate.

4.2.2 Waste Elimination Culture

At the core of Lean implementation is an operations-focused, employee-driven, continuous improvement-based culture of waste elimination. Lean methods employ a process-based viewpoint of waste throughout value streams, actively engage employees in the improvement efforts, continuously improve systems, and develop, track, and visually display performance metrics. In many ways, this is exactly the kind of organizational culture that environmental agencies have wanted to develop for EMS implementation, pollution prevention programs, and

other environmental initiatives. As mentioned previously, organizational acceptance represents the largest element of a successful implementation of new systems into the workplace. If the organizational culture fostered by Lean is conducive to EMSs, then the most challenging aspect of EMS implementation is already in place. As discussed, the drivers for Lean are much stronger financially than for environmental management, and "...to the extent that improved environmental outcomes can ride the coattails of Lean culture change, there is a win for business and a win for environmental improvement" (Ross and Associates, 2003).

4.2.3 Lean Tools in EMS Implementation

In addition to the environmental benefits naturally resulting from minimizing Lean production waste, there are other means that Lean can enhance EMS implementation. Tice et al. (2005) describe three main ways. Firstly, Lean can improve the impact of an EMS by connecting its initiatives with the strong financial drivers of Lean. By partnering Lean activities with EMS objectives, a framework is provided that not only seeks to achieve environmental goals, but also the Lean priorities of production flow, customer satisfaction, and capital productivity. A common approach for both systems can be a powerful combination. Secondly, Lean offers a valuable set of tactical methods and tools to support EMS implementation. Lean offers a method to integrate EMS roles, responsibilities, and procedures into operations, and effectively communicate to all workers. Lastly, Lean has also seen prominence in non-production functions, including documentation and other administrative practices. Lean can be an effective vehicle for EMS implementation, and an excellent point of synergy.

4.2.4 EMS Knowledge in Lean Implementation

Waste is often thought about differently between EMS personnel and Lean practitioners, and understanding waste from both perspectives can lead to significant improvements for Lean implementation. Tice et al. (2005) describe two main ways that EMSs can improve Lean implementation. Firstly, Lean

activities can be expanded to assess beyond the typical production wastes the approach is meant to identify, and uncover additional areas for environmental improvement. As discussed, Lean possesses a number of weaknesses related to environmental risks of processing and materials and product lifecycle management. Incorporating environmental considerations into the process also provides an even wider, holistic understanding of the process. By effectively incorporating EMS knowledge, Lean activities can address these weaknesses. Secondly, EMSs are proactive to regulatory compliance of environmental issues. Successfully employing EMS knowledge into Lean activities anticipates any potential violations to regulatory compliance and better ensures that the workplace understands the key areas and risks that affect compliance. Because of the rapid changes from Lean events, EMS knowledge can also help to minimize delays from regulatory constraints. This may include unexpected delays due to various environmental regulations, the need for permits, or any other requirements set forth in applicable laws. EMS knowledge within Lean implementations can truly enhance its overall effectiveness across further dimensions.

4.3 Integration Strategies

After careful analysis of the areas of synergy between EMS and Lean, several strategies were developed to integrate the systems. An enhanced system, capable of more than either system alone, is the primary benefit of effectively combining the paradigms. The strategies presented in this section propose integrating Lean and EMS across several dimensions, with inherent considerations of system strengths, weaknesses, areas of synergy, and both ISO 14001 and Shingo Prize Model requirements.

4.3.1 Integrated Policy and Objectives

Strategy #1: Identify the different types of environmental waste and integrate into EMS and Lean corporate policies.

The foundation of any management system is the establishment of a policy or vision statement. These statements outline a firm's strategy, goals, overall vision and purpose for the system, and are the blueprint for implementing system initiatives. As discussed, EMSs and Lean feature unique objectives. Minimizing environmental impacts, or environmental waste, is the objectives of EMSs, whereas minimizing production waste is the goal for Lean. To begin integrating the systems, it is recommended to identify the different types of environmental waste and incorporate them into both policies. As part of an EMS policy, environmental policies are the foundation of the system, and identifying environmental waste would further clarify EMS objectives. As part of a Lean policy, some consideration would need to be taken to avoid over-expanding the scope of Lean, however, merely including environmental wastes further clarifies Lean waste and is similar to its existing framework. In effect, this is a combination of objectives and a primary starting point for further integration of the tools and methods. There are many benefits and motives for this recommendation. By amalgamating the goals, the complementary nature of Lean and EMSs is demonstrated, and a collective purpose between the systems is established. This is a critical aspect from a cultural and practical standpoint.

By ensuring that objectives are aligned, cohesive and joint implementation is possible. In addition, the concept of waste is integrated between EMSs and Lean teams, and expanded beyond traditional production-model thinking to a more holistic understanding of the business. Lack of environmental consideration is also a key weakness of Lean, and addressed by combining objectives. That way, the existing environmental benefits of Lean are maximized and intentional.

Act Now (2007), an environmental consulting firm, has identified seven additional wastes that might be considered as part of this recommendation. The company has identified:

- Waste due to energy inefficiency
- Waste due to excess water usage
- Waste of natural resources (natural capital)
- Waste due to excess packaging
- Waste due to emissions
- Waste due to effluents
- Waste due to landfills

The EPA (2007) has also attempted to identify environmental waste, and has listed them as:

- Energy, water, or raw materials consumed in excess of what is needed to meet customer needs.
- Pollutants and material wastes released into the environment, such as air emissions, wastewater discharges, hazardous wastes and solid wastes (trash or discarded scrap).
- Hazardous substances that adversely affect human health or the environment during their use in production or their presence in products.

Alternatively, if integrated policies are not desired, a separate corporate policy can be developed that explicitly states the complementary elements and working relationship between EMS and Lean functions.

4.3.2 Integrated Implementation Strategies

Strategy #2: Use Lean to implement EMS objectives and initiatives.

While ISO 14001 requirements provide a set of management elements that need to be in place, the methods to implement the efforts are not explicitly stated. In order to best execute EMS initiatives, use Lean. Lean tools and techniques are operations focused and well suited to effectively undertake EMS objectives. As discussed in section 4.3.3, an integrated Lean toolset for EMS deployment is even more powerful. Tice et al. (2005) confirm this notion: "...a proactive and deliberate integration of Lean and EMS initiatives could lead to a strategic approach for employing Lean methods in ways that achieve EMS objectives" (Tice et al., 2005). In addition, encouraging partnership between Lean and EMS initiatives establishes a common approach for general operations improvement, and is a significant consideration for organizational acceptance. Ross and Associates (2004) recommend using Lean to meet EMS and other performance objectives, citing improved environmental performance in industry studies. Lean can be the vehicle to achieve EMS goals, and a strong opportunity for integration.

Strategy #3: Encourage joint initiatives by 'piggy backing' EMS objectives with Lean activities. Leverage Lean culture change for EMS deployment.

Process efficiency and strong business cases have been identified as the main weaknesses of EMS improvements. Lean, on the other hand, excels at exactly where EMSs fall short. As such, tremendous opportunity exists to synergize the approaches through joint initiatives, such as joint kaizen events. Lean has high potential for dramatic results with strong financial motivations. By 'piggy backing' EMS objectives into Lean activities, EMS initiatives can be connected with the attractive financial incentives, strong business cases, and process-efficient focus of Lean projects. This tactic is efficient to company resources, requiring one joint implementation rather than two, and essential to installing improvements that mutually benefit both systems. The overall benefits, business cases, and success of joint initiatives are much improved over pursuing independent ventures by each team.

In addition, rapid change management is a requirement of Lean, and partnering with EMS activities can help to ease the impact on local workforces. By leveraging the rapid change management aspect of Lean, EMS objectives also have an additional opportunity to 'piggy back' with this culture change and increase acceptance to EMS objectives. Acceptance methods for Lean can jointly be used to implement EMSs. In industry study, it was noted that "...companies recognized the value of aligning their environmental and lean management practices to ensure that lean activities consider environmental performance and compliance" (Ross and Associates, 2004). Encouraging joint deployment builds team dynamics between EMS and Lean personnel and shatters the typical parallel functioning of Lean and EMSs.

Strategy #4: Use Lean concepts for EMS documentation requirements and all other support functions.

The power of Lean thinking goes beyond production and operations. Lean has seen prominence in many non-production functions, such as documentation, planning, and information management. By applying Lean to documentation practices and other support functions, it is possible to "eliminate excess documentation, unnecessary process steps, other wastes in an EMS, as well as improve the efficiency and effectiveness of a company's environmental department" (Ross and Associates, 2004). Using Lean throughout the organization for other types of functions also establishes a common management platform for the organization, optimizes an EMS in general, and "...provides the added benefit of familiarizing [EMS] staff with Lean terminology and tools" (Tice et al., 2005).

Strategy #5: Involve Lean managers in EMS implementation functions, including management review.

It has been discussed how the development of EMSs and Lean have operated in parallel, rather than jointly. To address this disconnect, it is recommended to involve Lean managers in the major EMS implementation functions, including management review. Since Lean has already been suggested to be the common

approach to execute EMSs, it is logical to involve the Lean team throughout the EMS process. Not only do Lean managers gain additional insight into EMS requirements, they provide practical, expert advice to best implement any improvement suggestions generated by EMS activities. By gaining the input from Lean managers, it is also an effective means to secure support for EMS initiatives.

Strategy #6: Cross-Train EMS personnel in Lean methods, and Lean personnel in EMSs.

Training between Lean and EMS personnel helps each team understand the needs and techniques of the other. By cross-training Lean with EMS, Lean teams are able to understand EMS considerations, and can identify issues that may need additional EMS expertise during Lean activities. EMS personnel trained in Lean learn the tools and techniques of a powerful implementation method, and gain better insight into how to combine EMS objectives in Lean events. By familiarizing each team with the needs and concepts of the other, the potential of conflicting improvements is reduced and better teamwork and joint deployment is possible.

Strategy #7: Track the environmental performance of Lean activities.

Environmental impacts of Lean activities are not explicitly considered in traditional Lean initiatives, nor openly tracked and stated. To maintain clarity between the impacts of Lean projects and environmental performance, it is recommended to measure environmental performance as additional indicators of project success. EMS personnel are able to define certain environmental metrics for certainf processes. It has been shown that many benefits already occur as a result of Lean activities, and it is a shame that the positive relationship is not celebrated. On the other hand, any negative environmental impacts as a result of Lean events should be discovered and addressed accordingly. Using environmental performance measures ensures that both the positive and negative impacts are measured, managed, and in line with EMS requirements.

4.3.3 Integrated Management Structure

Strategy #8: Solidify coordination between Lean and EMS teams by creating accountability under a single vice president, or other management position.

Strategies 1 to 6 encourage integrating Lean and EMS objectives, activities, and tools. By forcefully combining so many working elements between the teams, a strong working relationship between teams needs to be established and maintained. In turn, top management needs to sustain and manage this integration. Without direct leadership and support from a common management figure, it is not unlikely that the working relationship between Lean and EMS teams eventually disintegrates, or that conflicts in methods and improvements lead to a rapid breakdown in team dynamics. As such, it is recommended to ensure coordination between teams by placing the responsibility of Lean and EMS implementation under a single vice president, or other similar management position. This common manager ensures that any potential conflicts between teams are effectively managed, and that the strong joint relationship is supported and maintained.

The integrated strategies were developed in order to address the identified weaknesses of Lean and EMS. Table 4.3 summarizes the recommended strategies, and the relationship to Lean and EMS weaknesses.

Table 4.3: Summary of Integration Strategies and Lean and EMS Weaknesses

Integration Strategies	Environmental Weaknesses of Lean			Lean Weaknesses of EMS		Other Benefits
	Lean does not target environmental waste. Environmental benefits are unintentional.	EMS and Lean personnel are typically operating in parallel	Information and expertise of pollution prevention is not effectively transferred to Lean practitioners	EMS initiatives do not guarantee quick and substantial financial savings.	Weak business cases for major suggested improvements from EMS activities	
Strategy #1: Identify the different types of environmental waste and integrate into EMS and Lean corporate policies.	X					* Integrate concept of waste between EMS and Lean teams
Strategy #2: Use Lean to implement EMS objectives and initiatives.	X	X	X			* Establish common approach to process improvement
Strategy #3: Encourage joint initiatives by 'piggy backing' EMS objectives with Lean activities. Leverage Lean culture change for EMS deployment.	X	X		X	X	* Connect EMS objectives with strong business cases and financial drivers
Strategy #4: Use Lean concepts for EMS documentation requirements and all other support functions.		X				* Extend Lean concepts beyond production and establish a common management platform
Strategy #5: Involve Lean managers in EMS implementation functions, including management review.	X	X	X			* Gain additional insight into implementing EMS improvements
Strategy #6: Cross-Train EMS personnel in Lean methods, and Lean personnel in EMSs.		X	X			* Reduce conflicts, enable joint ventures, and build teamwork
Strategy #7: Track the environmental performance of Lean activities	X	X		X		* Expose positive and negative environmental impacts
Strategy #8: Solidify coordination between Lean and EMS teams by creating accountability under a single vice president, or other management position.		X				* Support joint ventures, minimize politics and manage conflicts

Note: X signifies that that integrated strategy addresses that weakness

4.3.4 Integrated Lean Tools

Lean suffers from weaknesses attributed to lack of consideration of environmental risk, and omission of material waste very early or late in the process. By integrating EMS knowledge with the Lean toolset, powerful and comprehensive sets of operations improvement techniques are created. With respect to the Lean tools discussed in this report, the following recommendations are suggested to address the environmental weaknesses of Lean, and provide an integrated toolset. This toolset is valuable to support the strategies previously discussed.

Kaizen

Lean kaizen events are excellent opportunities, as mentioned in previous strategies, to 'piggy back' with EMS objectives. The EPA (2007) has done significant work in relation to integrating the basic Lean tools with the environment, and recommends four steps to integrated kaizen events:

1. Train Lean team leaders to recognize EMS impacts
2. Identify an EMS contact for kaizen event teams
3. Use an EMS checklist for Lean events to identify EMS needs
4. Proactively involve EMS staff in Lean events

As discussed in previous strategies, training Lean personnel to identify environmental impacts emphasizes the usefulness for all staff to understand EMS impacts. An EMS contact is essential at this point to address any questions, and a checklist ensures environmental considerations are conducted rigorously. By proactively involving EMS personnel in kaizen events, Lean leaders gain even more insight and understanding into Lean activities from an EMS and regulatory compliance standpoint, such that kaizen activities do not produce unwanted environmental impacts or compliance issues. EMS team involvement is particularly valuable around clarifying processes that are environmentally sensitive, where regulatory uncertainty and unknown response times exist (Ross and Associates, 2003). Act Now (2007) has included six questions helpful in problem solving environmental impacts from kaizen events:

1. Can waste streams be eliminated at their source?
2. Can the amount of contaminant or chemical being removed (i.e., washed) from product or equipment be reduced?
3. Can any waste streams be reused in the process?
4. Can any waste streams be processed into valuable product?
5. Can any waste streams be processed to be good for some part of the natural environment (i.e., compost)?
6. Can any waste streams be processed to be benign in nature?

Visual Workplace and 5S

The EPA (2007) recommends implementing 6S, a variation of 5S methods. The extra 'S' stands for safety, implying the need to create a safe working environment for employees. Incorporating EMS needs into 6S audits and procedures ensures that environmental considerations are met. As a reminder, 6S stands for Sort, Set in Order, Shine, Safety, Standardize, and Sustain. During Sort, the EPA (2007) recommends using yellow tags to clearly mark materials that represent potential risks to environmental waste or other types of hazards. As part of Set in Order, Safety, and Standardize, yellow-tagged items should be carefully organized, safely managed, and standard procedures developed. During the Shine and Sustain phase, inspection and audit questionnaires can be specifically tailored to evaluate environmental opportunities by working with local EMS staff to determine particular details.

Another major element of a visual workplace is the need for controls and measurements to be easily visible. Typically, production controls and performance is what is captured. To incorporate EMSs, it is recommended to extend these practices beyond production performance to include environmental performance. By working with EMS teams to identify environmentally sensitive or risky processes, visual controls and indicators can be put in place in the same manner as 5S or 6S practices. This ensures that processes are not only being tracked for environmental impacts, but that they are visible to all workers and

clearly understood. Visual controls and metrics can also alert staff of impending hazards or violations to compliance or regulations.

Just-In-Time (JIT) Production

One environmental criticism of JIT is the added deliveries required. JIT requires materials to be delivered only when it is needed, and only what is needed, as opposed to a bulk purchase that is stored in inventory. JIT results in multiple, small-sized deliveries, resulting in extra emissions and added packaging waste from several smaller packages rather than fewer larger ones. As part of an EMS, it is important to understand these impacts as part of operational activities. By identifying the environmental impacts of JIT, the tradeoff between low inventory and environmental waste can be considered. One possibility to eliminate packaging waste from JIT is reusable containers. JIT has environmental benefits too. Case studies have shown that by employing JIT for hazardous materials with limited shelf lives, negotiating purchasing agreements for smaller quantities may ensure that these materials do not go unused and ultimately disposed (Ross and Associates, 2004).

Value Stream Mapping (VSM)

VSM is designed to capture the sequence of activities and information for a particular value stream. The missing element of this method is the environmental impact of events throughout the value stream. The EPA (2007) recommends the following techniques to incorporate EMSs into VSM:

- Use icons to identify processes with EMS opportunities.
- Record environmental data for processes in value stream maps.
- Analyze materials use versus need in a “materials line” for value stream maps.
- Expand the application of value stream mapping to natural resource flows.
- Find Lean and environment opportunities in future state value stream maps.

Some processes require special consideration because of their regulatory requirements, environmental risk or hazard, or potential for pollution. Separately identifying these activities is important for future suggested improvements, and a note for intervention by EMS staff. Using special icons or indicators is one method to accomplish EMS opportunities. In order to properly gauge a process, measurements pertaining to environmental performance should be used. This helps to uncover environmental waste and leads to opportunities for improvement. VSM typically focuses on time and value added time, but not often the amount of resources consumed in the process. Evaluating the amount of consumed resources helps to identify additional sources of material waste. In addition, value stream maps can be used to assess more closely the inputs, outputs, and information flows with respect to energy, water and materials. Value streams of these resources can be charted for environmental waste, as well as the information streams to regulatory agencies. The previous steps all help to identify environmental waste in value streams, and this information should be fully utilized for any future state mapping or improvement efforts.

Six Sigma

Six Sigma is not able to integrate with EMS the same way as Lean, as it is comprised of a set of analytical and statistical tools rather than implementation methods. As such, Six Sigma offers many techniques that are well suited for EMS objectives. The DMAIC methodology is an excellent approach to embed within Lean and EMS initiatives, and the statistical tools are perfect for tracking and analyzing either kind of project. Six Sigma is recommended to measure, track and analyze ongoing performance of EMS and Lean initiatives.

4.4 Integration Strategies and ISO 14001

The integration strategies presented in section 4.3 were also developed with ISO 14001 requirements in mind. The following list exemplifies the benefits to ISO 14001 across several of the major requirements:

Environmental Policy and Planning

Strategy #1 recommends including environmental wastes as part of the environmental policy. In turn, organizations can be clearer about EMS objectives, enabling faster, better, and more specific performance improvements. This strategy is in line with ISO 14001 Planning requirements for specific objectives and targets.

Implementation and Operation

Strategy #8 suggests consolidating the leadership of EMS and Lean implementation under a single management figure. This recommendation is aligned with the ISO 14001 requirement for a clearly defined authoritative structure.

Training, awareness and competence is another vital ISO 14001 requirement. By extending EMS training to Lean teams as in strategy #6, the level of awareness and competence is increased while satisfying this ISO 14001 condition.

Lean thinking was recommended for usage within EMS documentation and all other support functions. Documentation and document control practices are conditions for ISO 14001 compliance. Documentation requirements can be very involved, and to the extent that Lean can optimize these requirements, as in strategy #4, presents an obvious opportunity to improve the EMS structure itself while satisfying ISO 14001 requirements.

Operational control is another critical element of ISO 14001 requirements. By proactively including EMS personnel in kaizen events, EMS staff can be directly involved in Lean activities around environmentally sensitive processes. EMS personnel can also provide valuable insight into operational controls and potential regulatory and compliance issues.

Checking and Corrective Action

It was recommended to utilize Six Sigma techniques for tracking and monitoring environmental performance. Through this recommendation, organizations gain powerful and proven statistical tools able to effectively monitor and analyze environmental performance. Utilizing the DMAIC methodology can also generate operational improvements, with Lean implementing those ideas. Six Sigma is an ideal method to satisfy ISO 14001 monitoring and measurement requirements. As part of the integrated Lean toolset, 5S and 6S concepts were also suggested to expand and include environmental aspects as part of operational controls, measured visual performance, and inspection audits. These recommendations all contribute to meet ISO 14001 checking and corrective action conditions.

Management Review

Strategy #5 suggests including Lean managers in the management review of EMSs. This recommendation is directly aimed at enhancing the review process. As Lean has been suggested to be the common platform to execute EMS objectives, it is natural to directly involve the Lean team throughout EMS implementation and management review functions. Lean managers provide practical, expert advice around suitability, and the best way to implement any improvement suggestions. This also leads to higher potential for successful EMS changes and greater support for EMS initiatives, ultimately resulting in better fulfillment of more ISO 14001 requirements.

4.5 Integration Strategies and the Shingo Prize Model

The integration strategies presented in section 4.3 were created in consideration of Shingo Prize Model requirements. The following list exemplifies the benefits to Shingo Prize Model requirements across its four dimensions:

Cultural Enablers

Environmental and safety systems are already a requirement of the Cultural Enabler phase, and incorporating EMSs into Lean amply satisfies this condition. In addition, encapsulating EMS objectives within Lean initiatives infuses a commitment to eliminating waste beyond the typical production focus, and towards the general health of society. This is a solid demonstration of business ethics, a key requirement of the model.

Continuous Process Improvement

Shingo Prize model requirements grade organizations on their level of deployment and understanding of Lean principles throughout current operations. Cross-training EMS employees and using Lean to implement EMSs directly aims to achieve this condition, as the overall understanding and utilization of Lean is further diffused throughout non-production functions. In addition, using Lean in EMS documentation, as recommended in strategy #4, satisfies the model requirement for continuous improvement principles in support processes. As part of the integrated Lean tools, utilizing VSM to map natural resources and material flows also adds to this requirement.

Lean Enterprise Thinking

Enterprise thinking is the result of truly understanding Lean thinking. The Shingo Prize Model looks for implementation across all critical aspects of a Lean enterprise, including financial reporting, information management, and policy development. Integrating the concept of waste, and listing environmental wastes in environmental policies are recommendations in line with Lean enterprise

requirements. In addition, Lean was recommended to be the common platform for all EMS support functions. This recommendation is also another step towards enterprise thinking, expanding Lean into the EMS aspects of the business.

Business Results

According to model requirements, the results of Lean activities must be visible to the organization. By using Lean to accomplish EMS objectives, environmental metrics are needed to demonstrate the success of the ventures. Strategy #7 is just that. It was also recommended in strategy #3 to 'piggy back' EMS initiatives with Lean activities. As such, environmental benefits are deliberate and tied to the results of that Lean activity. Measuring, tracking, and promoting environmental results in addition to Lean benefits adds to the business results requirements that the Shingo Prize Model evaluates. In addition, establishing visual controls and measurements as part of 5S or 6S ensures that environmental performance is constantly tracked and openly visible to all employees.

Chapter 5: Conclusion

5.1 Summary of Contributions

The contributions of this report have been the following:

- A summary of EMSs, ISO 14001 requirements, Lean Manufacturing, and Shingo Prize Model requirements.
- Clear identification of similarities, differences, weaknesses, and areas of synergy between Lean concepts and EMSs.
- Eight strategies to foster the integration of Lean concepts and EMSs based on thorough analysis of strengths, weaknesses, areas of synergy, and ISO 14001 and Shingo Prize Model requirements.
- Relationship of integration strategies to ISO 14001 requirements.
- Relationship of integration strategies to Shingo Prize Model requirements.

5.2 Conclusion

As a central issue in the world sphere, the problem of climate change has initiated strong efforts around the world to minimize environmental impacts and reduce harmful emissions. Many companies have implemented environmental management systems (EMSs) in an effort to minimize the carbon output of their operations. EMSs are vital to managing and improving an organization's environmental performance. The challenge, however, has been the integration of EMS requirements into existing business functions.

Traditionally, enhancing business performance has seen the usage of a variety of process improvement methodologies. A prominent example in industry has been the application of Lean Manufacturing concepts. Lean concepts have seen great success, and have yielded remarkable benefits to many worldwide firms. However, gaps in the approach are noticed when considering EMSs. Lean concepts were never designed to include environmental considerations, and the objectives of Lean concepts are very different from the objectives of EMSs. EMS activities typically operate separate or isolated, and thus, Lean concepts are not well aligned with EMS activities. The integration of environmental initiatives into existing corporate practices, however, is critical to ensure an effective and socially valuable program. In fact, an opportunity exists to create a synergy between the systems, producing an enhanced capability able to accomplish more than either system alone.

This report has aimed to confront the disconnect between EMSs and Lean concepts by exploring the potential to integrate the systems. A summary of EMSs has been provided discussing the objectives, history, drivers, benefits, and implementation strategies. Lean Manufacturing and concepts has also been discussed across the same aspects. A review of ISO 14001 requirements and a description of the Shingo Prize model have also both been provided. After comparing Lean concepts and EMSs across several dimensions, analyzing areas

of synergy, and identifying the weaknesses of each approach, several integration strategies and tools were presented to bridge the gaps of each system. The integration strategies were also designed with ISO 14001 and the Shingo Prize Model in mind, and the relationship to the requirements were discussed.

The integration of Lean concepts and EMSs is a small yet commanding stride towards environmental sustainability. It is also a prime example that the cost of environmental protection does not necessarily sacrifice profit or efficiency. In fact, it can be quite the opposite. To the extent that integrated Lean concepts and EMS strategies can provide financial, environmental, and social benefits, an extremely promising opportunity exists.

5.3 Future Work

Opportunities for future research within this subject are highly encouraged. Literature has been relatively light on the topic, and the EPA has performed the bulk of practical research in this area. However, case study analysis of integrated EMS strategies within industry has been thin. Likewise, the value of the recommendations and analysis from this report are practically designed, yet entirely theoretical. Future research can be performed within this subject by conducting practical case studies involving implementation of the integration strategies and integrated tools within industry, particularly in partnership with an environmental agency for added support. The results can then be studied for key learning opportunities and further development on EMS integration.

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