

## Evaluation of Approaches to Safety in Lean Manufacturing and Safety Management Systems and Clarification of the Relationship Between Them

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**Abstract:** This paper discusses the relationship between Lean Manufacturing environments and Safety Management Systems. The creation of a Lean environment in a workplace requires employee motivation and good management. All the different levels of an organization need to put forth their best efforts on a day-to-day basis and work together toward achieving improved performance and reducing waste. 5S (Sort, Set in order, Sweep, Standardize, Sustain) is one of the most effective tools of Lean manufacturing because it is the basis for an effective Lean implementation. Recently 5S was changed to 6S (5S+Safety). In this paper, approaches to Lean Manufacturing, workplace organization (in terms of 5S and 6S), Environmental Management Systems, Environmental Health and Safety and Safety Management Systems are described and their relationship is discussed. It was demonstrated that 6S is the foundation for all improvement programs: waste reduction, cleaner and safer work environment, reduction in non-value added time, effective work and visual workplace vision. So 6S can be used instead of a Safety Management System in organizations and be considered as one of the Lean tools and techniques.

**Key words:** Lean Manufacturing • Safety Management Systems • 5S • 6S • Workplace organization • Environmental Management Systems • Environmental Health and Safety

### INTRODUCTION

Lean Manufacturing (LM) refers to a business concept wherein the goal is to minimize the amount of time and resources used in the manufacturing processes and other activities of an enterprise; its emphasis is on eliminating all forms of wastage. Health and safety hazards can actually be increased by LM because it mixes previously separated exposures and this has additive and cumulative effects. The intensification of work leads both to higher plant productivity and to greater adverse ergonomic and stress-related health effects for workers [1].

The 5S Process (Sort, Set in order, Sweep, Standardize, Sustain), or simply "5S", is one of the most effective tools of LM because it is a basis for an effective Lean implementation. The 5S practice was initiated in the manufacturing sector in Japan and then extended to other industries and the services sector [2]. The 5S Process is a structured program to systematically achieve total organization, neatness, cleanliness, standardization and

discipline in the workplace [3]. A well-organized workplace leads to a safer, more efficient and more productive operation. It leads to boost the morale of the workers, promoting a sense of pride in their work and ownership of their responsibilities and increases an organization's profitability and competitiveness in the market place.

A key to worker safety in LM operations is the development of informed, empowered and active workers with the knowledge, skills and opportunity to act in the workplace (5S) to eliminate or reduce hazards [1]. In addition, Ansari and Modarress [4] point out those safety strategies are crucial to world-class competitiveness; companies that fail to utilize a strategic approach to company safety will be less successful over the long term.

Recently, 5S was expanded to 6S by the addition of "safety". This paper discusses the 5S expansion to 6S as one of the most important tools and techniques of LM that focuses on effective workplace organization and standardized work procedures. The 6S process simplifies the work environment, reduces waste and non-value

activities while improving quality efficiency and safety. The aim of this study is to evaluate safety in LM approaches and Safety Management Systems (SMSs) and clarify the relationship between them.

This paper is organized as follows. Section 2 summarizes approaches to LM. In Section 3, workplace organization (5S and 6S) is introduced. The relationship between LM and Environmental Management Systems (EMSs) is discussed in Section 4. In Section 5, the relationship between LM and EMS is discussed, then Environmental Health and Safety (EHS) and SMSs are introduced and this section concludes with comparisons between SMS and LM and between SMS and 6S. The final section (6) discusses and presents a conclusion to our findings in relation to our research objectives.

**Lean Manufacturing:** Lean Manufacturing is an integrated socio-technical system whose main objective is to eliminate waste by concurrently reducing or minimizing supplier, customer and internal variability [5]. It is a production philosophy that emphasizes the minimization of the amount of all the resources used in the various activities of the enterprise. It involves identifying and eliminating non-value-adding activities in design, production, supply chain management (SCM) and customer management. Lean manufacturers employ teams of multi-skilled workers at all levels of the organization and use highly flexible and increasingly automated machines to produce volumes of products in potentially enormous variety.

The five primary elements to consider when implementing LM are manufacturing flow, organization, process control, metrics and logistics [6]. These elements represent the variety of aspects needed to sustain a successful LM implementation program. As a result, the LM program may be, mistakenly, viewed as a failure in the early stages of implementation [7]. The more successful the implementation is, the more rapid the reduction rate of waste [8]. The approach of LM is in direct opposition to traditional manufacturing approaches that are characterized by economic order quantities, high capacity utilization and high inventory [6]. Feld [6] states that in order to create a LM environment an organization needs to be aware of where it is at that point, know why it needs to change and why change is important. It is necessary to provide the employees with answers to these questions so that they become more engaged in the process.

Lean identifies waste/muda (overproduction, waiting/idle time, unnecessary transportation, non-value-added processing, unnecessary stock on hand/excess



Fig. 1: Five Elements of Workplace/5S

inventory, motion and efforts, defects/producing defective goods, unused creativity) [9, 10] and applies tools and techniques (workplace organization, Kanban, Just-In-Time (JIT), Total Quality Management (TQM), total preventive maintenance, standardization of work, point-of-use-storage etc.) [2] to optimize systems. These wastes are commonly referred to as non-valued activities and to Lean practitioners they are known as the Eight Wastes. Taiichi Ohno (co-developer of LM) (cited in [11]) suggests that these account for up to 95% of all costs in non-LM environments.

### Workplace Organization

**5S:** 5S (Sort, Set in order, Sweep, Standardize, Sustain) is a workplace organization tool that improves worker efficiency by organizing the contents of the work area and standardizing work procedures; it is a method of creating a self-sustaining culture that perpetuates an organized, clean and efficient work place (Figure 1). Ho *et al.* [12] report that Takashi Osada formalized the first framework for applying 5S within a business in the early 1980s.

Boeing in USA pursues 5S as a world-class strategy [4]. However, Hylan *et al.* (cited in [3]) found that among the 10 continuous improvement tools they investigated the usage and perceived importance of 5S was lowly ranked.

**6S (5S + 1S = Safety):** 6S is a method used to create and maintain a clean, orderly and safe work environment. 6S is based on the five pillars of 5S in LM, plus a separate pillar for safety. The first five of these elements were taken from the Toyota Management System (TMS) but the sixth 'S' was added by Universal Coordinated Time to emphasize safety in the workplace [13]. Besides, 6S is often the first method companies implement in their Lean journey

Table 1: Six pillars of 6S

No	Pillar	Definition
1	Sort/Get rid of it	Separate what is needed or not needed in the work area.
2	Set in order/Organize	Organize what remains in the work area.
3	Sweep/Clean and solve	Clean and inspect the work area.
4	Safety/Respect workplace and employee	Create a safe place to work.
5	Standardize/Make consistent	Standardize cleaning, inspection and safety practices.
6	Sustain/Keep it up	Make 6S a way of life.

because it serves as the foundation of future continual improvement effort [14]. This tool allows workers to be able to know and find tools easily, file the tasks conveniently and save time spent on looking for things.

The six pillars work together to support improvement efforts in a company. They help reduce defects, make accidents less likely, reduce costs and increase productivity (Table 1). Also, 6S fosters a culture of continual improvement and employee engagement that is essential for successful implementation of Lean. Moreover, 6S often makes it easier to implement other Lean methods such as cellular manufacturing, one-piece flow and JIT production. Finally, the visual impact of a 6S event makes the improvement it produces impossible to miss and this creates a real sense of achievement and pride that can form the beginning of a more significant cultural transition [15].

As a consequence, 6S is a tool of LM whose value is readily grasped and the concept of "a place for everything and everything is in its place" is easily understood. Also, another great quality of 6S is that it is doubly enabling for employees: it enables people to be free of aggravations that hinder their work and it is a positive way to involve people in improving their own work settings [15].

**LM and Environmental Management System:** The Lean concept itself was not a single point invention, but the outcome of a dynamic learning process that adapted practices emanating from the automotive and textile sectors in response to environmental contingencies in Japan at the time [16-18]. Lean is a process improvement methodology widely used in industry that focuses on identifying and eliminating wastes to improve productivity and reduce costs. Lean wastes include delays caused by transportation or waiting for the next production step, defective products, excess inventory and unnecessary movement or processing. If environmental wastes, such as wastes created during production, are considered, then Lean methodology can also be used to achieve environmental objectives [11]. Holweg [18] states that the fundamental ideas of LM are universal-applicable

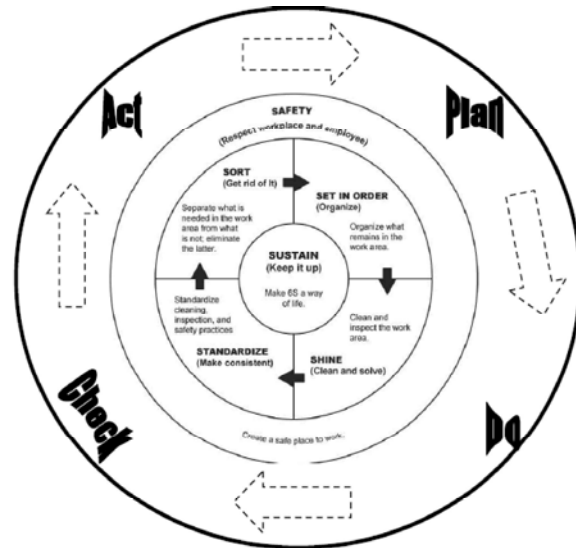


Fig. 2: Combination of the Six Pillars of 6S and PDCA Cycle

anywhere by anyone-and that many non-Japanese companies have already learnt this.

An EMS is a management framework for reducing environmental impacts and improving organizational performance over time [19]. EMSs provide organizations of all types with a structured approach for managing environmental and regulatory responsibilities to improve overall environmental performance, including areas not subject to regulation such as unregulated risk, resource conservation and energy efficiency. An EMS helps an organization better integrate the full scope of environmental considerations and get better results, by establishing a continuous process of checking to make sure environmental goals are met. The EMS approach is based on the concept of TQM that was initially developed as a tool by the private sector to achieve higher and more consistent product quality. The framework is based on a plan-do-check-act (Figure 2) continual improvement approach that leads an organization through a regular cycle of planning, implementation, performance monitoring and review/improvement.

Typically, an EMS is used to support continual improvement of activities relevant to environmental performance by helping an organization identify and act on opportunities for improvements.

#### **Relationship Between LM and EMS**

**EHS:** There are three key reasons why leaders of business, Lean practitioners and EHS managers follow efforts to organize Lean and environmental management activities [14]:

#### **Learn to See Hidden Environmental Waste and Hazards:**

Learning to see and eliminate unseen environmental wastes during Lean implementation can lead to more efficient production by improving the time, cost and quality, results of Lean initiatives. Chemical substitution, changes in process and other strategies can reduce the need for non-value added actions, such as regulatory compliance management and investment in pollution control equipment that might otherwise be overlooked by Lean alone.

#### **Enhance the Effectiveness of Lean Implementation:**

Coordination of Lean and environmental management can facilitate more process improvement and make it easier to apply Lean to processes with environmental regulatory constraints. EHS personnel can assist Lean implementation by anticipating and addressing environmental constraints such as the need to obtain permits and by identifying environmentally friendly process alternatives.

**Deliver What Customers and Employees Want:** A significant competitive advantage can be attained by providing customers with products and services with less environmental impact and by improving the work environment for employees.

The Occupation Health and Safety Assessment Series (OHSAS) 18001 is intended to help organizations control occupational health and safety risks. It was developed in response to widespread demand for a recognized standard against which to be certified and assessed.

Although LM is substantially more efficient and productive than traditional manufacturing systems, it also concentrates health and safety hazards in small areas where large-scale engineering controls of hazards in spread-out assembly lines are frequently no longer possible [1]. To fully protect workers in a LM environment, it is necessary to combine a traditional

industrial hygiene approach and a greatly expanded role for workers themselves. The traditional industrial hygiene approach involves the recognition, evaluation and control of workplace hazards. Given the combination of previously separated hazards in LM, as well as the frequent changes in production, occupational safety and health professionals at these plants must increase their hazard identification, evaluation and control activities [1]. The concept of a safe working cycle that originated in Japan, similar to 5S, is a type of management tool that can be used to solve difficulties in different aspects of the management systems [20].

The occupational safety and health arena similarly needs empowered workers able to identify, evaluate and suggest controls for hazards arising in their work areas that have frequently changing materials, machinery and related hazards [1].

The standard industrial hygiene approach of anticipation, recognition, evaluation and control of hazards continues to be applicable to Lean operations, but more intensive efforts are required to evaluate combined and mixed hazards and then to implement flexible and effective controls. A key for both maximum productivity and optimal worker safety in LM operations is informed, empowered and active workers with the knowledge, skills and opportunity to act in the workplace to eliminate or reduce hazards. In theory, LM should open the door to and institutionalize meaningful worker participation on the shop floor [1].

**SMS:** A SMS reflects an organization's commitment to safety and it is an important ingredient in employees' perceptions about the importance of safety in their company [21]. The purpose of SMS is to help organizations tackle occupational safety and health challenges continuously and improve control on factors influencing health and safety. SMSs have recently experienced an increasing diffusion between companies [22].

Mak [23] suggests 14 elements in SMS: Safety policy; Safety organization; Safety committee; Safety promotion; Safety training, In-house safety rules and regulations; Program for inspection of hazardous conditions; Job hazard analysis; Accident investigation; Process control program; Evaluation, selection and control of sub-contractor; Emergency preparedness; Health assurance program; and Personal protection program. These 14 processes form the basic skeleton of a SMS. A SMS has four main elements: safety policy, safety risk management, safety assurance and safety promotion (Table 2) [24].

Table 2: Elements of a safety system (based on [24])

Elements	Functions
Safety Policy	Providing a fundamental approach to manage safety which is to be adopted within an organization
Safety Assurance	Safety Risk Management Identifying the hazards, assessing, analyzing and controlling the risk
Safety Promotion	Making sure that organizational products/services meet or exceed safety requirements
	Combining safety culture, training and data sharing activities that support the implementation and operation of an SMS in an organization

Table 3: Set of policies and practices of SMS [based on 21, 22]

Elements/Specifications of SMS	Authors
Provide policy and organization, management practices and procedures, monitoring and auditing	European Process Safety Centre [26]
Identify and analyze both latent and visible hazards	Booth and Lee [27]
Provide a set of policy strategies, practices, procedures, roles and functions	Kirwan [28]
Improve the safety standards of operations, enhance communication, morale and productivity	Cox and Vassie [29]
Suggest a viable means to achieve and maintain a high level of safety and a reduction in losses	Mitchison and Papadakis [30]
Recommend a set of interrelated/interacting elements to establish safety policy and objectives	ILO [31]
Analyze specific topics of SMSs, such as risk analysis	Demichela <i>et al.</i> [32]
Provide policy, planning, implementation and performance evaluation	Law <i>et al.</i> [33]
Offer SMSs a performance instance of risk analysis	Basso <i>et al.</i> [34]; Hurst [35]; Frick <i>et al.</i> [36]; Robson <i>et al.</i> [37]

Table 4: A comparison between SMS and LM

5 Pillars of Systematic Safety in SMS	Lean Tools and methods
Planning and documentation	Plan (Deming Cycle)
Managing and organizing	Do (Deming Cycle) and 5S
Checking and assessing	Check (Deming Cycle) and 5S
Analysis and evaluation	Act (Deming Cycle) and 5S
Information and motivation	MIS and tools of protreptic and motivation

Obviously, many companies tend to adopt the principles and theories of quality management in safety management because there are similarities between them. Standardization and discipline are types of management tools that can be used to solve difficulties in different aspects of the management systems [20].

A hazard is any activity, situation or substance that can cause harm. Occupational hazards are divided into two broad categories: (1) health hazards and (2) safety hazards. Generally, health hazards cause occupational illnesses, such as noise-induced hearing loss. Safety hazards cause physical harm, such as cuts, broken bones and so on. Hazards exist in all workplaces [25]. According to different authors, the major factors in the creation of hazards in companies are: employees demotivation, lack of or unclearly defined working procedure and tasks, lack of control, lack of instructions or appropriate training, unsafe worker behavior, low management commitment to safety, no consensus on what an SMS exactly is and on the corresponding scope [20, 25]; all these can be controlled in LM environments. The details of specifications of SMS are shown in Table 3.

Reason and Hobbs [38] claim that the errors of total productive maintenance (one of the cornerstones of LM)

have been identified as major contributing factors to accidents in complex systems and the counter-measures proposed can be extended to maintenance in manufacturing environments. According to Saurin *et al.* [39], Poka-yokes for safety purposes should go beyond Personal Equipment Protective (PEP) and safeguards; devices need to be developed with a major preventive role that can be linked to specific and serious types of errors. Moreover, because Lean systems have gradually matured in construction and elsewhere, the time has come to investigate whether there has been correlation between safety and production performance [39]. Fernandez *et al.* [21] and Bottani *et al.* [22] show what the main factors in the creation of hazards in companies are; all these can be controlled in LM environments. Moreover, all the SMS policies and practices referred to in Table 3 are available in LM/6S.

**A Comparison Between SMS and LM:** Kelly [40] and Hendrick [41] point to five pillars of systematic safety in SMS: planning and documentation, managing and organizing, checking and assessing, analysis and evaluation, information and motivation. If we compare the SMS approach with the LM approach we find that all of the noted pillars of SMS are common in LM too (Table 4).

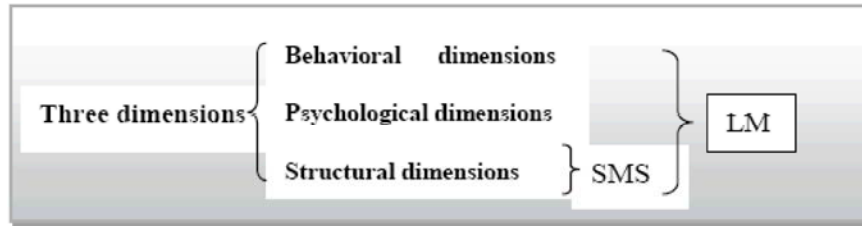


Fig. 3: A comparison between SMS and LM

Table 5: A comparison between SMS and 6S

SMS		6S
Safety implementation	---	The first tool of LM in Co
Safety hazards	---	Safety hazards and waste
Safety policy/promotion	---	Safety culture
Safety assurance	---	Safety standard
Safety environment	---	Safety for workplace and employees
Safety measurement	---	Deming (PDCA) Cycle

According to Flannery [42], safety culture is determined by 3 key dimensions: behavioral, psychological and structural. Flannery [42] points out those only structural dimensions are used in SMS. However, all dimensions of safety culture are used in LM (Figure 3).

**A Comparison Between SMS and 6S:** A comparison between SMS and 6S based on six parameters is shown in Table 5.

In addition to being a philosophy, LM is a Tool Box. 6S is one of the tools of efficient process of Lean practices, it is a foundation for all improvement programs and it provides a cleaner and safer work environment. LM creates a suitable environment for implementing SMS and a desire for implementing SMS.

## DISCUSSION AND CONCLUSION

LM, which establishes small production “cells,” or teams of workers, who complete an entire product from raw material processing through to final assembly and shipment, increases health and safety hazards by mixing previously separated exposures. The intensification of work through LM leads to greater ergonomic and stress-related adverse health effects, as well as increased safety hazards. Consequently, this allows us to evaluate the incremental effect of organizational context and LM practice independent of industry effects. In a LM visual workplace, anyone will know “who, what, when, where, why and how” of an area within five minutes. LM is the Tool Box and 5S is one of the Tools of efficient process of Lean practices.

5S is a foundation for all improvement programs: a focus on organization, simplification and waste reduction. Some of the benefits of 5S as an LM tool are: cleaner and safer work environment, reduction in non-value added time, effective work and the visual workplace vision. This provides support for the synergistic effects of implementing practices, representing multiple aspects of LM. As a result, some of the common characteristics of the Safety Department in SMS and in 6S (5S + Safety) are as follows: there are safer working conditions in which workers can find all the fire extinguishers; eye wash stations are accessible; slip, trip and fall hazards are reduced; better organization reduces associate travel time and distance, thus reducing the opportunities for accidents and so on. LM/6S has the highest level of support in SMS. Active and open management supports Lean Principles because it makes companies more competitive in the market place. 6S helps to get production staff involved in identifying needs and developing safe work procedures as part of the work instructions process. 6S and SMS follow reduction of waste and hazards in the workplace. However, the final results and recommendations are as follows:

- Companies with LM approaches create a desirability environment for implementing SMS.
- LM creates a suitable environment for implementing SMS that can be easily manipulated.
- LM can guarantee health and safety in companies/organizations through 6S.
- According to SMS and Lean approaches, 6S can be used instead of SMS in companies/organizations. In other words, SMS can be used as a tool/technique for the successful performance of LM.

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