Lean Black Belt Course 4: Advanced Lean Tools and Practices
Participant Workbook

The course aims to refresh the concept of Lean Thinking and its associated principles and benefits. It will outline the differences between value-added and non value-added/ wasteful elements in processes and how Lean can be used to identify and reduce/eliminate waste. In doing this, the course will explain how to gain a thorough understanding on customer perspectives in order to accurately define what is value in a process, and how Lean can then be used to deliver this value in the most efficient manner through optimizing process flow and capacity and improving workplace organization.

MODULES

4. Optimizing Process Flow

5. Optimizing Process Capacity

6. Workplace Organization

Course Overview

This overview aims to prepare you for the content of Course 4 by providing details of this course's goals and assignment.

Course Goals

On successful completion of this course, you will be able to:

- [ ] Recall the origins of Lean Thinking and its principles and benefits
- [ ] Recognize value-add and non value-added/wasteful elements in a healthcare process
- [ ] Collect relevant data to gain an understanding of what customers perceive as value-added in a process
- [ ] Identify the causes and types of variation in processes
- [ ] Recognize the differences between demand, capacity, activity and backlog in a process
- [ ] Identify the tools used to measure and align demand and capacity
- [ ] Identify the Lean tools and practices used to understand and analyze value streams, optimize process flow and capacity and improve workplace organization

- [ ] Use the relevant Lean tools and practices to optimize process flow and capacity in an organization and improve and sustain workplace order and organization

The course consists of seven modules:

1. Introducing Lean
2. Understanding customer and staff perspectives
3. Understanding value streams
4. Optimizing process flow
5. Optimizing process capacity
6. Workplace organization

Course Assignment

For this assignment, you will be required to describe your own ‘Lean journey’ and your deployment of Continuous Improvement tools/techniques through various projects and initiatives that you have undertaken. In doing so, you should outline how the more advanced tools and techniques could have contributed to one of these projects and where they might now be best applied.

You will be required to identify a number of projects that you were directly or indirectly involved in.

You need to create an assessment report as outlined below. The executive overview and summary should frame your Lean journey to date, projects you have been involved in, tools and practices used and the impact that these projects have had. You should then aim to focus on one particular project and focus on plans for preparing for the project, other employees engaged in the project, the Lean tools implemented, change vision, communications plan and how Lean and continuous improvement was understood, demonstrated and sustained.

The report should identify **what went well and what could be improved** related to the project and how Lean was received or adopted by end users and key stakeholders. Please use the information you have learned from the module in framing the lessons learned section. The report should provide enough detail to clearly communicate your understanding of the change initiative and how you would improve the implementation of the change given the opportunity to apply the advanced Lean tools and practices learned from the module.

Assignment Deliverables

The assignment should have a **maximum total word count of 9,500 words** and include the following:

1. Lean and Continuous Improvement Journey Overview (500-1,000 words)
2. Specific Project Strengths (minimum 1,500 – maximum 2,500)
3. Areas for Improvement (minimum 1,500 – maximum 2,500)
4. Lessons Learned for Future Implementations (minimum 1,500 – maximum 2,500)
5. Summary (500-1,000 words)

Assignment Assessment

The assignment will be assessed against each of the following weighted assessment criteria:

1. Professional appearance of assessment report (10%).
2. Scope of the process improvement undertaken and tools used (10%).
3. Demonstration of effective Lean implementation (20%).
4. Evaluation and assessment of tools and their effectiveness for the executed change (10%).
5. Reason for selection of tools and approaches clearly identified (10%)

6. Assessment of the initiative and how the implementation can be improved (10%).
7. Evidence of ongoing/standardized process improvement in the target area (20%).
8. Completeness of thought process (10%)

The scores for each component will be totaled to produce an **overall score of 100**.

References and further optional reading

If you would like to do further optional reading about this course's topic, you may wish to consider the following resources that the creators of this course drew on in preparing this course:

- **Bichero J and Holweg M 2016,** *The Lean toolbox: the essential guide to Lean transformation,* PICSIE books, 5th Edition.

- **Rother M and Shook J 2003,** *Learning to see, The Lean Enterprise Institute*, Brookline, Massachusetts.

Note of Links:

If you find that a hyperlink used in this course is out of date, please notify us at cdneducationlead@leadingedgegroup.com. You may also be able to find an out of date web resource by searching for the expired URL at http://archive.org/web/web.php

1. Introducing Lean

Module Overview

This module provides a refresher understanding and appreciation of the key elements of Lean Thinking. The module identifies and discusses each of the five core principles of Lean Thinking and their application in environments, focusing on the concepts of waste elimination and value creation within processes. The module outlines and explains the main steps involved in implementing any Lean initiative, and it stresses the importance of employee contribution, commitment, and performance in the Lean implementation.

Modules Objectives

On successful completion of this module, you will be able to:

- Define the term ‘Lean Thinking’
- Outline why organizations typically implement Lean Thinking
- Identify and distinguish between the principles of Lean Thinking
- List the core goals of Lean Thinking
- Identify the main types of waste
- Distinguish between value-added, non value-added but necessary and wasteful activities

Required Reading

- **Bichero J and Holweg M 2016,** *The Lean toolbox: the essential guide to Lean transformation,* PICSIE books, 5th Edition. Pages 1-48.

Module Topics

The topics that will be covered in this module are:

1. Background and origins of Lean
2. Principles of Lean
3. Features of a Lean

Reflection and Self-assessment

There are no reflection or self-assessment exercises for this module.

1

1. Background and Origins of Lean

The term ‘Lean Production’ was first used by an MIT graduate student in his masters thesis and was brought to a wider audience by Womack, Jones and Roos in their seminal text The Machine That Changed The World, published in 1990, and by Womack and Jones in their subsequent book Lean Thinking, which was first published in 1996. The term ‘Lean’ has since been universally accepted as the generic label for the production and management systems and tools developed and adapted by Toyota during the previous half-century, and known as the Toyota Production System (TPS).

Lean is a systematic approach to identifying and eliminating waste or non-value-added activities in a process through continuous improvement. The key focus of Lean Thinking is identifying the value of any given process by distinguishing value-added steps from non-value-added steps, and eliminating waste so that eventually every step adds value to that process. This is achieved by enabling the flow of a product or service at the pull of the customer in pursuit of perfection.

The benefits of Lean Thinking have spread beyond manufacturing processes. It is now being applied to non- manufacturing areas such as the financial services and healthcare sectors because of its outstanding effectiveness.

The Lean system used in the TPS is based around the concept of a house. Each element of the house – foundation, pillars, roof, and rooms – incorporates the elements of a Lean system. Figure 1 demonstrates the TPS house.

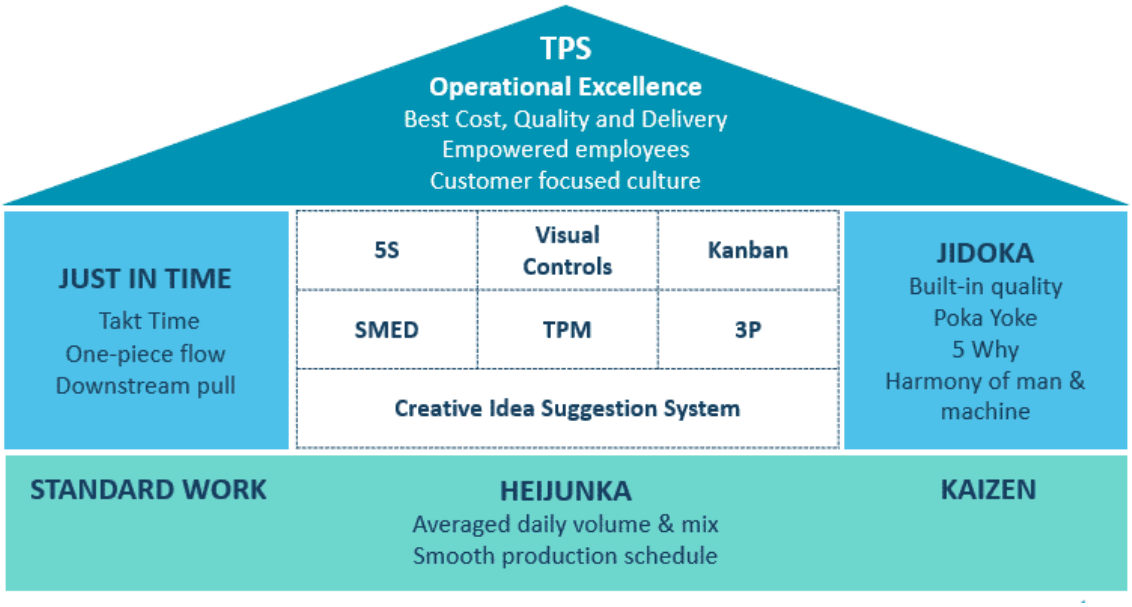


Figure 1 .1: The TPS house

The foundation represents the underlying principles of Lean systems. These principles are based on establishing continuous improvement and a standard way of working to ensure that production schedules are optimized and run smoothly and efficiently. The pillars and rooms of the TPS house represent the tools that are used in the Lean system to support and implement it.

Within the house are people. Toyota places a huge significance on the role of people within the organization. There are numerous concepts contained within this element of the house, including teamwork, cells, cross-training and continuous improvement methodologies. Employee safety and morale also fall into this portion of the house.

Finally, the roof represents the primary aims of any Lean system – operational excellence and a culture that is focused on the customer with the goal of optimal quality, cost and efficient delivery of products and services.

Production or manufacturing organizations would typically implement Lean Thinking in order to more efficiently meet the following customer requirements:

- Quality requirements
- Quicker response times
- More product or service options
- Shorter product or service life cycles
- Cancellations/revisions
- Price pressure/cost reductions

Lean Thinking is not only a manufacturing strategy or a cost-reduction program, but a philosophy that can be applied to a variety of organizations. This is because it is focused on processes. All organizations are made up of a series of processes, or sets of activities or steps intended to create value for those who are dependent on them – customers.The principles associated with Lean Thinking include understanding customer value, introducing flow approaches and the quest for perfection. All of these can be applied to non-manufacturing processes.

Continuing global expansion has made business in all industries more and more competitive. Using the principles and tools associated with Lean Thinking to reduce and eliminate waste enables organizations in numerous sectors to become more competitive by enabling them to:

- Operate more quickly and efficiently at lower costs
- Become more responsive to the needs of customers
- Increase revenue levels
- Increase service levels

This can help organizations reach a world-class standard where employees experience increased job satisfaction and fulfilment; and customers receive the highest quality of service.

Lean Thinking is based around the application of a number of tools and strategies aimed at streamlining all aspects of a business process. These tools are intended to reduce the labour, space, capital, materials, equipment, and time involved in the delivery of the appropriate products or services to end customers. Using these tools, Lean Thinking has been used to

identify and implement improvements and potential benefits away from the factory floor, in organizations from industries as varied as:

- Financial services
- Retail and food services
- Law
- Construction
- Government
- Healthcare

2. Principles of Lean

The following principles are fundamental to Lean Thinking:

- Specifying value from the **standpoint of end customer**
- **Eliminating waste**
- Making the product or service **flow**
- **Pulling** at the convenience of the customer
- Improving continuously in **pursuit of perfection**
- Adopting an all-inclusive approach that encourages **employee contribution**

2.1 Specifying Value from the Standpoint of End Customer

The value stream is the end-to-end collection of processes that create and deliver value for the customer. A value stream crosses departmental boundaries and typically incorporates only those steps or activities that add value as defined by the customer.

The value stream can include:

- People
- Tools, equipment, and technologies
- Raw Materials
- Inventory
- Physical facilities
- Communication channels
- Policies and procedures

Value provides a crucial starting point for the implementation of Lean within organizations. Value essentially consists of all activities which are perceived by the customer as directly contributing to the creation, transformation or delivery of the product or service that they have paid their provider to supply.

The value stream can be all of the steps currently required to move a product or group of similar products, from concept to launch, order to delivery, and delivery through recycling.

In identifying the value stream, it is important to challenge every step asking why each activity is necessary and would the customer's physical or mental state deteriorate if the step or activity could be left out? Many steps are only necessary because of the way firms are organized and previous decisions about assets and technologies.

2.2 Eliminating Waste

Anything that does not add value in the eyes of the customer is viewed as wasteful or non-value-added. Waste is typically the result of how a system or process is structured or organized.

Activities or elements in any process should therefore be classified as

- Value-adding
- Non value-adding but necessary
- Non value-adding or wasteful

2.2.1 Value-adding

Value-adding activities make a product or service more valuable from the customer's perspective. To be value-added, the action must meet all three of the following criteria:

1. The customer must be able to see how the activity adds value to a product or enhances the service provided
2. The action or activity must be carried out correctly in the first instance
3. The action must somehow change the product or service in a particular way

2.2.2 Non-value-added but necessary

These activities do not add value to a product or service from the customer's perspective, but are a necessity unless the existing process is modified.

2.2.3 Non-value-adding and wasteful

These activities do not add value to a product or service from the customer's perspective, and are not necessary in the existing process. The customer needs to have a clear perception that value is being added. They need to feel justified in terms of what they are actually paying for. Organizations need to adopt a customer perspective when assessing exactly what value is, and where they should add it in the processes that they undertake.

Waste can be defined as any element of a process that adds time, effort and cost but no value. Waste within any process is costly and impacts directly on profitability and resources. It means staff time is used inefficiently. This can have a negative effect on staff motivation if employees perceive such work as being ineffective. Waste may manifest itself through inefficient planning or scheduling processes or any non-value-adding activities. Taiichi Ohno, the founding father of the TPS, compiled seven types of waste. Table 1.1 outlines what each can be in manufacturing.

Types of Waste	Explanation/example
1. Overproduction	Producing more, sooner, and faster than required
2. Transportation	Any transportation of materials that does not add value to the product
3. Inventory (Work in Progress)	Maintaining excess inventory resulting in high costs and poor customer service
4. Processing	Excessive documentation: Doing more work than is necessary
5. Waiting	Idle time for a machine or its operator
6. Correction/Making defective products	All repairs to products necessary to fulfil customer requirements, any response to errors in paperwork
7. Motion	Looking for missing information; Excessive motion to pick up parts or stock

Table 1.1: Types of waste and their corresponding examples in manufacturing

Something should not be branded as waste unless the total value stream has been assessed. In an enterprise that's considered Lean, taking time out that does not add value is far more important than speeding up individual work processes or activities. The emphasis must be on eliminating waste with the goal of creating value that can apply to all stakeholders. A stakeholder is an individual or group with an interest in maintaining the success of an organization and upholding the viability of the organization's products and services.

Eliminating waste is not the only way to become a Lean organization, but it is a valuable learning experience which brings all the team together to understand problems which they are then encouraged to solve.

2.3 Making the Product or Service Flow

Once value has been clearly defined, the value stream identified and obvious wasteful steps removed, the next step is to make the value-creating steps flow. All the steps that truly create value should be analyzed and ordered so that they occur in rapid sequence. The principle should be based on the idea that, in general, things flow better when done in order of arrival, not in batches.

Ideally, every step in the process should be:

- Right every time
- Always available
- Flexible to meet changing customer demand
- Optimized to avoid bottlenecks without being oversized

All areas should be in constant open communication regarding schedules, relevant information, available materials, equipment and resources. This is easier to achieve once waste is eliminated and value is identified. Processes should be organized to meet specific customer needs based on minimum inventory levels and bottlenecks within the process.

2.4 Pulling at the Convenience of the Customer

Pull refers to the actual customer demand that drives a business process. It is a system based on a cascading process from downstream to upstream activities in which nothing is produced or delivered by the upstream supplier until the downstream customer signals a need.

Processes should be organized to meet specific customer needs based on minimum inventory levels and bottlenecks within the process. Critically, it is based on a pull system where

materials, equipment, documentation and resources are pulled through the system based on customer requirements, rather than a push system where materials are pushed through the system to suit operational needs or simply because capacity requirements are available.

A useful way to visualize a pull system is to consider how best to move a chain across a table. Pushing the chain will result in a tangled mass of links at the far end, whereas by pulling the first link and maintaining tension in the chain, it can be moved to the far end of the table, with all the links separate and in the same sequence as when they started

2.5 Improving Continuously in Pursuit of Perfection

Perfection refers to any ongoing activity that is aimed at achieving better results. Perfection is an ideal, so anything and everything can be improved.

Some principles in seeking perfection are:

- Maintaining that the status quo is unacceptable
- Putting aside preconceived ideas
- Finding root causes to problems
- Focusing on the process, not the people
- Accepting that the employees are the experts
- Allowing yourself the right to fail

Lean Thinking is not about developing elaborate and expensive solutions which may take months and years to develop and implement. Rather it reflects the commitment within a Lean organization to look for improvement opportunities on an ongoing basis.

As organizations move through the previous principles, it becomes increasingly apparent that there are opportunities to reduce effort, time, cost, space and errors while delivering services more closely aligned to real customer requirements. Getting value to flow faster exposes waste in the value stream and impediments to flow are highlighted as pull systems are

implemented. Almost unlimited opportunities are therefore identified to further improve the processes within the value stream.

Every process failure, delay or unplanned occurrence must be regarded as an improvement opportunity. Another key ingredient in the perfection principle is that improvements are not delayed or deferred while the optimal solution is developed; rather small improvements should be frequently implemented as the opportunity present themselves. An additional benefit of this approach is that implemented improvements often uncover previously unseen issues and opportunities, which are often missed when optimal-type solutions are being developed. Consider the ongoing improvements as peeling layers of waste from the value stream - each new layer often only becomes visible and certainly becomes clearer as the preceding layer is removed.

This principle also contains cultural implications for organizations implementing Lean. Specifically, it is only by involving employees in the identification of waste, as well developing and implementing improvements that the organization can achieve meaningful and sustainable improvements over the longer term

2.6 Adopting an All-inclusive Approach that Encourages Employee Contribution

Successful Lean initiatives need high performing, flexible, motivated and multi-functional staff. Given that Lean is often focused on reducing costs by eliminating waste, there is a common misconception that the elimination of waste and cutting of costs involves reducing the workforce through layoffs. Such a belief can lead to employee fear, skepticism and mistrust. It is vital that these fears are allayed immediately at the start of the journey to Lean implementation. Having committed to a Lean initiative, it is vital that management administrators make it clear to all employees that such an initiative will not involve any reduction in the workforce:

- Make it clear that the Lean initiative is aimed at utilizing existing materials, resources and procedures as efficiently as possible
- Outline that the benefits will not only extend to customers, but also to the work environment, making job roles and responsibilities more efficient and satisfying

- Explain that it is an approach that helps empower employees to plan how and when to implement improvements to best meet customer requirements and expectations

When implementing Lean, employees should be regarded as the most important element of the initiative. Healthcare management and administration should immediately seek employee involvement. Their ideas, suggestions, thoughts and opinions should be taken into account when developing and implementing any Lean strategy.

By showing respect for employee opinions and contributions, management can gain full commitment to the Lean initiative. Any management strategy should be developed so as to help foster and maintain dedicated and high- performing employees. Where employee roles or responsibilities need to change, then existing employees should be retrained if necessary, rather than recruiting any new employees. These people have invaluable experience in existing processes and procedures, so their continuing contribution and involvement throughout the Lean implementation is vital. Employee needs, as well as customer needs, should be catered for in any implementation of Lean.

3. Features of a Lean

In a Lean, the customer defines the value of a product. Waste, therefore, can be defined as anything that does not add value from the customer's perspective. Since the price the customer pays must cover the cost of manufacture, the customer is ultimately paying for all the waste in the manufacturing process. Waste can be incurred in several ways. It may be an inbuilt part of the product design or specification. It may be due to inefficiencies in the manufacturing process, or in the activities that support manufacturing, such as procurement, inventory management, and distribution.

The following are the components of a typical Lean[1]:

Lean Suppliers

A Lean encompasses suppliers that are responsive to changing requirements. They deliver on time and operate in a culture of continuous improvement. Their prices are generally lower due to Lean processes, and their quality is such that incoming inspection at the next step is not required. Lean suppliers generally work to a proactive long-term goal.

Lean Procurement

Some Lean procurement processes can consist of e-procurement and automated procurement. E-procurement conducts transactions and bidding using information technology (IT) applications. Automated procurement uses software that removes the human element from multiple procurement functions, and integrates with financials.

Lean Manufacturing

Lean manufacturing systems produce what the customer wants, in the required quantity and within the required delivery time frame, using minimal resources. Lean is initiated in manufacturing as resources are freed up quickly. Subsequently, continuous improvement is stimulated in other areas, thereby creating a pull on the rest of the organization.

Lean Warehousing

Lean warehousing involves eliminating non-value-added steps and waste in product storage processes. The kinds of warehousing waste that can be found throughout the storage process include:

- Defective products that are returned
- Inefficiencies and unnecessary processing steps

- Transportation steps and distances
- Information processes

Lean Transportation

Lean concepts in transportation include:

- Core-carrier programs
- Improved transportation administrative processes and automated functions
- Combined multi-stop truckloads
- Cross docking
- Right sizing equipment
- Inbound transportation backhauls

In a core carrier program, the shipper bids out its freight to achieve the lowest possible rates for extra freight density. This approach is based on the theory that in order to reduce costs, the shipper must capture the lowest rate per lane.[2]

"Solid core carrier programs focus on having just the right number of carriers to adequately leverage freight spend, ease administrative requirements, and maintain effective carrier relations with consideration to communication and performance measurement."[3]

Multi-stop truckloads are aimed at increasing the amount of weight for one specific truckload movement. They are focused on having a minimum number of shipments per day. "Typically, before significant savings can be achieved, daily volume should be in excess of 50 shipments a day in or out of a location, with the size of shipments being between one- quarter and three-quarters of a truckload. Creating multi-stop truckloads can result in estimated savings of from 5 to 90 percent per shipment."[4]

Cross-docking routes goods to their end destinations as soon as they are received. "It is used to decrease inventory storage by streamlining the flow between the supplier and the manufacturer."[5]

Backhauling is where goods are collected directly from a dispatch point immediately after a delivery. "For example, a factory may deliver finished goods in trucks, but they also need a supply of parts from other sources in order to make those goods. Instead of having those parts delivered, they could use their returning empty vehicles to collect those parts."[6]

"With backhauling, retailers are simply making use of the space in their trailers that becomes available after a delivery is made to a store. Why not pick up some product from a manufacturer on the way back to the retail distribution center rather than coming back empty-handed"[7]

Optimized mode selection and pooling orders determines the best transportation mode through the use of regional pool or cross-docking operations to consolidate shipments into truckloads. The transportation planning and execution requires specific times for collection at the vendor shipping locations.[8]

Lean Customers

Lean customers value speed and flexibility, and expect high levels of delivery performance and quality. They expect value from the products they purchase, and provide value to the consumers with whom they interact.

Lean Customer Relationship Management

Lean customer relationship management involves working openly with key customers to ensure a "win-win" ethos. It is critical to be close to the customer in order to understand their needs, values, and requirements.

Excellent companies utilize such intelligence in a proactive way to enable them to anticipate customer needs. At a secondary level, close customer contact ensures processes such as end distribution and inventory levels are adjusted and controlled to suit demand. This helps in the elimination of demand variability and non- value-added activities.

Lean Customer Service Management

Very often, companies no longer sell a single product, but include additional service levels to suit customer requirements. For example, a supplier may provide regular free updates with the

purchase of software, and offer direct links to technical support specialists. Changing market dynamics may motivate them to provide improved product information.

Organizations should always deliver on - or exceed - customer expectations. An ability to innovate and experiment should be priority for management. They should constantly seek improvements and new ways of adding value for the customer.

Lean Supplier Relationship Management

The aim is to strive for long-term strategic supplier agreements that lead to on-going collaboration. This can be a highly challenging objective, given that many suppliers will aim to retain an independent stance. However, leading companies have shown how effective these arrangements can be if approached with a win-win mentality. They encourage suppliers to make the Lean transformation, and involve them in Lean activities. Working to deepen trust; and undertaking mutually beneficial and innovative process improvements, will, in the long term, achieve real gains and cost benefits.

Lean Demand Management

Lean demand management is a key element in "leaning" the customer demand is one of the biggest sources of uncertainty. A responsive sales forecasting team is a primary requirement. Integrating this team with demand planners and schedulers is an essential element of a more responsive. Striving to break away from the "silo" mentality is a dilemma for many larger organizations, but it needs to be dealt with effectively.

Lean Logistical Flow

Order fulfillment and Lean logistical flow require smooth integration of planning, manufacturing, and logistics. They should be implemented across. Management should regularly analyze distribution facilities and capacity, pipeline inventory, and transportation operations. Visibility is key - suppliers must be able to "see" into their customers' operations,

and customers must be able to “see” into their suppliers' operations. This requires close liaison with up and downstream partners and suppliers.

Value logistics seeks competitive advantage in delivering on niche customer requirements, rather than simply treating logistical operations as cost centres. Many large retail operators favour regional distribution centres. This reduces overall transport costs, and allows for central billing/invoicing.
A balance must be struck between economies of scale in bulk shipments, and individual or niche deliveries that can attain added value and/or anticipate future customer developments. An example is Tesco's development of an on-line shopping service.

Lean Manufacturing Flow Management

Leveraging manufacturing and services and sourcing for flexibility and efficiency is vital. Many leading companies have developed highly sophisticated outsourcing and sub-contracting of different parts of their production or service needs. Others have collaborative partnerships with suppliers.

For example, a leading Irish drinks manufacturer with worldwide facilities employs a third-party international utilities company to manage its energy and service needs (gas, water, electricity, etc.) on a contract basis. The utilities company can maximize operational efficiency by accurately forecasting the plant's energy needs. They can bulk-buy the necessary inputs at competitive rates from a range of main suppliers. They could purchase surplus gas from a supplier in Europe and use that to supply the Irish or UK facilities. In addition, if they purchase in excess of what one client uses, they can transfer this to another user. Hence, energy costs are contained and man- aged much more efficiently than if the drinks manufacturing company alone tried to manage them.

While the use of collaborative partnerships with suppliers has become more widespread, it also needs careful managing- it extends the outside the enterprise, and involves more third parties in the company's operation. Within a production system, the key objective at all times should be to ensure that product is pulled through the manufacturing process at the level of customer demand, rather than being pushed through just because a plant has spare manufacturing capacity. Flexibility to meet demand enables the enterprise to minimize inventory in the pipeline, ensuring a degree of cost containment. In addition, there should be a strong emphasis on ongoing projects to reduce both cycle- and lead- times for all process operations.

Lean Product Development

Time to market is dependent on smart design that allows for ease of manufacture and assembly. Experienced project and product development teams need to be in place to monitor and reduce cycle and lead times. Designing a process system that is Lean yet adaptable, and easily altered to allow for upgrade and advances in product design, creates obvious competitive advantages.

The following table summarizes the differences between traditional and those that are considered to be Lean.

Feature	Traditional	Lean
Production	Based on forecast	Based on actual orders
Customer Service	Not responsive	Responsive/flexible
Plant Layout	Functional/Depart- mental	By product or service flow
Planning and Scheduling	Haphazard/Limited	Detailed/long term/ focused
Processing	Batch and queue	Continuous
Quality	Lot sampling	Assured by the process
Logistics	Cost based/Limited focus	Develop 'value' logistics
Supplier	Adversarial/Win-lose	Partnership/ Win-win
Supplier Returns/Recyclables	Very limited	Growing and essential
Environment	Poor awareness	Integral
Information Technology	Slow/manual	Fast/automated

3.1 Lean Benefits

Apply Lean to ensures increased speed and optimization and an operational culture based on rapid responsiveness and efficient decision making. The main benefits include:

- Reduced inventories
- Reduced costs

- Improved customer satisfaction
- Increased market competitiveness

References and Further Optional Reading

1. http://www.tompkinsinc.com/article/2004/lean-thinking-supply-chain/
2. http://mhlnews.com/logisticstoday/logistics_services/outlog_story_6999/
3. http://www.tompkinsinc.com/article/2007/tips-securing-solid-core-carrier-program/
4. http://www.logisticsquarterly.com/issues/13-1/article5.html5
5. http://www.elogistics-trendwatch.com/index.php/2007/supply-chain-management/how-to-be-a-lean-mean-cross-docking-machine/6
6. http://www.5es.co.uk/oldsite/about_distribution_and_logistics/types_of_distribution/reverse_logistics/backhauling.htm7
7. http://subscribers.supermarketnews.com/mag/hope_backhaul/wall.html?return=http://sub- scribers.supermarketnews.com/mag/hope_backhaul/8
8. http://www.inboundlogistics.com/articles/3plline/3plline1104.shtml

If you would like to do further optional reading about the topic, you may wish to consider the following resources that the creators of this course drew on in preparing this module:

- **Kaizen Institute** (http://www.kaizen.com)
- **Womack JP, Jones DT and Roos D 2007,** *The machine that changed the world*, Simon & Schuster Ltd.
- **Womack JP and Jones DT 2003,** *Lean Thinking: Banish waste and create wealth in your corporation*, Free Press, London & New York, 2003.

2. Understanding Customer Perspectives

Module Overview

This module outlines and explains how to use Voice of Customer (VOC), Kano analysis and affinity diagrams to gather and use relevant internal and external customer opinions and feedback in order to provide the basis for improvement initiatives. The module explains how to get staff and managers to see and understand what customers require.

Modules Objectives

On successful completion of this module, you will be able to:

- Define customers and stakeholders
- Identify the guidelines for gaining an understanding of customer perspectives
- Identify the purpose of Voice of Customer (VOC), affinity diagrams and Kano analysis
- Identify the VOC techniques used to collect data
- Identify when and why each VOC data gathering technique is used
- Outline the steps involved in developing affinity diagrams and carrying out Kano analysis
- Develop an affinity diagram based on customer feedback provided
- Use VOC, affinity diagrams, and Kano analysis to gather customer feedback for the purpose of developing functional requirements for a specific process improvement initiative

Required Reading

- **Bichero J and Holweg M 2016,** *The Lean toolbox: the essential guide to Lean transformation*, PICSIE books, 5th Edition. **Pages 233-246, 256-271**

Module Topics

The topics that will be covered in this module are:

1. Defining Customers and Stakeholders
2. Using Voice of Customer (VOC) Analysis to Collect Customer and Stakeholder Perspectives
3. Ranking and Prioritizing Needs
4. Developing Functional Requirements

Reflection and Self-assessment

On completion of this module you will be asked a self- assessment question.

1

1. Defining Customers and Stakeholders

The first 'Lean' principle is to understand what the customer values. In order to achieve this, it is necessary to understand what internal and external customers value from a product and service offering. This allows organizations to set priorities, goals, and objectives that are consistent with customer requirements; and to determine those customer needs that can be met in a profitable manner. Furthermore, it is often those closest to the processes that are best placed to give useful feedback on the way they work and how they can be improved. Hence, it is equally important to gain stakeholder perspectives and feedback on processes and how they work.

To gain effective feedback it is important to understand those people or organizations who are customers and stakeholders.

Customers can be defined as follows:

- A person or company who requests or demands work
- A person or company who finances or pays for work
- A person or company who uses a product or service produced by the work (also known as a user)
- A stakeholder can be defined as a person or organization/company affected (directly or indirectly) by work.

Examples of stakeholders include:

- A person or organization that participates in a process affected by a product or service even if they do not use that product or service directly
- A person or organization responsible for a system or application with which the product or service interacts

2

2. Using Voice of Customer (VOC) Analysis to Collect Customer and Stakeholder Perspectives

Voice of Customer (VOC) analysis provides a framework for:

- Gathering customer and stakeholder perspectives on what they value and require and what works well for them
- Determining those customer and stakeholder needs that can realistically be met
- Setting priorities and goals for improvement initiatives that are aligned with customer and stakeholder needs

The main steps involved in carrying out VOC analysis are as follows:

1. Identify customer segments or subsets
2. Establish customer data sources
3. Collect relevant customer and stakeholder data

Video Tutorial: Data Analytics

INFORMS defines data analytics as "the scientific process of transforming data into insight got making better decisions." It is an end-to-end process beginning with identifying the

business problem through evaluating and drawing conclusions about the prescribe solution arrived at through the use of analytics. This tutorial describes the three classifications of data analytics and explains how it can help in service delivery.

Video Notes:

2.1 Identifying Customer and Stakeholder Subsets (George et al 2005)

All customers and stakeholders do not create equal amounts of value for an organization. Breaking down customers into specific groups enables the organization to identify and focus on those customers who generate the highest levels of value from a product, service, or process. The following steps should be followed when segmenting customers:

1. Establish the output that is being targeted - product or service?
2. Establish the customers of that product or service
3. Identify the characteristics that may influence how the customer views or responds to the organization and its products and services

4. Create profiles of the segments that will be targeted for the improvement project - high volume or low vow volume, a specific geographical location, etc.
5. Establish representatives from each segment that will be targeted for feedback

Customers might be grouped based on a number of criteria:

Economic	Revenue, profit, loyalty, company size, strategic goals
Geography	Location, demography

Sector	Type of business, industry
Attitude	Towards price, value, service
Internal or External	Are customers being served by the process inside or outside the organization or both?

2.2 Establishing Sources of Customer Data

Customer data can come from a wide variety of sources:

Existing company information

Existing company information can consist of product or service sales data; sales preferences; contract cancelations or renewals; referrals; testimonials; success rates regarding sales closure; etc.

Customer Contact Information

This can come from product or service complaints or positive feedback items; customer facing employees (sales, marketing, accounting, etc.); etc.

Direct and Indirect Research

Direct research gathers customer feedback through the use of interviews, surveys, focus groups, point-of-use observation; etc. Indirect research gathers customer information by analyzing market trends and studying the verdicts or analyses provided by industry and market experts.

2.3 Collecting Relevant Data

A number of methods can be used to collect data:

- One-to-one interviews
- Point-of-Use observation
- Focus groups
- Surveys

The more of these methods that are used, the more likely the chances of gathering accurate and thorough customer feedback.

ONE-TO-ONE INTERVIEWS | POINT OF USE OBSERVATION (POU) | FOCUS GROUPS | SURVEYS

Interviews are used to help understand the respondent's point of view on service issues, service attributes and performance indicators/measures. This method helps establish communication with individual customers and stakeholders. It provides the opportunity to delve more deeply and ask why. The respondent also has the opportunity to ask for clarification.

Interviews can be used at the outset of an improvement initiative to identify what is important to customers and stakeholders; mid way through the project to clarify specific points or issues, obtain ideas or suggestions, or test out ideas for improvement with customers and stakeholders and at the end of the project to validate potential improvements.

The following are guidelines (George et al., 2005) that should be adhered to when conducting interviews:

- Be clear and specific as to the aim of the interview
- Have a list of relevant open-ended questions prepared in advance of the interview
- Aim for a conversational feel: questions should be asked when it feels appropriate; they may be planned or spontaneous
- Decide on the most appropriate interview method – face-to-face, over the phone, etc.

- Consider using an interviewer who is external to the topic being discussed – for example, from another department or an external organization
- Decide on the number of interviewers and interviewees that will participate in each interview
- Practice interviews internally to refine questions and the approach that you are going to use
- Keep the number of interviews manageable; many improvement ideas can come from just a few interviews
- Decide on the method you will use to collect data during the interview – record using a dictaphone, take notes, use a tape recorder, use a computer audio program, etc.
- Contact customers and stakeholders to gain their consent and to guarantee confidentiality and anonymity

Point of Use observation (POU) focuses on recording the customer experience with regard to a product or service that they are receiving. POU also helps to monitor and measure service performance. It provides objective, observational feedback that needs to be balanced by other approaches, for example by obtaining the views of the staff providing the product or service.

POU should ideally be carried out by a member of staff who is unfamiliar with the process being observed so that they can ask as many questions as possible to gain a complete understanding of the particular process being observed.
It should be carried out based on the following steps (George et al, 2005):

1. Develop a clear objective for the exercise – What is the aim of the observation? What will the information gathered be used for?
2. Identify the process that is to be observed and what aspect you want to focus on – Will it be the distribution process? Will the focus be on how customer orders are received? Will the exercise focus on how customers use the product or interact with the service being offered
3. Identify when the observation will take place – Will you observe the process at different times of theday?

4. Establish where the observation will take place - This will obviously be dependent on the focus area orprocess.
5. Develop and test a suitable observation template in advance of the exercise itself. The template should be designed so that relevant data is collected based on the observation
6. Carry out pilot POUs on some smaller processes first
7. If the observation is to take place on a customer's premises, contact them in advance to gain their permission, and, in doing so, to outline the objectives behind the exercise; what will be observed; their role in the exercise; etc.
8. Once the exercise has been completed and data analysis and follow-up recommendations developed, contact the customers and stakeholders to thank them for taking part and to outline how the exercise has contributed to future product and service improvements

A focus group is an informal gathering of people who share common characteristics. They meet to discuss and debate their experiences about a specific issue. The focus group is a mechanism for obtaining customer feedback on existing services or ideas for possible improvements.

Focus groups provide:

- A useful way to listen to a wide range of experiences about a single area
- Creative and open-ended answers on topics in a short time period
- A platform for participants to bounce ideas between each other
- A mechanism to define and clarify needs
- Insights into how customer needs should be prioritized
- A mechanism for identifying issues that are deemed critical and require further investigation through interviews and POU exercises
- A mechanism to follow-up service improvement initiatives to validate how well the initiative has worked

A focus group should be conducted as follows (George et al., 2005):

1. Clarify the purpose, objectives and timings of the group.
2. Establish how you will fund expenses before setting up the group.
3. Identify the number and target size of the group based on available time and expenses. Groups should comprise of 6-12 people.
4. Identify participants based on the purpose and objectives of the group.
5. Establish a venue for the group. Make sure the venue is accessible to all participants.
6. Send an invitation letter explaining the process, what is expected and what the expected outcomes are.
7. Agree ground rules and an agenda for the group.
8. Develop questions and themes for the group that relate to the issues that will be discussed.
9. Appoint a suitable facilitator for the group. This person should not seek to lead but has strategies to help the group if there are any obstacles that may prevent progress.
10. Record comments during focus group session for future analysis.
11. Use statements to develop follow-up service improvement recommendations.
12. Provide feedback to all participants on the outcome of the session.

Surveys provide a mechanism for obtaining quantitative data across a group of customers and stakeholders regarding a particular product or service. Surveys can be used to gather a large amount of information from a large group of people and carry out analysis that can provide baseline data for service improvements. A survey can be used as a follow-up to interviews or focus groups to quantify any perceptions or feedback received through those exercises. They can also be used to identify issues that form target areas for interviews or focus groups. Surveys should be conducted as follows (George et al., 2005):

1. Develop clear objectives.
2. Determine the number of people that the survey will target.

3. Develop draft questions for inclusion in the survey based on the specific information that you need to obtain. In doing so, you should:

    a. Involve users in devising questions.

    b. Structure questions carefully ensuring an appropriate balance between multiple choice, yes/no and user input questions.

    c. Use numerical scales (1-5 ratings, etc.) where appropriate as these are easier to quantify and compare.

    d. Ensure that the survey is relatively short taking no more than 15 minutes to complete.

4. Pilot the survey and refine where necessary to ensure that it meets your objectives.

5. Decide if survey targets are to be anonymous or not.

6. Ensure that the survey explains clearly:

    a. Its purpose.

    b. How each section should be addressed.

    c. Date by which it should be completed and returned.

7. Decide how to reach your target group:

    a. E-mail.

    b. Mail/Post (include a freepost or stamped-addressed envelope for returns).

    c. Include on website.

    d. Leave in waiting rooms or day rooms.

    e. Hand out at reception.

8. Distribute survey.

9. Collate and analyze the results.

3. Ranking and Prioritizing Needs

Once all data has been collated, it then needs to be analyzed to understand the value placed on each aspect of the service being utilized. Kano analysis and affinity diagrams can help achieve this.

3.1 Kano Analysis

The Kano model of customer (consumer) satisfaction classifies product and service attributes based on how they are perceived by customers and their effect on customer satisfaction. The model, developed by Japanese quality expert Dr. Noriaki Kano, describes the complexities of customer needs and their relationship to customer satisfaction in an easy to understand visual format. It provides insight into product and service attributes that are perceived as important to customers and is an important tool for helping teams focus on differentiating and prioritizing service features. The Kano model is typically used to identify and prioritize needs and determine functional requirements for a product and service.

The model is based on three levels, basic requirements, performance requirements and excitement requirements (George, et al., 2005) :

1. **Basic requirements (Dis-satisfiers)** - Basic requirements are the expected attributes or "musts" of a product or service. If these requirements are not fulfilled, then the user will be extremely dissatisfied. Customers will rarely outline basic requirements when asked to identify what in a service is important to them because these attributes are taken for granted.
2. **Performance Requirements (Satisfiers)** - Performance requirements are those attributes for which more is generally better, and will improve customer and/or staff satisfaction. Conversely, an absent or weak performance attribute reduces satisfaction. Of the needs customers verbalize, most will fall into the category of performance requirements. These attributes will form the weighted needs against which service concepts will be evaluated.
3. **Excitement Requirements (Delighters)** - Excitement requirements are unspoken and unexpected attributes by customers but their inclusion in a service can result in high levels of satisfaction. However, their absence does not lead to dissatisfaction. Excitement attributes often satisfy latent needs – real needs of which customers are currently unaware.

Figure 2.1 below illustrates the Kano model.

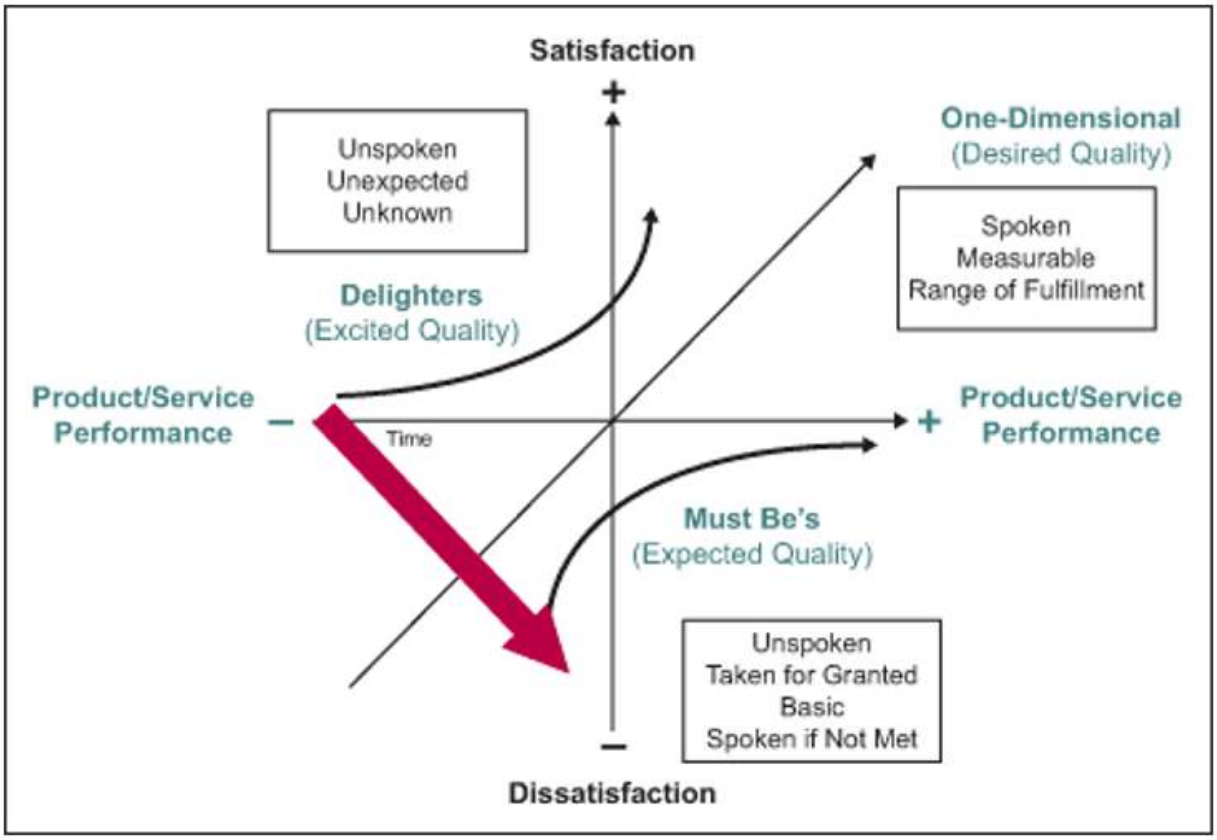


Figure 2.1: Kano model Source: Stroud (2010)

The horizontal axis of this figure indicates how fully functional a product/service is. The vertical axis indicates how satisfied the customer is. The line going through the origin at 45 degrees, represents the situation in which satisfaction is directly proportional to how fully functional the product/service is. In other words, it represents the situation in which the customer is more satisfied with a more fully functional product/service and less satisfied with a less functional product/service.

Kano terms such requirements as "one-dimensional" requirements. A 10 percent improvement in functionality results in a 10 percent improvement in customer satisfaction.

For example, the faster the response time on a system, the more the customer likes it.

Kano Analysis should be conducted based on addressing the following questions:

1. What is the magnitude of satisfaction and dissatisfaction with a particular service?
2. Which service attributes are most important to the formation of satisfaction?
3. How do customers evaluate the service across a range of performance attributes?
4. What action priorities should be set for improving customer satisfaction?

A comprehensive list of critical service performance attributes should be determined through the use of qualitative and qualitative research including in-depth interviews, focus groups, telephone interviews, etc. Once the attributes are identified, a carefully worded questionnaire with appropriate measurement scales must be designed to facilitate the data collection process. For example, overall satisfaction can be rated on a numerical scale from very satisfied to very dissatisfied. Direct importance can be measured by asking respondents to rate on a numerical scale the importance of each attribute from extremely important to not at all important. Any accepted data collection technique (for example, mail, telephone, personal interviews, etc.) can be used to gather responses from a representative sample of customers.

After the data is collected, the overall satisfaction, performance, and direct attribute importance ratings are analyzed and the attributes are classified as being dis-satisfiers, satisfiers and delighters.

Once all requirements have been classified, use the information for service improvement initiatives by:

- Dealing with any basic requirements (dis-satisfiers) as a priority
- Evaluating how many of the satisfiers can be incorporated into the service
- Enhancing or strengthening any delighters that already exist in the service
- Identifying any new features (delighters) once all dis-satisfiers and satisfiers have been addressed

Video Tutorial: Kano Analysis

The Kano diagram visually demonstrates how customer satisfaction increases when products/services are fully functional. This tutorial discusses the questions to ask when conducting Kano analysis and describes how to use Kano analysis to understand customer requirements.

Video Notes:

3.2 Affinity Diagrams

Affinity diagrams are used to organize and categorize large numbers of ideas, facts, opinions, issues into as natural and logical groups to try and establish a theme or relationship. Affinity diagrams are typically used when:

- You are confronted with a large number of facts or ideas that appear to vary considerably
- Issues seem too large and complex to grasp

- Group consensus is necessary

Categories may be predetermined or they may emerge from the focus group data during the content analysis. The goal of this process is to identify those characteristics which are important to the customer in determining the quality of service. From these characteristics, come measures for assessing satisfaction. Figure 2 is an example of an affinity diagram.[1]

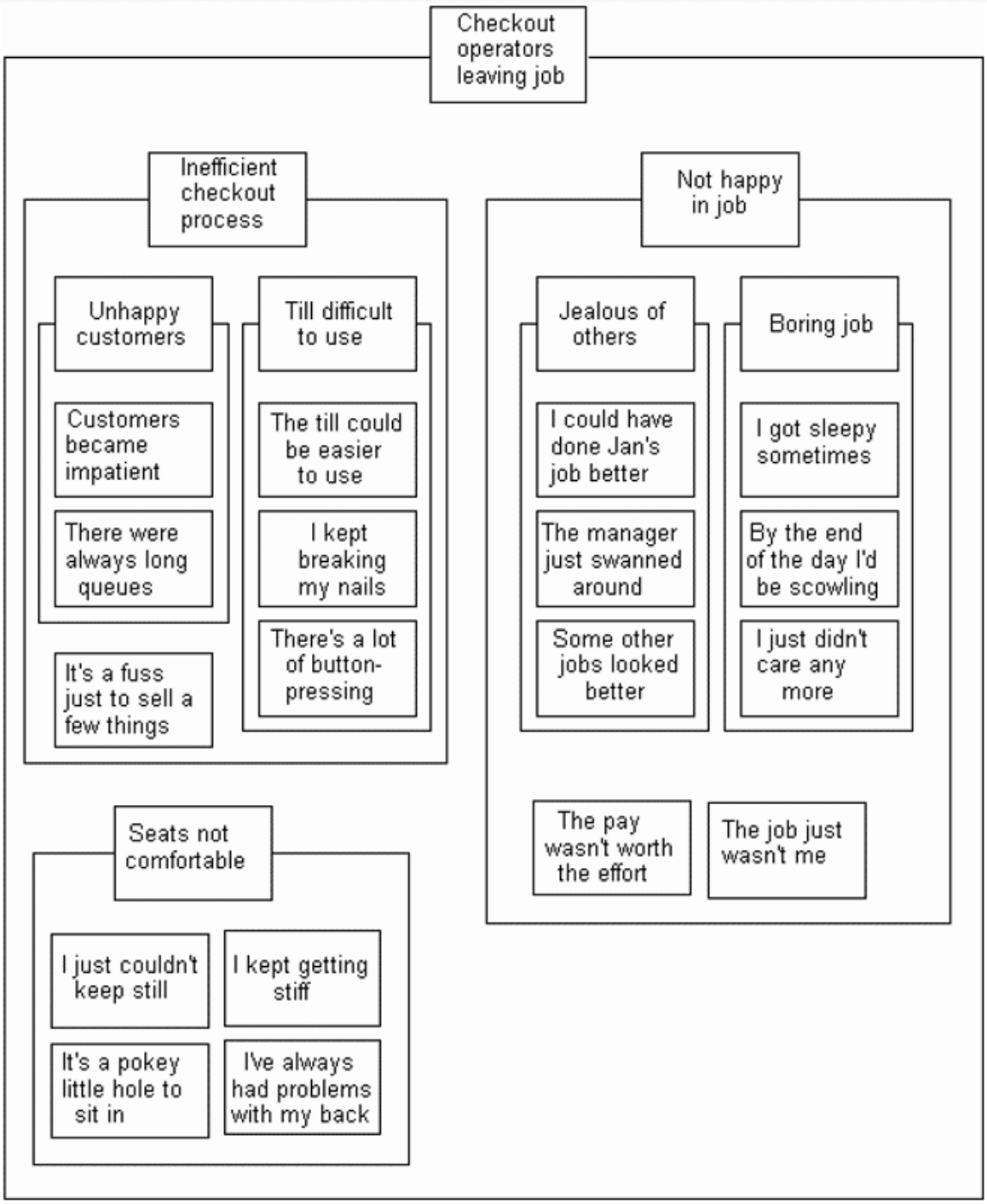


Figure 2.2: Affinity diagram. Source: Syque

The following are the steps involved in developing effective affinity diagrams:

1. Gather all feedback and data from interviews, surveys, focus groups, etc.
2. Record each idea on a card or sticky note. Each card should have a separate idea.
3. Randomly spread each card notes on a large work surface so all notes are visible to everyone.
4. The team should now gather around the notes and, without talking to each other, look for cards that seem to be related in some way. Place them side by side, and repeat until all notes are grouped. It's OK to move a note that someone else has already moved. If a note seems to belong in two groups, make a second note.
5. Participants should now discuss the shape of the chart, any surprising patterns, and especially reasons for moving controversial notes. A few more changes may be made.
6. Once the grouping has been finished, agree on a heading for each.
7. Look for a note in each group that summarizes the prevailing theme or meaning of that group and place it at the top of the group itself. If there is no such note, write one.
8. Create a diagram based on the groupings and associated themes.
9. Discuss the diagram and try and develop service improvement requirements based on the needs that emerge.

Video Tutorial: Affinity Diagrams

This tutorial describes the steps necessary to create an affinity diagram.

Video Notes:

4

4. Developing Functional Requirements

Once customer and stakeholder feedback has been gathered and needs/requirements have been established and prioritized, it is important to use these to develop quantitative and qualitative functional requirements. These requirements can then act as metrics for any Lean Healthcare projects or improvement initiatives implemented to address customer and stakeholder satisfaction. Once the metrics have been met, they can be refined further to ensure continuous improvement.

Depending on the feedback received, these requirements could typically be:

- Time per visit with a target of one hour

- Waiting time with a target of 10 minutes
- Treatment time with a target of 25 minutes
- Waiting time until next appointment with a target of four days
- Number of used resources
- Overtime cost
- Number of retained customers
- Amount of employee non-value-added tasks that need to be eliminated from an employee's workload

Having used affinity diagrams and Kano analysis to categorize customer feedback and establish any common themes, it may then be necessary to probe as to why a customer or stakeholder feels the way that they do. It may be necessary to follow up to clarify statements. Further contact and follow-up should be conducted to establish quantifiable targets or tolerable levels for service delivery. For example, how do customers define "timely", well-organized", "responsive", etc.? Based on the feedback received, requirements that are as quantifiable as possible should be developed.

The more VOC methods you use for establishing customer or stakeholder perspectives and the more focused and specific your approach in each case is, the easier it will be to develop quantifiable functional requirements with minimal follow-up or probing.

References and Further Optional Reading

1. http://syque.com/quality_tools/toolbook/Affinity/example.htm

If you would like to do further optional reading about the topic, you may wish to consider the following resources, which the creators of this course drew on in preparing this module:

- **ASQ,** *Affinity Diagram* (http://www.asq.org/learn-about-quality/idea-creation-tools/overview/affinity.html)

- **George ML, Maxey J, Rowlands DT and Price M 2004, T***he Lean Six Sigma Pocket Toolbook: A Quick Reference Guide to 100 Tools for Improving Quality and Speed; McGraw-Hill.* **Chapter 2, page 30-31; Chapter 4.**
- **Greenbaum T 1998,** *10 tips for running successful focus groups.* (http://www.groupsplus.com/pages/mn091498.htm)
- **Hunter P,** *Choosing the best way for listening to the customer.* (http://www.isixsigma.com/methodology/voc-customer-focus/choosing-best-method-listening-customer/)
- **Stroud JD 2010,** *The Kano analysis: customer needs are ever changing, iSix Sigma* (http://www.isixsigma.com/tools-templates/kano-analysis/kano-analysis-customer-needs-are-ever-changing/)
- **Syque,** *Affinity diagram: examples, Syque Quarterly* (http://syque.com/quality_tools/toolbook/Affinity/example.htm)
- **Thomas D,** *Turning customer data into critical-to-satisfaction data.* (http://www.isixsigma.com/methodology/voc-customer-focus/turning-customer-data-critical-satisfaction-data/ **)**

Module 2 Self-assessment

1. Select an area that you feel is underperforming in your organization. Design what you feel is an effective 1-2 page survey questionnaire for gaining appropriate customer feedback and information that can be used as the basis for designing improvements

3. Understanding Value Streams

Module Overview

In trying to design or redesign a process so that you provide optimal levels of quality and service, you now need to understand the sequence of events that make up a process. This is known as the value stream. This module outlines and explains the tools and techniques used to understand and map processes and how these should be applied to help visualize the current state and develop the “ideal” future state. It explains the Value Stream Mapping technique in detail and outlines how to “value stream map” extended or multiple processes.

Modules Objectives

On successful completion of this module, you will be able to:

- Distinguish between the tools used to understand value streams
- Identify the steps involved in undertaking a Value Stream Mapping exercise both for in-house and extended value streams
- Identify a suitable product family to value stream map
- Develop a current state map for an in-house and extended value stream
- Develop a future state map for an in-house and extended value stream
- Understand the components of a Value Stream Plan for achieving future state improvements

Required Reading

- **Bichero J and Holweg M 2016,** *The Lean toolbox: the essential guide to Lean transformation*. **Pages 153-174; pages 175-181; and pages 193-205.**
- Advanced Lean Tools and Practices Module 4 Case Study.

PDF

Advanced Lean Tools and Practices Module 4 Case Study.pdf
485.5 KB

Module Topics

The topics that will be covered in this module are:

1. Understanding the Value Stream
2. Tools for Understanding the Value Stream
3. Implementing Value Stream Mapping (VSM)
4. Developing a Current State Map
5. Analyzing the Current State
6. Mapping the Future State
7. Realizing the Future State
8. Mapping The Extended Value Stream

Reflection and Self-assessment

There are no reflection or self-assessment exercises for this module.

1

1. Understanding the Value Stream

A value stream is essentially the sum of all the steps that must be performed in the defined sequence to create and deliver value to the customer. The complete value stream includes all the steps required to recognize demand and to plan (information) as well as to process (execute). The value stream includes all process steps - value-added and non- value-added. It illustrates both the physical flow of a product or service through a process as well as the information and work flow related to that product or service.

Mapping the value stream is a vital step in any Lean transformation and, when rigorously undertaken, it provides a powerful and effective link between Lean strategy and actual

execution. A value stream map is a diagram identifying all the activities needed to receive orders and supplies, develop, and deliver a product or service to a customer. When visualizing or mapping the value stream, it is important to illustrate the process steps involved as well as all associated physical locations and objects. Once the value stream has been mapped, the challenge is to eliminate all the nonvalue- added steps, and minimize those steps that are value-added but necessary to the business. Being able to visualize, map, and understand the value stream will enable the business to enhance value and ultimately eliminate waste.

2. Tools for Understanding the Value Stream

The approach involved in understanding and improving any value stream should be based on the following:

1. Depict the current “as is” value stream that captures the process as it works today
2. Create the ideal future “should be” value stream that depicts the way it should work without any of the restrictions that are presently affecting it
3. Develop the updated “to be” value stream that describes the new process flow after changes are implemented

The following tools can be used to gain an understanding and visualization of value streams:

- Process Mapping
- Spaghetti Diagrams
- Swim-lane Flowcharts
- SIPOC Diagrams
- Value Stream Mapping (VSM)

Depending on the nature of the value stream you are mapping, these tools can be used separately or in conjunction with each other. High level process maps should be used to depict the major elements of a value stream and how they interact. They should also show the role of feedback and information flow. They should pick up areas for improvement that are straightforward (for example reducing the number of handovers) and may also identify problem areas for more detailed value stream mapping exercises.

Process mapping is focused on carrying out a high level mapping of a process by a cross functional group of people who represent the different roles that are directly and indirectly involved in that process. It will help to look for opportunities for improvement by visualizing how the whole process currently works and identifying inefficient areas. It can capture the reality of a process and identify duplication, variation, and unnecessary steps. It also provides the foundation for generating improvement ideas, and helps a team to know where to start to make those improvements that should have the biggest impact.

The following are the main steps involved in creating a process map:[1]

1. Invite 8-10 staff representatives who are directly and indirectly involved in the relevant stages of the process
2. Participants should identify the steps in the current “as is” process and outline each step on a “post it” or card using the appropriate and agreed symbols
3. As a team, arrange the steps in order by posting the cards/post its on a flip chart, whiteboard, table, or wall. Ensure that the cards/post flow in one direction - typically left-to-right or top-to-bottom. The flow should only be reversed for decision loops where steps need to be repeated. The map should also include relevant roles and relationships
4. Discuss and analyze the results to ensure that it accurately matches how the process actually works and modify where necessary
5. When complete, number the steps sequentially through the most direct route.
6. Number any off-line tasks
7. Transfer the completed map on to paper

8. Walk the process and analyze the map by asking questions such as the following - Could some tasks be carried out by one person instead of several people? Are there any bottlenecks? How much rework is being carried out? What is the approximate time between each step?

9. Develop the ideal or "to be" map by redesigning or removing elements to identify areas of improvement

Spaghetti diagrams are used to depict the flow of information, materials, and people in a process. They are typically used to improve the layout of a work space or cell. A spaghetti diagram exposes inefficient layouts and identifies large distances traveled between or within key steps. The tool helps identify areas where time can be saved by illustrating unnecessary movement of products, inventory, tools, equipment, and workers. The spaghetti diagram tool is based on drawing a diagram or plan of the area that is being evaluated and depicting lines on it to trace the 'as is' flow of movement. The diagram is analyzed and assessed to help redesign the process so that flow is improved.

Here are the main steps involved in creating a spaghetti diagram:[2]

1. Identify the area for analysis and what is to be observed - material, information, and/or staff flow. You may also decide to analyze a number of these at once

2. Form a cross functional team that is representative of the target area to develop the spaghetti diagram

3. Draw a diagram or plan of that area, including all elements therein – each element should be clearly labeled

4. Work from an existing flow chart or brainstorm to develop the list of process steps in their correct order

5. Mark on the diagram/plan where the first step occurs and draw an arrow from there to where the next step takes place. Continue until all steps have been mapped. Where a number of flows are being analyzed, use different colored lines to represent each flow. Any inherent interruptions in the path should also be marked

6. Analyze the final diagram to see where lines intersect. Try and establish if the workspace can be rearranged and modified to reduce or eliminate these intersections. Also analyze to

see where lines repeatedly come back to the one location. Where this occurs, try and establish if the work performed there can be combined or undertaken at the same time to reduce or eliminate unnecessary back and forth travel

Swim lane flowcharts are very similar to process maps except that they arrange the map on a table where the rows indicate the "who" (an individual, a department, or an organization) does the process step. The advantage of this approach is that it can depict hand-offs or changeovers in a process - any flows that change "lanes". Hand-offs or changeovers can typically feature a lack of coordination and communication that can cause process problems. Swim lanes can also show who sees each part of the process.

A swim lane acts as a visual container to show the activities carried out by a certain participant in the process. A circle can represent the start of the process. Boxes can be used to represent tasks or steps in the process. A diamond can be used to represent a gateway or a decision point. Arrows indicate the direction of flow.

Here are the main steps involved in creating a swim lane flow chart:[3]

1. Identify the various participants involved in the target process. These should be listed down the left side of a sheet of paper or on a whiteboard
2. Identify each of the steps in the process and write each one on a separate 'post-it' or card
3. As you work through each step in order, place it in its appropriate swim lane using agreed symbols for the steps. Be sure to outline formal and informal communication lines. For example, use an arrow for formal lines and a dotted line/arrow for informal lines
4. Where a task or step has one or more exits, it probably means that a decision is required or the step may not have been broken down effectively when first identifying the steps/tasks
5. Analyze the resulting "as is" swim lane flow chart to see how flow can be improved

SIPOC diagrams are used to identify all elements that are relevant to a value stream improvement initiative before work on that initiative commences. It is used to define the scope and elements of an improvement project

SIPOC focuses on:

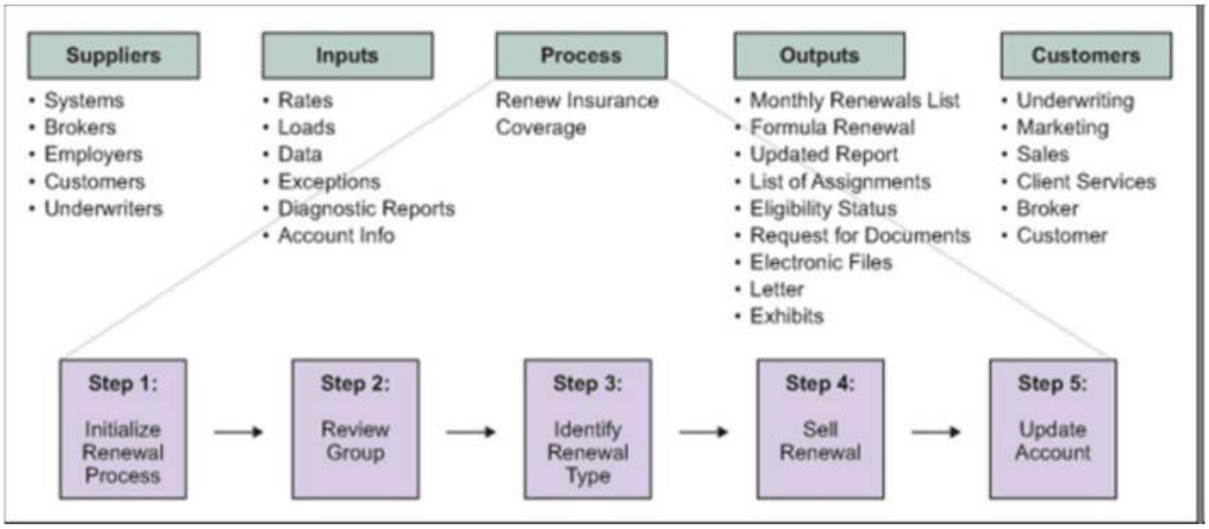
- Suppliers in a process
- Inputs to a process
- Process to be improved
- Outputs of the process
- Customers who are in receipt of process outputs

SIPOC diagrams help those elements that supply inputs to a process, the actual customers of a process, and their associated requirements.

When developing a SIPOC diagram, the team should adopt a consultative approach with all stakeholders in the project. The following steps should be adhered to:

1. Map the process across its main or high level steps
2. Identify and outline the outputs associated with the process
3. Identify and outline the customers that will be in receipt of the outputs of the process
4. Identify and outline the inputs required by the process for it to flow efficiently
5. Identify and outline the suppliers of the required inputs

The following illustrates an example of a SIPOCdiagram.[4]



PROCESS MAPPING	SPAGHETTI DIAGRAMS	SWIM LANE FLOWCHARTS	SIPOC DIAGRAM	VA

The main practice required to implement LEAN in any organization is Value Stream Mapping (VSM). A VSM strategy follows a product or service from beginning to end, and draws a visual representation of every process and activity in the material and information flow.

It provides a means for:

- Identifying non-value-added activities within a value stream
- Providing a common approach and methodology to Lean teams (ties together Lean concepts and techniques) and a blueprint for implementation
- Providing a platform to improve quality and productivity while also reducing inventory and floor space requirements
- Providing an organization with a means to understand its current processes
- Creating a vision of what is achievable for the organization with quantifiable gains
- Providing a framework and impetus for implementing Lean
- Providing a plan with quantifiable gains to aim for in the short, medium, and long term

Before implementing Lean, it is important to recognize the organization's current position or state. This allows the organization to see where costs can be reduced and where improvements can be made. VSM is used in obtaining this information, and is invaluable in conducting bottom-up studies in individual organizations.

VSM portrays the current ("as-is") process in graphic format through a current state map. This enables one to see where value is added and where value is lost in a process. The current state map includes every aspect of the process - the process as it happens today, not how it should work, rather how it actually works. It incorporates the physical process and any supporting information flow systems. Once VSM is complete, it generates the time it takes to complete the process and deliver the product or service - actual lead time - and the time spent actually working (adding value) on that product or service - cycle time.

Subsequently, a future state map can be designed where wasteful or nonvalue- adding (NVA) steps or activities are eliminated and continuous flow is introduced. A future state map is used to reflect the desired process performance going forward. It is an organization's statement of intent as to where it wants the process to get to.

VSM can be an important tool to define, analyze, and quantify waste. The actual procedure in undertaking VSM is as follows:

- Select an area or process to be analyzed
- Form a cross functional team that is representative of the process or area being analyzed
- Specify value from the perspective of the customer
- Determine VSM by identifying all of the steps required to create value; mapping the value stream; and challenging every step
- Line up value and create steps so they occur in rapid sequence
- Create flow with capable, available, and adequateprocesses
- Pull human resources, materials, equipment, supplies, and information from customers
- Continuously improve to reduce and eliminate waste

3. Implementing Value Stream Mapping (VSM)

The steps undertaken to implement VSM are as follows:

1. Select a product or service family and agree the start and end points of the process to be mapped; Appoint a suitable Value Stream Champion and a relevant Value Stream team
2. Map the current state
3. Map the future (Lean) state
4. Plan and implement those changes identified to reach the future state

1

Selecting a Product or Service Family, a Value Stream Champion, and a Relevant Value Stream Team

Lean is most effectively implemented through a team effort. It is vital that a Value Stream Champion be appointed to steer a team through the VSM exercise. This person must have appropriate experience in LEAN techniques. The support team should be a cross section of people from within the process being mapped, as well as suppliers and customers of the product family or service.

It is imperative to apply VSM to only one product or service family at a time in order to keep the activity within manageable boundaries. If the entire facility or operation is tackled at the same time, VSM will not be carried out effectively. A product or service family is a group of products or services that pass through similar processing steps in an organization's downstream process. Such families should be categorized from the viewpoint of the customer who is the last point on the value stream. A product or service family may be for example a particular treatment type, admissions following falls that require a certain type of care path, or hospital insurance claims.

Selecting a product or service family to value stream map is a critically important step and considerable thought should be given to this task. When selecting a product or service family to value stream map, it is important to categorize the similarities and differences that exist across products and services and select a product or service family that represents a significant part of the day to day business.

It is vital to ensure that the scope of what is to be mapped is manageable. As a guideline, if a process consists of more than 20 steps, it should be mapped in segments of no more than 10-15 steps.

2

Mapping the Current State

Once the Value Stream Mapping team have been assembled, the product or service family selected, and the scope of what is to be mapped agreed, the next step is to develop the current state map. The current state map provides a detailed account on how the process works. The team should physically walk through a process and use face-to-face informal interviews with middle managers from the various functional areas to gather initial and primary data on the process. In order to drill down fully, secondary data should be attained through a combination of internal data, direct observation, and personnel interviews with various employees. This team may also include the customers who could be internal or external to the organization or external to the organization.

The current state can be mapped after the team completes the following:

A quick walk through to identify the main processes

- Defines all relevant and process, product, and service information – cycle times, number of shifts, machine uptime, etc.
- Documents customer and supplier information
- Counts inventory and/or waiting times
- Establishes information flow - how does each process step know what to do next?
- Identifies where the materials, information, equipment, and inventory are being pushed rather than being pulled
- Quantifies lead-time against processing time

3

Mapping the Future State

The Value Stream Champion uses the information garnered in the current state map to develop a future state map in conjunction with the cross functional team. The future state map should be focused on:

- Providing a vision that the organization can aspire to
- Eliminating waste
- Creating flow
- Creating a flexible, reactive system that quickly adapts to changing customer needs
- Producing and delivering on demand

4

Planning and Implementing those Changes Identified to Reach the Future State

The future state map is implemented through a Value Stream Plan that:

- Is tied to the organization's business objectives
- Outlines what needs to be done, by whom, and when
- Establishes appropriate value stream reviews and when they need to take place

4. Developing a Current State Map

Value stream maps - current or future state - are typically made up of mapping icons that represent the various elements in the value stream process.

VSM icons are universal. This ensures that they provide a common approach and methodology for teams that are implementing Lean. Figure 2 illustrates some of these icons.

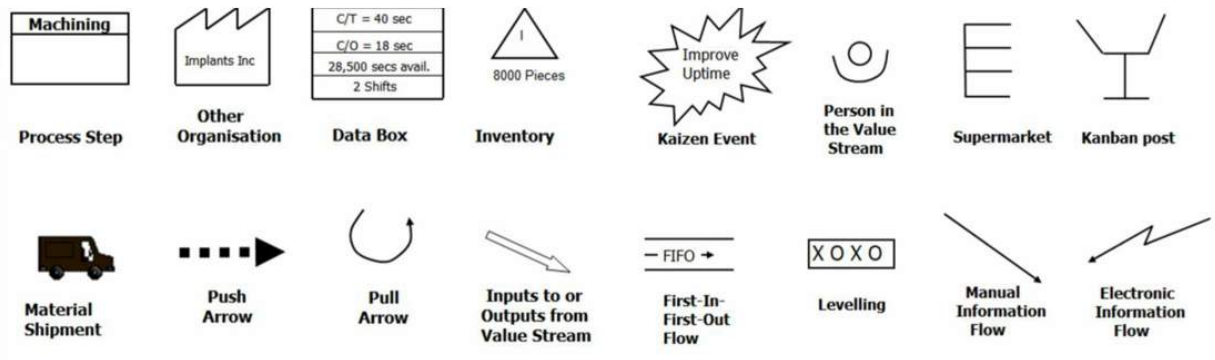


Figure 2 VSM Icons

In order to develop a current state map, a number of phases must be undertaken:

1. Locate operations/steps
2. Identify area inventory and/or waiting times
3. Measure area process specifics
4. Identify how product is processed
5. Identify customer process information demand and need
6. Identify customer information flow
7. Identify process information flow
8. Complete the current state map
9. Calculate value-added and opportunity

1

Locating Operations/Steps

In this phase, the Value Stream Champion and team need to walk through the current process, and record all physical data that is relevant to it. The team should list all the individual operations in the process as well as the flow of material between each one.

2

Identifying Area Inventory and/or Waiting

In this phase, the amount of waiting time or inventory used between each operation/step in the process is quantified. The map should initially outline the total amount of available inventory in relevant modules, and then the actual amounts that exist between each step in the process.

3

Measuring Area Process Specifics

In this phase, the team compiles the following data for each step in the process:

- Number of workers involved in each step
- Number of shifts
- Cycle time (C/T) of one part/module
- Working/available time (minus breaks)
- Number of product, supply, or service variations
- Any other information that describes the amount of work being done, or elements of activity in this process that are wasteful (for example, machine uptime less than100%)

Cycle time (C/T) is the typical time taken by a process to complete a part or product or complete a service. This is typically timed by observation.

4

Identifying how the Product is Processed

In this phase, the team needs to identify and depict the method by which products, raw material, inventory, etc. flow through the process - push or pull.

5

Identifying Customer Process Information

The current state map needs to include information on customer processing requirements for the selected service or product family. These details are acquired in liaison with the customer be they internal or external to the organization.

They typically include:

- The number of daily shifts required to complete a task or to provide the required service level
- Customer demand per month/week/day/shift
- Daily service or product requirement based on customer demand

The customer processing information is summarized in a data box in the upper right hand corner of the map.

6

Identifying Customer Information Flow

In this phase, the team identifies the information flow from all customers. It identifies the following details:

- Customer requirement details - the means by which requirements are communicated throughout the organization
- Frequency that these requirements are received, updated, and communicated throughout the organization

It is important to capture how each stage in a process is updated on how it should meet customer demand requirements.

7

Defining Process Information Flow

In this phase, the customer process information is fed into each operating step in the process. This information is used to drive the schedule and/or inventory for each step.

Completing the Current State Map

To complete the current state map, the following three steps must be undertaken:

- Draw a “stepped line” at the bottom of the map
- Specify the on-hand inventory levels (number of days) for each process step at the top of the stepped line
- List the cycle time for processing under each step

Each on-hand inventory figure is based on daily customer demand. The initial on-hand inventory figure is calculated by dividing the total number of inventory at each of the steps by the total number of inventory pieces required by the customer per day.

Consider a production process that requires 19,600 pieces of inventory per month to meet customer demand. The total amount required per day is calculated by dividing this figure by the total number of working days in a month – let’s assume 20. This provides a daily requirement of 980. The production process currently has a total of 8,000 pieces waiting to be worked on. So the initial on-hand inventory is calculated by dividing 8,000 by 980 = 8.2 days.

The on-hand figure for each process step is calculated by dividing the total amount of inventory used in that step by the total amount of pieces required per day. For example, a process step uses a total of 9,000 pieces. The on-hand inventory for this step is then calculated by dividing 9,000 by 980 = 9.2 days.

Calculating Value-added and Opportunity Time

Process Step	Cycle Time	Changeover Time	On-hand Inventory
1. Machining	30 secs	2 hrs.	6 days (initial)
			5 days (steps 1 and
2. Blasting	45 secs	25 mins	2)
			4 days (steps 2 and
3. Finishing	20 secs	16 mins	3)
			6 days (steps 3 and
4. Cleaning	15 secs	8 mins	4)
			7 days (steps 5 and
5. Assembly	20 secs	0 mins	6)
			5 days (steps 5 and
6. Shipping	0 secs	0 mins	6)

In this phase, the team calculates the total valued-added time and the total waiting and other non-value-adding times in the process. In Value Stream Mapping the non-value-added time in a process is called the "Opportunity time". Opportunity time represents the potential time that can be eliminated from the process without any negative impact on the customer. For example, if the opportunity time for a particular process is calculated as being 10 days, this is the amount of time that the organization can afford to remove from the production process. The more opportunity time that is reduced the "leaner" the process becomes.

Value-added time (v/t) is calculated by adding the cycle times for each step in the process. Adding all the cycle times and on-hand inventory quantities provides the total process lead time. Let's assume that the following information has been taken from a completed current state map (see table below).

- The total value-added time for this process is 135 seconds (30 secs + 45 secs + 20 secs + 15 secs + 25 secs).
- The total process lead time is 135 secs PLUS 33 days (6 days + 5 days + 4 days + 6 days + 7 days + 5 days).
- Therefore, the opportunity time for the process is 33 days.

5. Analyzing the Current State

Once a current state map has been developed, the information that it provides is used to analyze and assess how well the existing process flow meets the rate of customer demand. To help establish this, it is important to calculate the Takt time for the production process.

Takt time is essentially the rate at which the process needs to work to meet customer demand for each product or service. It is calculated by dividing the operating time for each shift by the customer requirement for each shift.

Takt time is initially calculated in hours, and then manipulated into minutes and seconds, depending on the organization. Some organizations measure production in seconds, others measure it in minutes.

Consider a food production process where staff members have an actual working time of 300 minutes in a single shift. There are two shifts per day and a daily requirement to produce 1,800 portions. The Takt time for the process is calculated as follows:

The available time per shift is 300 mins and the daily requirement is 1,800 portions. This equates to 900 per shift (1800/2). takt time is calculated by dividing the operating time per shift (300 mins) by the customer requirement per shift (900 portions) = 300/900 = 0.33 mins. So, to meet customer demand, the process needs to produce a portion every 0.33 mins. This number does not include time for equipment downtime, changeovers, or scrap.

Once a Takt time figure has been established, the organization needs to examine its processes and inventory levels to see how it can build or produce to attain this figure in the most efficient way. The organization can assess if:

- Its rate of production aligns with customer demand for the product or service
- Inventory lot sizes for each step in the process are too big for the number of products or services that are required
- Inventory, data, or materials are being pushed or pulled through the process

A Value Stream Champion and team can then establish:

- The elements of the process that are preventing flow
- The elements of waste that are evident in the current state map If the current state map is a push or a pull environment
- How long it takes to produce a batch in assembly and test/inspect that batch
- Any other “issues” that could be potentially uncovered in the map

The information gained from assessing and addressing these issues forms the basis of the ideal production process that the organization should aspire to. This is depicted in a future state map.

6. Mapping the Future State

To develop the future state map, the Value Stream Champion and team need to update the current state map by carrying out the following steps:

- Modifying existing process, information, and material flow where necessary
- Identifying those parts of the process that need to be addressed by specific Kaizen Events. These Events are shown on the future state map as lightning strikes Recalculating production lead-time and opportunity time
- Recalculating production lead-time and opportunity

Modifying Existing Process, Information, and Material Flow

Based on the Takt time for the process, the team needs to examine the current process, information, and material flow. This involves analyzing customer demand and supplier raw material information to assess if there is an opportunity to reduce inventory for the process and implement a pull system. In most processes, discrepancies exist between the customer demand information that is fed to Production Control and the raw material requirements that are then fed to suppliers. For example, customer demand might be fed to Production Control by means of a daily fax, but raw material suppliers receive weekly updates on requirements. As a consequence, the suppliers provide more inventory than is actually required each day. Aligning this information ensures that there is only enough inventory to meet the specific daily customer demand.

The organization also needs to decide if it needs to implement some or all of the following:

- Production and/or resource leveling
- Kanban and First-In-First-Out (FIFO) processing
- Supermarkets

Production Leveling

Leveling is typically applied in a process where two or more different parts or services are processed at each operating step. It helps create a smooth process, and enables the value stream to respond to situations where specific product requirements or services are requested at any given time. For example, let's assume that an organization is providing two testing services - X and Y - to be provided over two shifts per day. Without leveling the day shift typically provides one service - for example, service X - and the night shift provides the other service - Y in this instance. If a request to test Y occurs during the day shift, it cannot be delivered upon without having to undertake extra setups or waiting until that evening's shift. Implementing leveling means that X and Y are processed throughout both shifts, so additional requests to test can be efficiently dealt with at any time.

Kanbans

Kanban is based on a pull system where materials, products, supplies, or documentation are pulled through the system based on actual usage requirements. When developing the future state map, the value stream team needs to establish if Kanbans are required, and if so, where in the process they should be used, and how.

Kanbans are effective in eliminating inventory from production floors by storing small quantities at the point-of-use.These are then replenished as required. This works well in areas of high inventory usage because Kanbanshelp reduce the space required, and provide a visual aid for inventory. When Kanban stock is taken by the next step in the process, a signal is sent to the provider of that stock to replenish to the agreed level.

In theory, Kanbans can be used anywhere to reduce stock holdings. However, they are not as powerful in areas of low process variability where the same part is manufactured all the time without any change, and where inventory usage is steady.

First-In-First-Out Processing

First-In-First-Out (FIFO) is a philosophy based on the principal that the first piece of inventory, documentation, or supply required in an activity is delivered first. The oldest piece of work should always be the one that is processed first. A FIFO lane can be used to ensure this. The FIFO lane:

- Holds a specific and pre-defined amount of work, inventory, supplies, information, or files between two steps in a process
- Incorporates a signalling system for notification when the lane has reached its capacity - has the specific amount of material outlined above

Kanbans and FIFOs would not typically be applied to systems or processes based on queue or waiting times. These tools are more suited to administrative, supply, or consumable based processes or systems. For example, consider the processing of medical insurance claims. FIFO could be applied in such a process whereby a form that is entered in the system today is always processed ahead of a form that would be entered in the following day.

Supermarkets

Supermarkets are storage locations used for products, parts, and supplies that are not fully processed. Part- processed products are shipped to the supermarket, and are stored there until they need to be completed to meet specific customer demands. Supermarkets help implement a pull system, and are therefore used to prevent any product or inventory backlogs occurring in the process. Once the product has been manufactured to a predetermined state, it is stored away, and is only completed when required by the customer. This has a number of advantages. It reduces storage costs because parts are classified as unfinished goods. This allows the organization to be flexible in the face of uncertain product demand. Supermarkets also enable organizations to facilitate specific customization of a product for different customers.

Supermarkets work well in production scenarios where the product being developed is varied or the customer demand for the product varies significantly. Typical situations include organizations that manufacture localized products or implement new product launches where the specific market demand is volatile. For example, an organization that manufactures laptops may use supermarkets to store laptops that have been processed without specific localized parts such as the keyboard. When a number of orders from specific countries are received, the laptop is moved from the supermarket so that it can be processed with the appropriate keyboard for that country.

Supermarkets are not required where products are well established and no product variability exists. In such cases, all markets receive the same product, so customer demand is predictable and does not change significantly. There is also no significant requirement for customized

products. However, supermarkets can help reduce inventory-holding costs for any organization.

Kanbans, FIFO processing and supermarkets will be covered in depth in upcoming modules for this course.

7

7. Realizing the Future State

To attain the aspirations outlined in the future state map, it is vital that the organization formulates an effective value stream plan that:

- Identifies all the actions and tasks needed to achieve the future state
- Identifies the person responsible for the work associated with each action/task, and when this work needs to be completed
- Is resourced sufficiently
- Is implemented by dedicated personnel – either from within the company, or external consultants with relevant experience
- Is assessed on a regular basis - the Value Stream Champion and team should review implementation progress against the plan
- Has top management approval, commitment, and on-going support

To create the plan, the team needs to identify those tasks required to realize the future state. In many cases, it will be necessary to prioritize actions so that the team can focus on those actions that will provide the greatest improvements.

8. Mapping The Extended Value Stream

Having optimized their internal value stream, most organizations will want to extend that efficiency beyond the walls of the facility to suppliers and customers raw material course to the actual final product users - the extended or entire value stream.

"An extended value stream is simply all of the actions — both value-creating and wasteful — required to bring a product from raw materials into the arms of the customer."[5]

To be able to map this extended value stream, it is important to understand the specific wastes that exist within it:[6]

- **Overproduction** - The main cause of overproduction in the extended value stream is poor information flow or communication between facilities
- **Transportation** - Excess transportation of products and raw materials in the extended value stream is typically caused by selecting a supplier without taking into consideration that supplier's facility location. Supplier selection should be based on the impact it has on the entire value stream or production process
- **Excess Inventory** - Again, this is caused by poor information of communication flow between facilities. Suppliers typically store and hold on to inventory to satisfy the requirements of a customer who has implemented LEAN. This will eventually impact on the customer through an increase in price or a reduction in quality. It may also lead to redundant inventory storage at both the supplier and customer side
- **Excess or Unnecessary Processing and Defects** - As with some of the other wastes, this can stem from ineffective communication between facilities with the wrong parts delivered or parts delivered that require rework
- **Excess Waiting and Motion** - These wastes are essentially the same as those in the internal value stream that exists within the one facility

The following are the key characteristics that make up an extended value stream that is considered to be Lean:[7]

- All of those involved in the value stream know the Takt time and customer demand rate
- Lead time from raw material order to product delivery to the customer is kept to minimal
- Transportation and inventory levels are kept to a minimum

The relevant actions to be mapped consist of two flows: (a) orders traveling upstream from the customer (or from the sales department when forecasts substitute for confirmed orders) and (b) products coming down the value stream from raw materials to customer. Together these constitute a closed circuit of demand and response.

Maps of the extended value stream can be drawn for products currently in production or for future products being planned. The only difference is that the "current state" map for a product in production shows conditions as they exist today while the "current state" map for a new product shows the "business as usual" approach to making the product compared with alternative "future states" and "ideal states" with less waste and greater responsiveness.

Mapping an extended value stream essentially follows the same steps as that of an in-house VSM exercise. However, because you are essentially incorporating multiple facilities in the exercise, selecting a suitable product family, defining the scope of the process to be mapped, and selecting the Value Stream Team need to be approached differently.

8.1 Selecting the Product Family

When selecting an appropriate product family to map, you should start at the point that is nearest the customer and define product families at that location. The product family will include a group of product variants passing through similar processing steps and using common equipment just prior to shipment to the customer.

"In a power tools business, a product family might be medium-sized electric drills utilizing a common chassis and passing through a common assembly cell as the last manufacturing step, even though the finished product has many different features and customer labels. Alternatively the mapping team might define the product family as the motor going into the medium drills and map back upstream from that point.

In the auto industry, a product family might be a car platform (e.g., Ford Explorer and Mercury Mountaineer) produced in an assembly plant. Alternatively it might be a major component supplied to auto assemblers — let's say an alternator— using a common design architecture and assembled in a cell, but with varying power outputs and with different attachment points for different vehicles.

In the aerospace industry, a product family might be an entire airframe (e.g., the Boeing 737 or Airbus A320). Alternatively, it might be a major subassembly, for example the vertical tail. The sub-assembly may have many variants for different buyers of the completed aircraft. For example the tail structure might incorporate different aerials and fairings for navigation and communication equipment. And the products within the family chosen for mapping might differ slightly in dimensions. For example, the basic tail design might be slightly longer for use on a stretched airframe. However, the vertical tail clearly constitutes a product family because all variants follow the same manufacturing path and have no commonality with tails for other aircraft, even if they are made in other areas of the same facilities by the same firm utilizing parts from the same suppliers."[8]

Because the product family is identified from the final step mapped, you can define product families from many starting points and map back upstream from there. Your first map should ideally follow the path of a single family and a single component in a product. The wastes that you uncover through following one component upstream will probably be equally as relevant for all the components that form part of the final product. Mapping the value stream of every component that forms part of the product would be too time consuming and costly by virtue of the time and resources it would involve and the amount of data that would require analysis.

8.2 Defining Process Scope

As with trying to map every component that forms part of a final product, trying to capture the entire value stream can also be overwhelming and time consuming. In their publication - Seeing The Whole - Womack and Jones recommend that an initial extended VSM exercise should stretch to 1-2 upstream supplier facilities from the point where the product family has been defined.

Selecting the Value Stream Team

An extended value stream map can involve multiple facilities and organizations. Although Value Stream Champions may be selected for the relevant portion of the value stream relevant to each facility or organization, an overall manager needs to have responsibility the entire stream across all of those organizations involved. This person will co-ordinate the maps from each facility and/or organization manage the exercise.

“The most successful firms we have encountered using these techniques have Product Line Managers who think about product marketing and engineering as well as production and purchasing. With all the elements of marketing, design, and production under his or her oversight, this individual is in a unique position to judge the performance of the many functions touching the product. Indeed, as we will see in a moment, a continuing assessment of functional performance along with precise prescriptions for improvement is one of the most important benefits of product line management.

However, we do not usually recommend what is sometimes called a “product team structure in which all of the engineering, operations, purchasing, and marketing employees supporting the product are put on a dedicated team. Doing this causes a large amount of organizational disruption during the transition and this structure still does not address the behavior of upstream partner firms. What’s more, it is really not necessary in most cases if the PLM takes an energetic approach to the job.” [9]

The value stream team needs to include representatives from all of the organizations and facilities that are included in the value stream. It should also include representatives from the relevant departments within each organization. Including these representatives may make a walk of the value stream a little unwieldy. Therefore, as a guideline, the team should be kept fairly small - 8-10 members with a minimum of one representative per organization.

References

1. The Lean Six Sigma Pocket Toolbook, Michael L. George et al, 2005,p.40

2. The Lean Six Sigma Pocket Toolbook, Michael L. George et al, 2005, p.42
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7. http://www.emsstrategies.com/dd120104article2.html
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9. http://www.lean.org/Library/Seeing_the_Whole_Part1.pdf

4. Optimizing Process Flow

Module Overview

This module introduces the Lean tools and practices used to improve process flow. Any Lean implementation begins with Value Stream Mapping (VSM) to establish where and how improvements can be made in terms of process flow and overall quality. The module outlines and explains some of the techniques that may emerge as a result of a VSM strategy. It introduces the Bullwhip Effect and its impact and focuses on counter measures such as Just In Time, One Piece Flow, and Milkrounds. The Theory of Constraints and how it can be used in conjunction with Lean to increase throughput and reduce inventory waste is also dealt with in detail.

Modules Objectives

On successful completion of this module, you will be able to:

- Identify the causes of Bullwhip Effect and outline suitable counter measures
- Identify the principles associated with the “Milkround” concept
- Identify the principles that underpin effective Just In Time (JIT), Pull systems, and One-Piece-Flow
- Use Heijunka box, Kanbans, Supermarkets, and FIFO Lanes to smooth production flow• Use suitable line balancing and work cell design strategies to ensure optimal process flow
- Identify the steps involved in implementing the Theory of Constraints (TOC) and apply TOC to a process to eliminate bottlenecks and improve overall process flow

Required Reading

Please note that, because the module deals with a number of different topics, the required reading for each is referenced after the notes provided. You should aim to access and read these before moving on to the next topic.

Module Topics

The topics that will be covered in this module are:

1. The Bullwhip Effectand Milkrounds
2. Just In Time (JIT) and Pull Systems
3. Kanbans and FIFO Lanes

4. Production Leveling and Heijunka
5. One-Piece Flow and Cell Design
6. Theory of Constraints

Reflection and Self-assessment

There are no reflection or self-assessment exercises for this module.

1

1. The Bullwhip Effect and Milkrounds

Demand amplification results from batching and any inventory control policies or strategies that occur. The greater the degree of amplification, the harder it is to maintain smooth flow.

The Bullwhip Effect occurs when a retailer's orders to their suppliers tend to have a larger variance than the consumer demand that triggered them. This demand distortion has an upstream impact with amplification occurring at each stage affected.

The following are typical causes of the Bullwhip Effect:

- Ineffective stocking policies
- Inaccurate or misaligned demand forecasting
- Batching of orders and stock
- Price promotion and forward buying
- Over ordering

Demand forecasters across will try and store "safety" inventory stocks to buffer or guard against demand variation. Moving up from end-consumer to raw materials supplier, each

participant has greater observed variation in demand and therefore greater need for safety stock. In periods of increasing demand, downstream parties will increase their orders. In periods of falling demand, orders will fall or stop in order to reduce inventory. The effect is that variations are amplified as one moves upstream (further away from the customer).

Order batching occurs as part of an effort to reduce the cost of ordering and to maximize transportation capacity and usage. Batching can also result from an organization trying to take advantage of price promotions or discounts so it forward buys to take advantage of low prices.[1]

All of the above causes are based on poor levels of information and communication or value stream.

“Distorted information from one end to the other can lead to tremendous inefficiencies: excessive inventory investment, poor customer service, lost revenues, misguided capacity plans, ineffective transportation, and missed production schedules.”[2]

As well as an increase in safety stock, the Bullwhip Effect results in inefficient production or excessive inventory as the producer is continually required to meet the demand of its upstream predecessor in the process.

Bicheno cites the use of a centralized information system as an effective means of countering Bullwhip. In such a system actual demand forecasts are provided by the first stage to all of those involved in the process.

Other counter measures include:

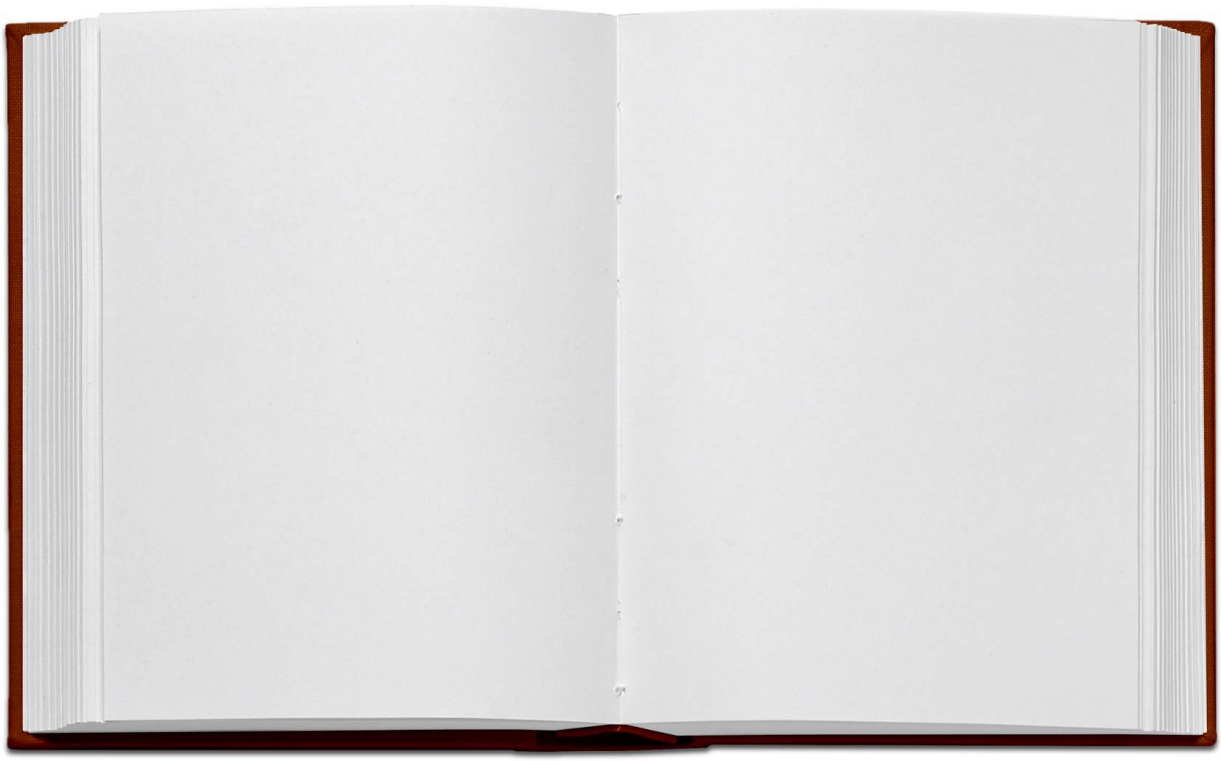
- Milkrounds
- A Just In Time (JIT) stock replenishment system
- Tighter co-ordination and alignment between retailers and suppliers to ensure that deliveries are more in tune with actual customer demand
- Smaller and more frequent stock replenishments

- Orders that are based on actual demand instead of orders that reflect a “just in case” philosophy

1.1. Milkrounds

The milkround concept implemented by manufacturing/production plants in conjunction with suppliers has proved to be a useful counter measure to the Bullwhip Effect and demand amplification. It is based on a system where a vehicle travels on a specific route each day or every second day, beginning and ending at the plant itself and calling to each supplier enroute. Batches of parts are collected at each supplier in a set window of time - for example 30 minutes. If structured and managed sufficiently, it has a number of benefits:

- Reduces demand amplification
- Encourages a more even flow of material
- Reduces transport waste
- Decreases lead times
- Fosters more synchronized and aligned scheduling across



Required Reading

John Bicheno and Matthias Holweg, *The Lean Toolbox: The Essential Guide to Lean Transformation,* **pp. 276-278**

2

2. Just In Time (JIT) and Pull Systems

LEAN manufacturing is really about minimizing the need for overhead. It should:

- Concentrate precisely on only what is necessary
- Link interdependent supply system decisions and actions
- Be visual, responsive, and simple to manage

Just-in-time (JIT) is a production and management philosophy dedicated to eliminating waste, and keeping minimal levels of inventories. It was originally used in Japan by Toyota to address limited space and resource availability.

JIT has become one of the most widely advocated manufacturing philosophies. It is especially prevalent in large- volume, repetitive manufacturing environments such as the motor and electronics industries. JIT has been defined as the production of the necessary items in the necessary quantities, at the necessary time.

It is based on continuous and forced problem solving (forced by driving inventory out of the production system). Supplies and components are 'pulled' through system to arrive where they are needed when they are needed, with the goal of achieving the minimal level of resources required to add the necessary value in the production system.

Pull material replenishment systems are based on the principle that items are pulled through a process based on actual usage requirements. This helps reduce the amount of obsolete in-process and pre-process inventory.

Why a pull system?

- It aligns product or service delivery rate to the demand rate for quick throughput; quick find and fix of errors
- It allows workers control of pace, ensuring quality first
- It gives customers the feeling of being in control

2.1 JIT Objectives

The objectives of JIT are focused on producing:

- Only the products and services that the customer wants

- Products and services at the rate that the customer wants them
- Products and services of perfect quality
- Products and services with minimum lead time
- Products and services with only those features that the customer wants

The main principle behind the JIT philosophy is to create flow production.

This can be achieved by:

- Positioning machines in order of the production processes
- Implementing a u-shaped cell layout
- Incorporating multi-process handling workers
- Carrying out easy moving/standing operations
- Defining standard operations

2.2. JIT Implementation

The necessary requirements for successful implementation of JIT are as follows:

- Regularity of demand - minimization of “surprises” from customers
- Ability to identify waste and determine “excessive” production
- Ability to make quick changeovers - this permits scheduling of small batches
- Use of small batch sizes so that all products are regularly scheduled in direct proportion to their level of demand
- Focused management/vision - not obsessing in lost efficiency
- Cooperation from suppliers/frequent deliveries - smaller deliveries are needed more frequently, these deliveries are required not too soon, not too late, but “just intime”
- Quality control/minimization of defects/quick changeovers

JIT can be implemented over the following phases:

1. Design flow process
2. Total quality control
3. Stabilizing schedules
4. Working with vendors
5. Reducing inventory
6. Improving product design

1

Design flow process

Design flow process involves linking operations appropriately, and reorganizing operation and production layout to achieve an appropriate flow. It also involves balancing workstation capacities and reducing lot size and set- up/changeover time, as well as emphasizing preventive maintenance.

2

Total quality control

To achieve total quality control, workers need to take responsibility for their actions in the workplace. The organization needs to enforce compliance and incorporate automatic and regular inspections of all processes.

Stabilizing schedules

Stabilizing schedules involves leveling schedules so that production can flow smoothly. The organization should aim to underutilize capacity so as to ensure that parts are always available to meet the demands of the schedule.Organizations should also aim to implement freeze windows at key stages in the production process. A freeze window in a schedule means that the schedule cannot change at all over a specified period of time. It is important that organizations pinpoint the appropriate stages in the production process so as to utilize the freeze window effectively, and, in doing so, guarantee the smooth, uninterrupted production of a product or service.

4

Working with vendors

Organizations should work closely with vendors with the aim of reducing lead time and establishing more frequent deliveries. Project usage requirements and quality expectations need to be established with vendors to ensure that the needs of customers in terms of delivery and quality are successfully and consistently met.

Reducing inventory

The organization should look to reduce inventory in all areas - stores, transit, carousels, conveyors, etc.

6

Improving product design

Organizations should aim for a standard product configuration, and align the process design with product design. It should also aim to standardize and reduce the number of parts required in the design of a product, as well as increasing quality expectations.

To successfully implement JIT, the organization needs to be effective in problem solving. It needs to establish the root cause as quickly as possible and adopt a team approach to addressing the problem.

Organizations need to provide continuous training and education for employees to ensure the highest levels of quality and performance are maintained at all times. Organizations should also aim to continually measure performance, track important trends, and always emphasize improvement

2.3. JIT Benefits and Drawbacks

"JIT makes production operations more efficient, cost effective and customer responsive. JIT allows manufacturers to purchase and receive components just before they're needed on the assembly line, thus relieving manufacturers of the cost and burden of housing and managing idle parts."[3]

JIT benefits include:[4]

- Decreased operating cost
- Improved performance and throughput
- Higher levels of quality
- More efficient delivery
- Improved flexibility
- Increased innovation

Mladen Radisic at the University of Novi Sad argues that “Maybe the major problem with JIT operation is that it leaves the supplier and downstream consumers open to supply shocks. With shipments coming in sometimes several times per day, the company is especially susceptible to an interruption in the flow.[5]

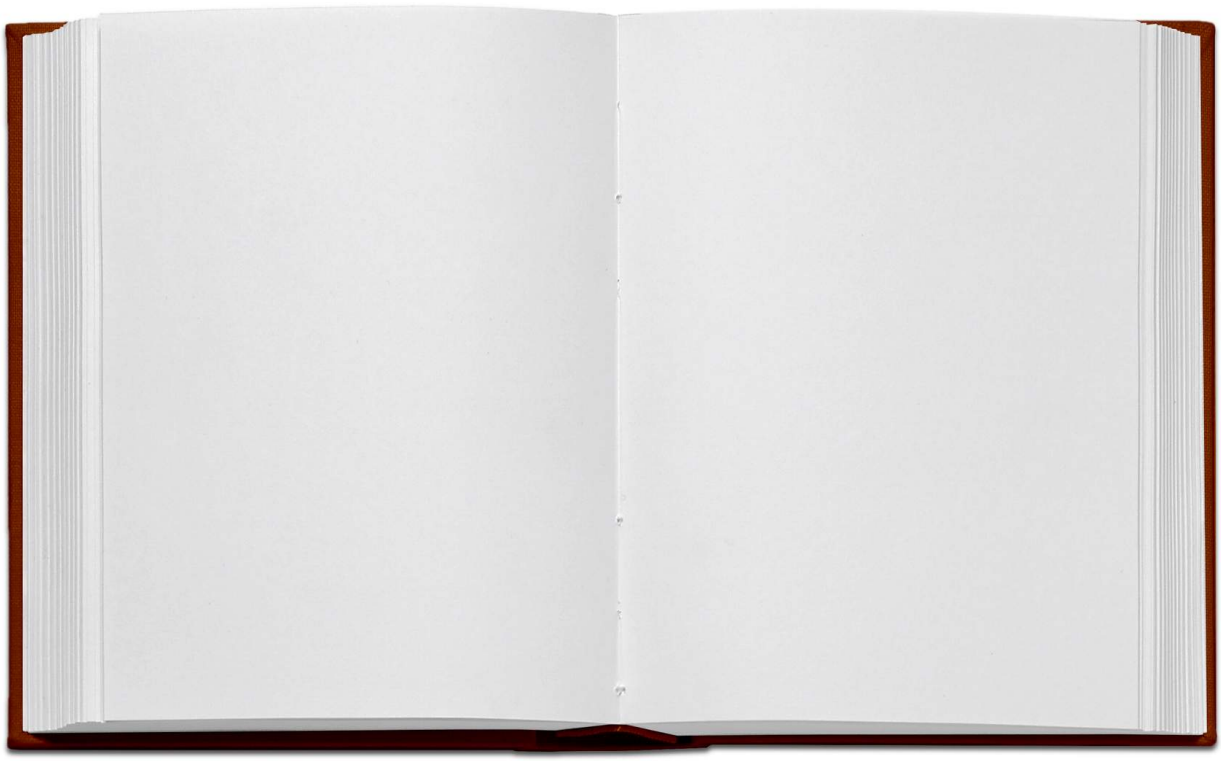
The key to countering this potential weakness is to use more than one supplier for assembly or production processes.

The drawbacks associated with JIT have been summarized by Broyles, Beims, Franko, and Bergman at Kansas State University as follows:

“Just as JIT has many strong points, there are weaknesses as well. In just-in- time, everything is very interdependent. Everyone relies on everybody else. Because of this strong interdependence with JIT, a weakness caused by a JIT weakness can be very costly to all linked in the chain. JIT processes can be risky to certain businesses and vulnerable to the situations such as labor strikes, interrupted supply lines, market demand fluctuations, stock outs, lack of communication upstream and downstream and unforeseen production interruptions.”[6]

However, they go on to outline that:

“Weaknesses in JIT systems are very important to recognize. “From Cisco routers to Dell computers to the Gap’s leather pants, companies have found their just-in-time manufacturing systems have let them down” (Johnson,2001). Companies must strongly evaluate the pros and cons of implementing JIT systems. The effects and risk must also be heavily considered. Although JIT has its weaknesses, in most cases, the benefits outweigh the risks to the JIT- enabled company. Planning for and recognizing when things may go wrong with the JIT system are vital for the success of JIT implementation across all areas.”[6]



Required Reading

1. http://www.1000ventures.com/business_guide/im_jit_main.html

3

3. Kanbans and FIFO Lanes

Kanban is the Japanese word for card, and is a system where materials, products, supplies, or documentation are authorized from downstream process activities based on physical consumption. It is based on a pull material replenishment system, with the principle that these items are pulled through a process based on actual usage requirements. The system helps reduce the amount of obsolete in-process and pre-process inventory.

Kanban systems provide only the materials, products, supplies, or documentation that are required at a particular time. Such items are pulled as they are needed. In essence, Kanban is a communications system that uses visual signals - card, flag, or verbal sign - to move supplies through a process. A downstream worker sends a signal to an upstream worker that they are ready to receive supplies to carry out their tasks. As supplies are consumed, they are reordered.

The Kanban system ensures that money allocated for supplies is the minimum required. All money spent on supplies is utilized efficiently. The system helps reduce the wastes associated with transport, inventory, and motion.

There are a number of benefits associated with the Kanban system:

- Products or services are built to the customers' requirements
- Cycle and changeover times are reduced
- Parts, supplies, and services are 'pulled' as required by the customer in aprocess
- Space is saved
- Inventory is reduced
- Quality is improved

Kanban can be used to help minimize inventories at a low cost. It is a simple system that does not require staff to input supply orders through complex IT-based systems. The Kanban can be a card that outlines precise details about the supplies or inventory being ordered including:

- Supplier or vendor name
- Pick-up date and time
- Type of supplies or inventory
- Order quantity
- Delivery date and location
- Storage location
- Equipment used to transfer

- Product description
- Product number

These details ensure that an organization only orders, receives, and pays for a precise quantity of inventory or supplies based on its specific requirements. This reduces costs incurred from paying for inventory and supplies that are not needed. It also means that valuable storage space is not taken up with excess inventory and supplies. The fact that the system is non-computerized means that it can be initiated and implemented at a very low cost.

Kanban systems can be based on a one or two card strategy or visual controls.

3.1 Two Card Kanban

This strategy is based on two types of Kanban card:[7]

1. **Production Kanban** - Authorizes or indicates that parts should be made for use or to replace stock
2. **Withdrawal or Move Kanban** - Requests that a specific number of modules be moved from one work area to the next

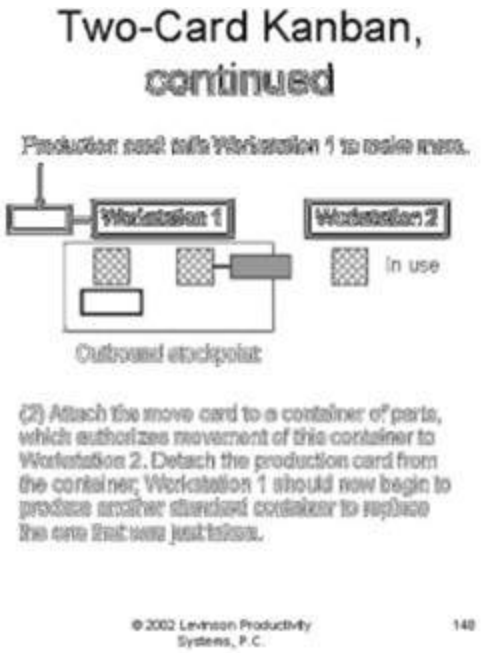
In a two card or dual Kanban system, there is one Kanban card to each container. Containers for each specific part are standard, and they are always filled with the same quantity of parts. No parts are made unless authorized by a Production Kanban card. If there are no Production Kanban cards at a work center, then the process remains idle, and workers will undertake other assigned tasks.

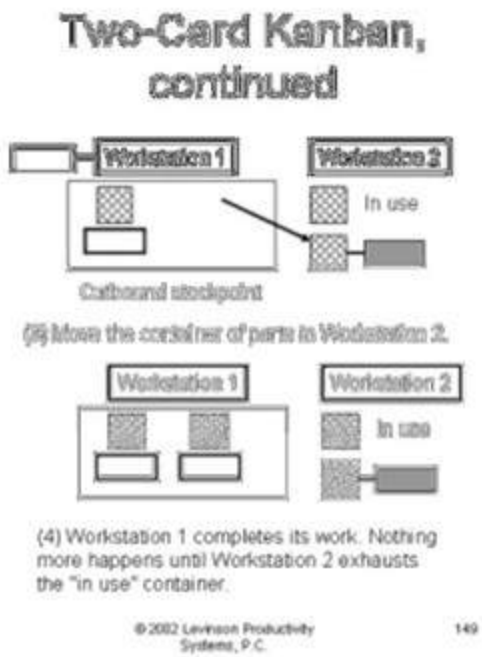
3.2. Kanbans and FIFO Lanes

Decisions regarding the number of Kanbans (and containers) at each stage of the process sets an upper limit on the work-in-process (WIP) inventory at that stage. For example, if 20 containers holding 14 parts each are used to move material between two work centers, the

maximum inventory possible is 280 parts, occurring only when all 20 containers are full. At this point, all Kanban cards are attached to full containers, so no extra parts will be produced.

Figure 1 illustrates how the Two Card Kanban system works:[8]





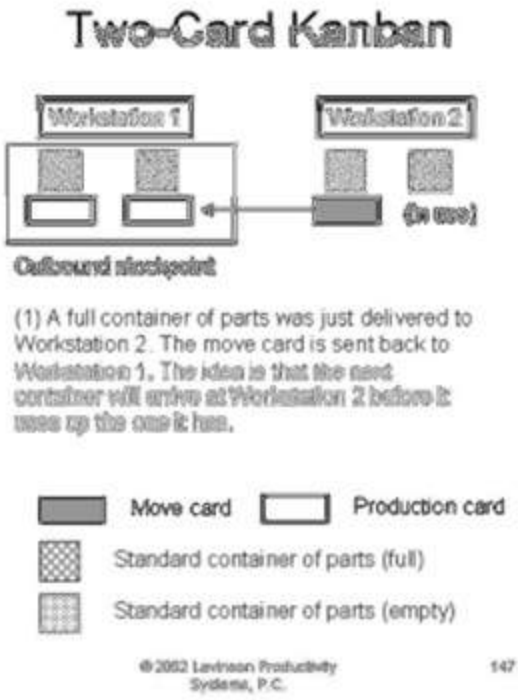


Figure 1. Two Card Kanban System

3.3. One Card Kanban

One Card Kanban systems use only a Withdrawal Kanban card. They are most appropriate in processes where work centres are located in close proximity to each other. An empty space in the outbound stock point becomes the order for another container. When the downstream work area “pulls” from a container, the Kanban card that is attached to it is sent back to the upstream work area to indicate production or replenishment of a replacement part.

3.4. Visual Control Kanban

This system is based on each work area being within sight of the other. An empty Kanban location between workstations acts as a signal for replenishment.

This is illustrated by the following diagram:[9]

Figure 2. Visual Control Kanban

3.5. Calculating the Number of Kanban Cards

The number of Kanban cards used should ideally reduce each time a process runs as this indicates that the amount of WIP is decreasing. However, obviously, there needs to be a starting point. The aim should be to start with a safe estimate as to the amount required and gradually refine the number as the required inventory amounts between each process step become more obvious and predictable.

Bicheno outlines specific methods for calculating Kanban numbers, and these are outlined in the required readings for this section

3.6. FIFO Lanes and Supermarkets

FIFO | SUPERMARKETS

The FIFO (First-In-First-Out) principle is closely associated with Kanban systems and is a principle that should underpin any Kanban implementation. FIFO is a philosophy based on the principle that the first piece of inventory, documentation, supply, module of work, etc. required in an activity is delivered first. The oldest piece of work should always be the one that is processed first.

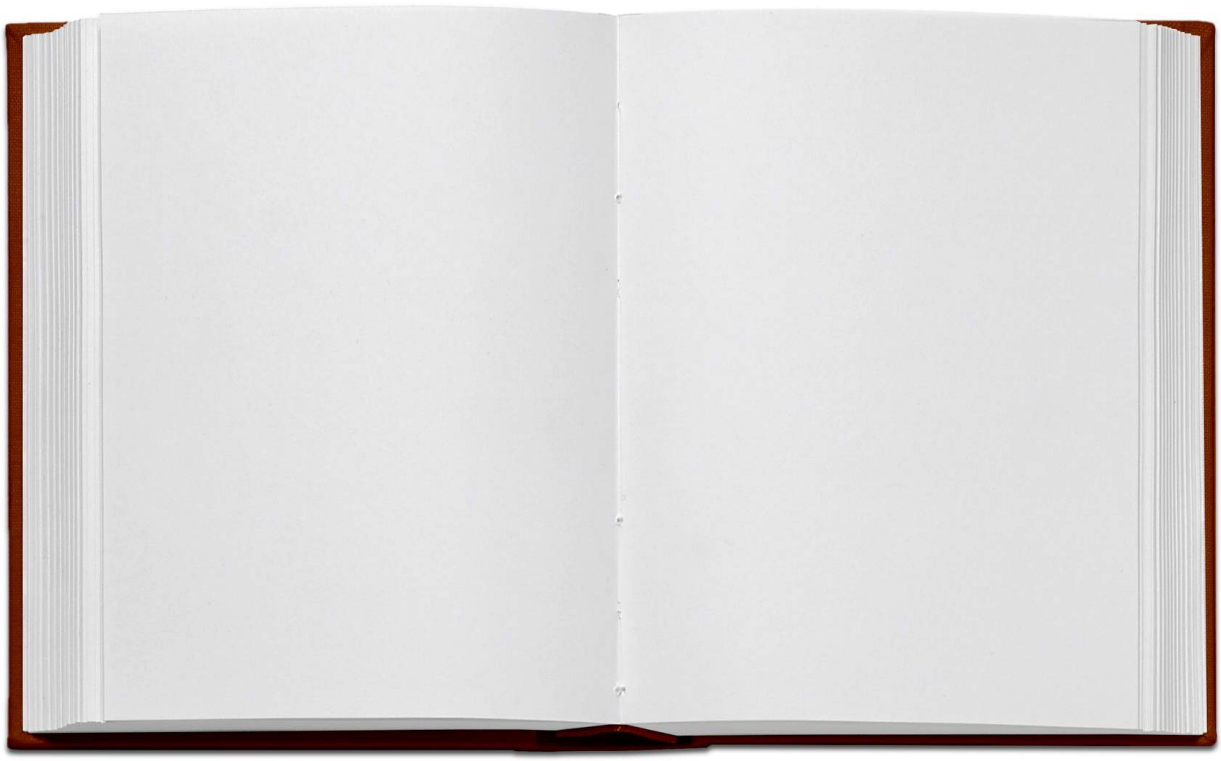
"Think of a FIFO lane as a chute that can only hold a specified amount of inventory. When the chute is full, the supplying process stops producing until the downstream process finishes "digesting" the inventory in the chute, and there is room in the chute again.

A FIFO lane could use a Kanban card or signal, but more commonly, a FIFO lane is used for more "unusual stuff" that often involves unique work instructions."[10]

Supermarkets are storage locations used for products, parts, and supplies that are not fully processed. Part-processed products are shipped to the supermarket, and are stored there until they need to be completed to meet specific customer demands. Supermarkets help implement a pull system, and are therefore used to prevent any product or inventory backlogs occurring in the process. Once the product has been manufactured to a predetermined state, it is stored away, and is only completed when required by the customer. This has a number of advantages. It reduces storage costs because parts are classified as unfinished goods. This allows the organization to be flexible in the face of uncertain product demand. Supermarkets also enable organizations to facilitate specific customization of a product for different customers.

Supermarkets work well in production scenarios where the product being developed is varied or the customer demand for the product varies significantly. Typical situations include organizations that manufacture localized products or implement new product launches where the specific market demand is volatile. For example, an organization that manufactures laptops may use supermarkets to store laptops that have been processed without specific localized parts such as the keyboard. When a number of orders from specific countries are received, the laptop is moved from the supermarket so that it can be processed with the appropriate keyboard for that country.

Supermarkets are not required where products are well established and no product variability exists. In such cases, all markets receive the same product, so customer demand is predictable and does not change significantly. There is also no significant requirement for customized products. However, supermarkets can help reduce inventory-holding costs for any organization.



Required Reading

- **John Bicheno and Matthias Holweg 2016,** *The Lean Toolbox: The Essential Guide to Lean Transformation*, **pp. 206-212, 215-216**

4

4. Production Leveling and Heijunka

veling is typically applied in a process where two or more different parts or services are processed at each operating step. It helps create a smooth process, and enables the value stream to respond to situations where specific services are requested at any given time. For example, let's assume that an organization is providing two testing services - X and Y - to be provided over two shifts per day. Without leveling, the day shift typically provides one service

- for example, service X - and the night shift provides the other service - Y in this instance. If a request to test Y occurs during the day shift, it cannot be delivered upon without having to undertake extra set-ups or waiting until that evening's shift. Implementing leveling means that X and Y are processed throughout both shifts, so additional requests to test can be efficiently dealt with at any time.

Heijunka is a production system focused on achieving a smooth and consistent flow of work. It is aimed at leveling production in terms of volume and product type or mix.11 The system is focused on manufacturing or building products according to the actual flow or rate of customer orders.

“Heijunka takes the total volume of orders in a period and levels them out so the same amount and mix are being made each day.”[12]

A lot of production systems are characterized by a strain on capacity during certain periods. Heijunka aims to counter this by focusing on production that is based on long term average demand and maintaining inventory that is relative to:

- How variable demand is
- How stable production is
- How frequent shipments are

Most processes manufacture and ship a mix of products so require a schedule that has the most appropriate production sequence of customer orders. Because customer orders vary, products are typically manufactured at an irregular rate.

4.1. Production Leveling and Heijunka

“The answer is to build a level schedule everyday by taking the actual customer demand, determine the pattern of volume and mix, and building your level schedule. If you know you are making five A’s and five B’s, you create a level schedule of ABABABAB. This is called leveled, mixed-model production.”[13]

4.2. Heijunka Box

The Heijunka box is used as a visual scheduling tool for leveling production in line with varying customer demand. The box schedules production in increments that align with the Takt time for each product. It is typically a grid with a number of rows and columns. Each row represents a product while each column is divided by a line corresponding to identical time intervals of production that align with Takt time for that product. Each column consists of a container that holds a number of Production Kanban cards that indicate the number of parts to process for that product type over that particular time interval.

The Society of Manufacturing Engineers provide a useful example of a Heijunka box and how it is implemented:[14]

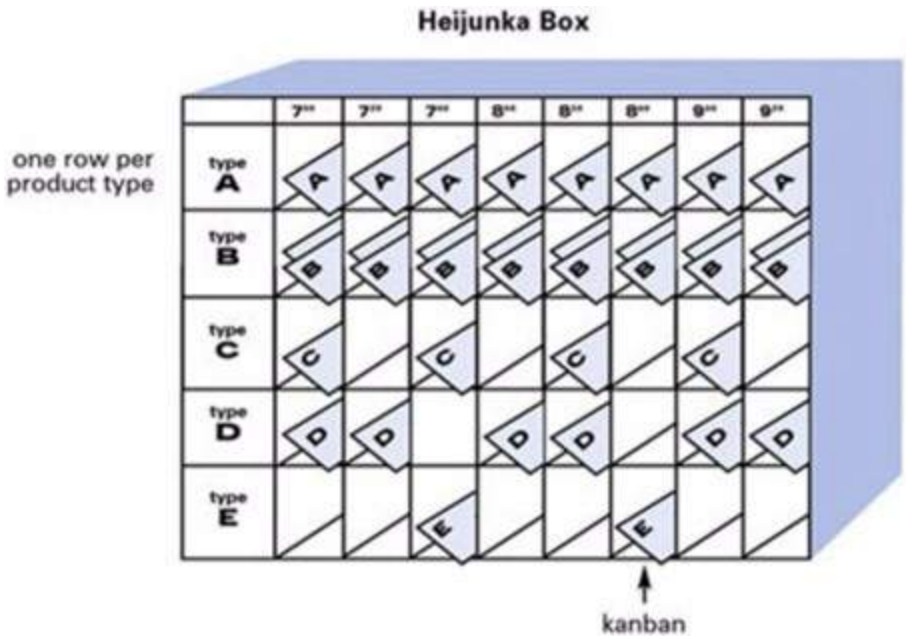


Figure 3. Heijunka Box

"In this example, the shift starts at 7 a.m. and Kanban are withdrawn by a material handler every 20 min for distribution to the pacemaker point along the value stream. (In a Lean production system of this type, there is only one pacemaker point along the value stream

where production instructions are introduced. From that point back up the stream, parts are replenished at each break in continuous flow by means of simple pull loops from upstream parts supermarkets.) In the first 20 mins, the value stream will produce one Kanban of Type A, two Kanban of Type B, one Kanban of Type C, and one Kanban of type D.

Whereas the slots represent the timing of material and information flow, the Kanban in the slots each represent one pitch of production for one product type. (Pitch is Takt time multiplied by pack-out quantity. This concept is important because it represents the minimum amount of material that can be moved from one operation to the next, and the number of items called for by a Kanban are sized to this amount.) In the case of Product A, the pitch is 20 mins, and there is one Kanban in the slot for each time interval. However, the pitch for Product B is 10 mins, so there are two Kanban in each slot. Product C has a pitch of 40 mins, so there are Kanban in every other slot. Products D and E share a production process with a pitch of 20 mins and a ratio of demand for Product D versus Product E of 2:1. Therefore, there is a Kanban for Product D in the first two intervals of the shift, and a Kanban for Product E in the third interval, and so on in the same sequence."[15]

5. One-Piece Flow and Cell Design

Many organizations manufacture products in large batches where parts can't move to the next stage in a process until all parts for the particular batch have been processed. The bigger the batch size is the longer the lead time to manufacture and ship the product will be. As well as that, queue times and WIP are increased within the process.

The one-piece flow technique is aimed at reducing lead and queue times and unnecessary inventory storage by focusing on manufacturing one part at a time correctly all of the time with no unplanned interruptions or unnecessary queue times.

It is based on producing one product in accordance with its Takt time. Therefore, parts are allowed to flow from one process step to the next in order to meet the Takt figure for that particular process.

The following illustration depicts the difference between batch and queue manufacturing and one-piece or continuous flow production.[16]

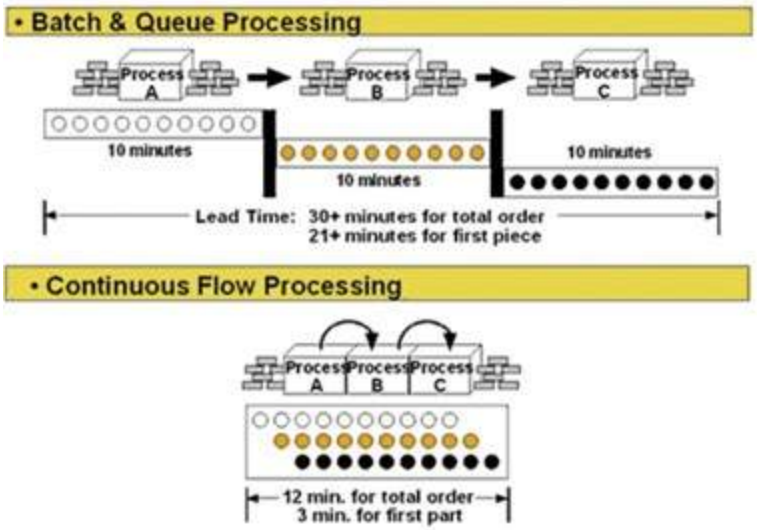


Figure 4. Batch and Queue V One-Piece Flow

here are a number of benefits associated with the technique. It helps:[17]

- Reduce defects and errors because parts are passed to each worker more frequently without lengthy waiting times, thereby ensuring that any problems are caught at the earliest possible stage in the process
- Reduce inventory costs because the amount of inventory stored between process steps is decreased. Therefore the costs involved in storing, transporting, etc. are decreased
- Increase productivity because there is a continuous flow of work through the process that aligns with customer demand
- Increase floor and storage space because WIP is reduced. One-piece flow requires steps to be close together so space between cells and equipment is reduced

- Increase flexibility because process lead time is reduced. This allows the process to be robust enough to respond to any unscheduled modifications

In order to implement an effective one-piece flow system, it is vital that the plant layout and work cell structure lends itself to the continuous flow of parts.

"Central to the idea of one-piece flow manufacturing is the concept of motion-motion of materials, motion of parts/assemblies, motion of personnel, and the motion of finished goods out of the plant. Cellular environments facilitate one-piece flow production through having everything that is needed for production within easy reach, and ensuring that each assembly step is completed before the part is moved along to the next."[18]

In a poorly balanced cell, work-in-process (WIP) piles up between each station. Quality re-work means you have to find the error and re-make or reprocess inventory. With one-piece flow, errors can be identified at the earliest possible stage and be addressed immediately before any knock-on effects are felt across.

Cells designed to eliminate waste help optimize material, people and information flow. U, J, or L-shaped cells, with stations and work areas interlinked eliminate wasted space so workers can move quickly from work area to work area and from work station to work station with no excess distance traveled. Parts should be provided from the rear of the cell to simplify replenishment and any lengthy changeovers or set-ups.

One goal of the cell design stage, therefore, should be to incorporate the appropriate-sized equipment to help meet Takt time whenever possible. If the manufacturing cell will also include overly capable equipment, the next step will be to balance operations and resources. Takt time also plays a role in the physical layout of cells. Of the various options, the U-shaped cell generally uses space more effectively and reduces the time spent handling materials and parts. S- shaped cells will work well when the process includes a large number of operations - for example a car assembly line. L shaped cells are effective when deploying a small number of operations. L shaped cells represent the least effective design because space is not optimized. According to the Society for Manufacturing Engineers, cell designers should strive to do the following when designing optimal cell layouts:

1. Minimize the size of the area used for each process step or operation

2. Allow space for small containers of parts
3. Minimize the length of conveyors
4. Implement counter clockwise process flow because most people are right-handed
5. Locate cell operators inside the U

In the final layout of a U-shaped cell, the process should flow from right to left, with the operators positioned as close together as is possible to allow for efficient communications. Cycle time for each operation or process step should be just below Takt time.[19]

6. Theory of Constraints

The Theory of Constraints (TOC) is an effective tool or model that an organization can use to implement and apply Lean Thinking to its processes. TOC was first described by Dr. Eliyahu M. Goldratt in his book, The Goal. It is based on the fact that the organization is limited in its journey by the speed of a constraint. A constraint is anything in an organization that limits it from moving toward or achieving its goal. For most organizations the goal is to serve the customer appropriately. Constraints can take the form of a process's capacity, company regulations that govern product and service quality, existing facilities, or customer demand.

TOC fits in well with LEAN Thinking as it seeks to reduce inventories and introduce customer flow throughout a process. The same principles are applied across the organization with the aim of producing and delivering just what the customer requires.

The Theory of Constraints identifies one constraint and prioritizes this as the main factor that determines output. Everything else is the subordinate to the constraint.
TOC is applied in a structured way across the process and organization. The steps involved in applying TOC are as follows:

1. Identify the system's constraints. Internal or external constraints are prioritized into ones that limit the organization from reaching and attaining its goal
2. Decide how to maximize the capacity of the system's main constraints.
3. Eventually, it will become clear what the single biggest constraintis.
4. Then, everything else is optimized to meet the demands of the constraint, and produce and deliver to that constraint no more that the constraint can handle
5. Subordinate everything else to the decision reached in Step 2. Since the constraint is keeping the organization from moving towards its goal, it applies all of the resources possible to assist in breaking the constraint and eventually eliminating it as a constraint completely
6. Elevate the focus on the system's constraint. If one continues to work towards breaking a constraint, at some point the constraint will no longer be a constraint. It will bebroken
7. If the constraint is broken, return to Step 1 and focus on the next constraint

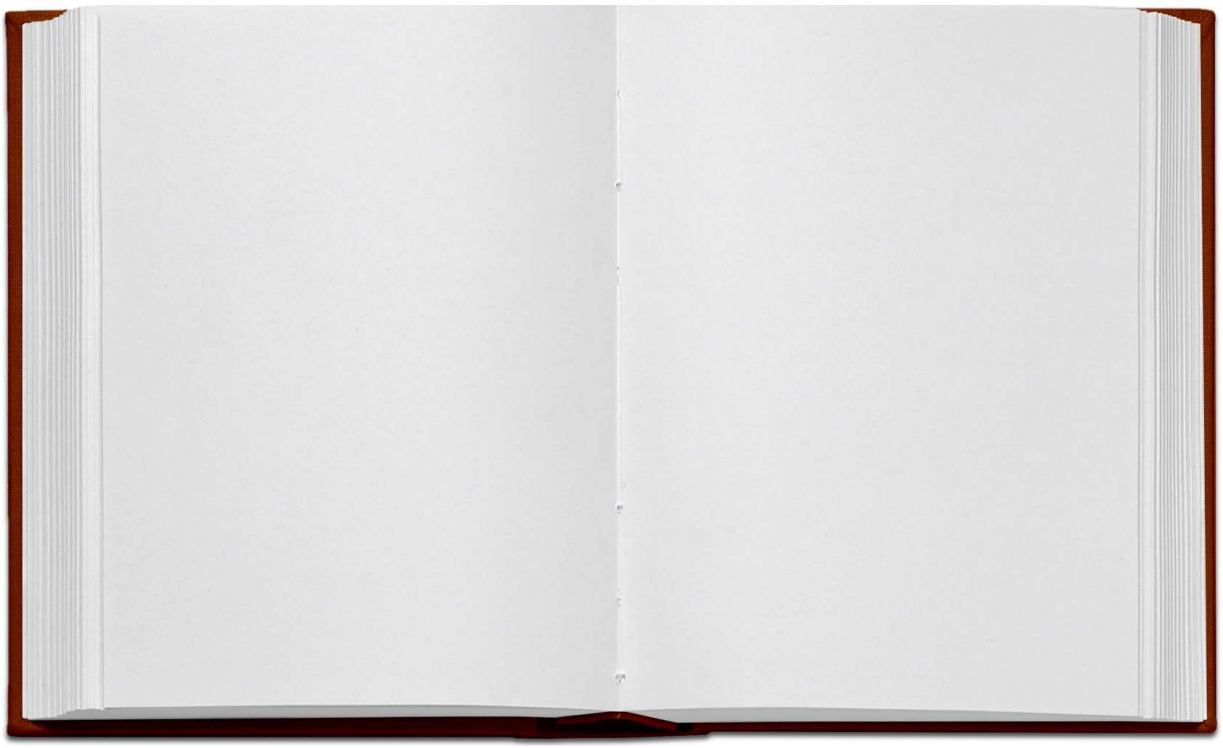
The above process must be reapplied again and again. The Theory of Constraints is as much about continuous improvement as any other factor.

Theory of Constraints can be used in any organization to help increase the quality and delivery of products and services without a requirement for a large amount of extra resources.[19]

Video Tutorial: Theory of Constraints

This tutorial discusses the main concept behind the theory of constraints, the types on internal constraints, and describes tools used to alleviate bottlenecks.

Video Notes:



Required Reading

- **John Bicheno and Matthias Holweg 2016,** *The Lean Toolbox: The Essential Guide to Lean Transformation*, **pp. 228-232.**

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5. Optimizing Process Capacity

Module Overview

This module introduces the Lean tools and practices used to improve process capacity. The concept of Jidoka (Built In Quality) is explored along with the use of Quality Filter Mapping to identify where defects exist. The module explains how techniques such as Poka Yoke, Total Productive Maintenance (TPM), and Overall Equipment Effectiveness (OEE) are used to ensure that errors, defects, and breakdowns are kept to a minimum so that can operate to its full capacity. Finally, the module explains how the Single Minute Exchange of Dies (SMED) methodology is used to reduce unnecessary changeover times within a process.

Modules Objectives

On successful completion of this module, you will be able to:

- Identify the principles that underpin the Jidoka philosophy
- Develop a Quality Filter Map for a specific process
- Identify the different types of mistake proofing that can be applied to a process
- Identify and distinguish between the various Poka Yoke systems and methods
- Suggest a suitable Poka Yoke deployment for a specific process
- Identify the aims and main pillars associated with Total Productive Maintenance (TPM)
- Calculate Overall Equipment Effectiveness (OEE) for a process
- Outline a suitable TPM implementation for a specific functional area or process

Required Reading

Please note that, because the module deals with a number of different topics, the required reading for each is referenced after the notes provided. You should aim to access and read these before moving on to the next topic.

Module Topics

The topics that will be covered in this module are:

1. Jidoka
2. Quality Filter Mapping
3. Poka Yoke
4. Total Productive Maintenance (TPM)

5. Single Minute Exchange of Dies (SMED)

Reflection and Self-assessment

There are no reflection or self-assessment exercises for this module.

1

1. Jidoka

According to the Toyota website:
“The term Jidoka used in the TPS can be defined as “automation with a human touch.” The word Jidoka traces its roots to the automatic loom invented by Sakichi Toyoda, Founder of the Toyota Group. The automatic loom is a machine that spins thread for cloth and weaves textiles automatically.

Jidoka refers to “automation with a human touch,” as opposed to a machine that simply moves under the monitoring and supervision of an operator.

Since the loom stopped when a problem arose, no defective products were produced. This meant that a single operator could be put in charge of numerous looms, resulting in a tremendous improvement in productivity.”

Jidoka is based on the principle of embedded or Built-In Quality achieved by automatically or manually stopping a line when a mistake occurs so that no defective parts are passed downstream that might upset flow.

Automatic line stoppage can be achieved through the use of limit switches or devices to shut down a process when the following occurs:

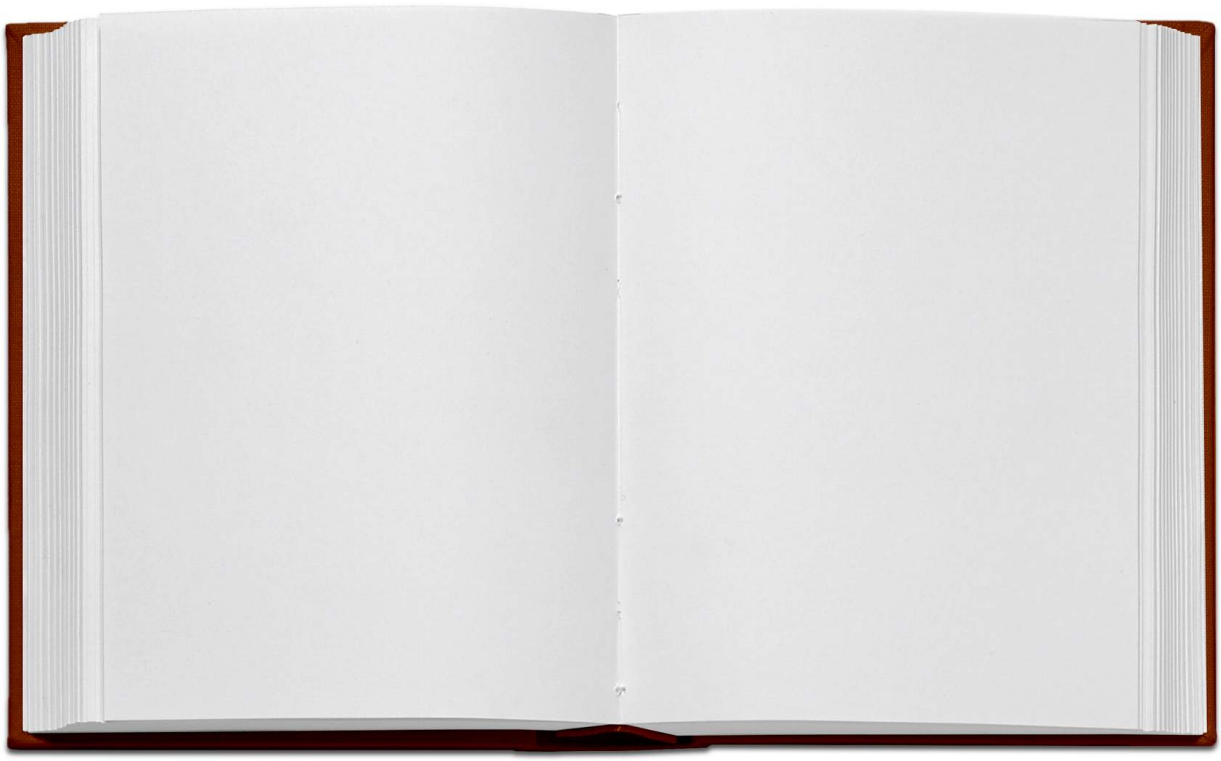
- The required number of parts or pieces have been manufactured
- The mechanism jams or freezes
- A part is defective

“The purpose is to free equipment from the necessity of constant human attention, separate people from machines, and allow workers to staff multiple operations. “[1]

There are 4 main steps associated with Jidoka and its appropriate implementation:[2]

1. Identify or detect the defect or error
2. Immediately stop whatever you are doing
3. Address and fix the issue
4. Establish the root cause and ensure that it will never happen again

There are a number of tools and techniques that help ensure Jidoka or Built-In Quality is embedded in the organization. These include Quality Filter Mapping, Poka Yoke, TPM, and SMED and are all dealt with in this module.



Required Reading

- http://www.strategosinc.com/jidoka.htm

2

2. Quality Filter Mapping

The Quality Filter Mapping technique is used to:

- Identify where quality problems exist
- Classify defects as product, service, or internal scrap
- Establish both internal and external quality levels

Each defect is mapped. The defects can be:

- **Product defects** - defects found in goods that have been passed on to the customer
- **Service defects** - defects that result from an accompanying level of service, rather than directly related to the goods themselves
- **Internal scrap** - defects that are caught prior to delivery to the customer

The following diagram illustrates a Quality Filter Map for an automotive manufacturing facility. It represents a process that commences from product distribution, back through to assembly; first, second, and third suppliers; and, finally, to raw materials. This approach illustrates where defects are occurring, and therefore helps identify any waste. It must be noted that not all defects are passed onto the consumer due to internal rejection and rework. This technique can be used internally by individual departments or teams instead of different companies.

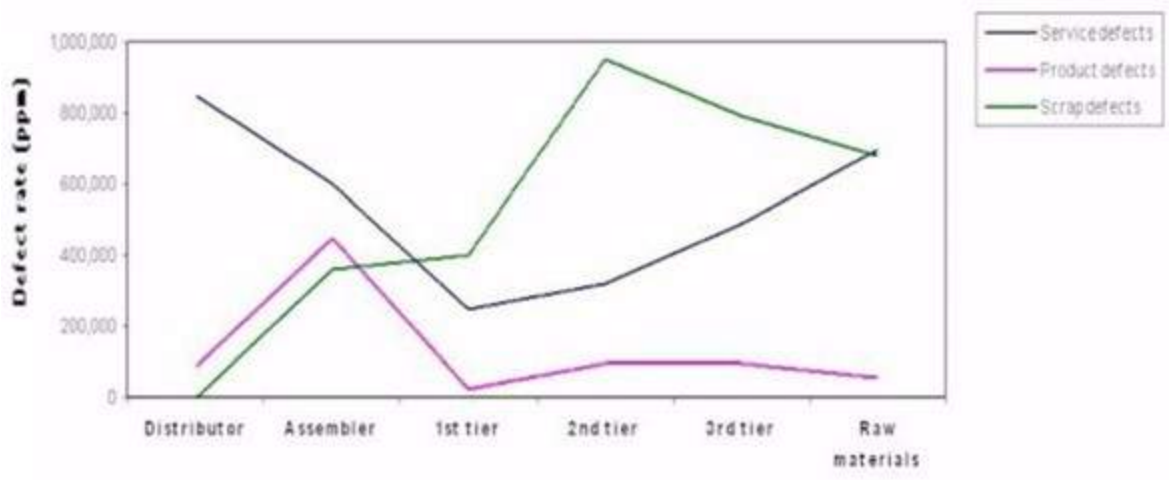
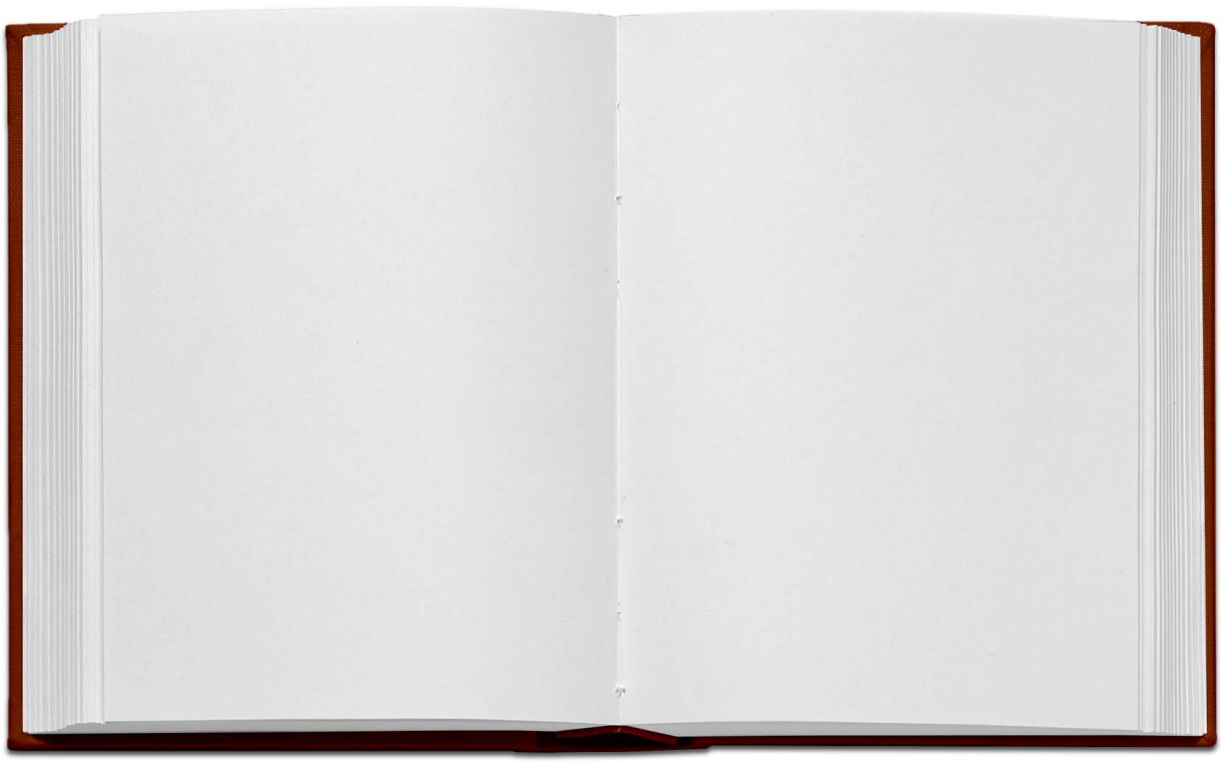


Figure 1. Quality Filter Map

The following steps should be carried out to develop a Quality Filter Map:[3]

1. Select a suitable target process or activity and map each step/function involved over a particular time period

2. Gather all relevant data - product and service defects and internal scrap - over the agreed time period and according to a specific volume of business - for example data relating to business activity over the past 3 months for 50,000 modules produced. For each failure, error, and rework that is recorded, the associated quantitative and qualitative costs should also be calculated and noted
3. Plot the results graphically with the various functions/steps that exist in the process located along the x-axis and the volume of defects along the y-axis
4. Identify and address the appropriate process step (s) or functional area (s) to target, based on the highest incidence of defects and the impact that these are having on the bottom line
5. Use the existing Quality Filter Map as a benchmark for other areas and repeat steps 1-4 for the original area until the process is defect free or has the minimal number of defects without an impact on the bottom line



Required Reading

- http://www.bizbodz.com/Business-Improvement/Lean/Quality-Filter-Mapping-How-to-Guide-Part-1.asp

3. Poka Yoke

Poka Yoke is a mistake proofing system where simple, low-cost devices are used to reduce errors. It prevents defective parts from being made or passed into the process. Poka-yoke is based on prediction and detection. That is, recognizing that an error can happen or recognizing that an error has actually occurred.

Video Tutorial: Poka-Yoke or Mistake Proofing

Poka-yoke, or mistake proofing, involves examining processes to uncover where human error occurs. This tutorial explains poka-yoke, and describes examples of mistake proofing.

Video Notes:

There are four types of mistake proofing:

Elimination

This form of mistake proofing focuses on the redesign of systems and processes to eliminate the chance of errors occurring.

Facilitation

This form of mistake proofing provides methods of guidance - hard and soft - to minimize the chances of an error occurring.

Mitigation

This form or mistake proofing minimizes the effect of the error if the resulting defect or mistake reaches the customer.

Flagging

This form or mistake proofing provides proven methods for insuring a 100% chance of capturing and removing all errors or mistakes prior to delivery to the customer.

The following are the guidelines associated with attaining Poka Yoke:

1. Implement quality processes - design “robust” quality processes to achieve zero defects
2. Utilize a team environment - leverage the team’s knowledge and experience to enhance improvement efforts
3. Eliminate errors - utilize a robust problem solving methodology to drive defects towards zero
4. Eliminate the “Root Cause” of the errors
5. Do it right the first time - utilize resources to perform functions correctly the “first” time
6. Eliminate non-value-added decisions
7. Implement an incremental continual improvement approach

Two Poka Yoke System approaches are utilized in manufacturing or environments. These will eventually lead to successful zero defect systems:

- **Control Approach** - shuts down the process when an error occurs and keeps the “suspect” part in place when an operation is incomplete
- **Warning Approach** - signals the operator to stop the process and correct the problem

Poka Yoke systems can consist of the following:

- Signals
- Sensors
- Counters
- Labels
- Graphical instruction
- Checklists

Poka Yoke systems consist of three primary methods:

- Contact
- Counting
- Motion-sequence

Each method can be used in a control system or a warning system, and each one uses a different process prevention approach for dealing with irregularities.

Contact Methods

These can be as simple as guide pins or blocks that do not allow parts to be seated in the wrong position in a product prior to processing. This method signals to the operator right away that the part is not in proper

Counting Methods

This method is used when a fixed number of operations are required within a process, or when a product has a fixed number of parts that are attached to it. A sensor counts the number of times a part is used or a

Motion-sequence

The third Poka Yoke method uses sensors to determine if a motion or a step in a process has occurred. If the step has not occurred or has occurred out of sequence, the sensor signals a timer or other

Physical contact devices

Physical sensors will not allow a machine to be opened while a part is processed and will only load a second part when the first is finished. These would be common in machine shops.

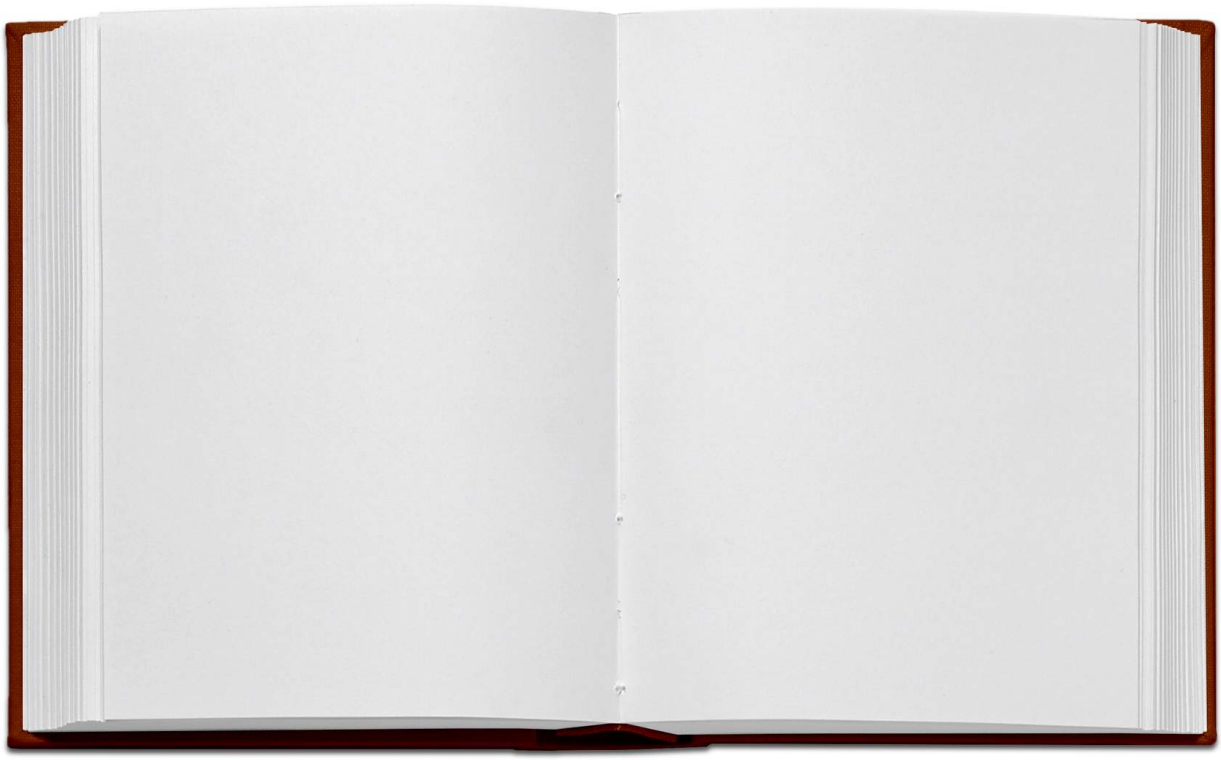
Energy sensing devices

A typical example of an energy sensing device can be found in the defibrillators used to start hearts in the case of a heart

attack. As the device charges, a prolonged loud

Warning sensors

Warning sensors can be seen in alarmed doors in buildings and doors on trains that remind users to watch their step. In industry, warning sensors are used in machines where an alarm activates if



Required Reading

- http://www.referenceforbusiness.com/management/Or-Pr/Poka-Yoke.html
- http://www.npd-solutions.com/mistake.html

4

4. Total Productive Maintenance (TPM)

Total Productive Maintenance (TPM) aims for zero breakdowns and for zero defects in medical devices, tools, and equipment.

According to the Society of Manufacturing Engineers:

"Total Productive Maintenance is a methodology and philosophy of strategic equipment management focused on the goal of building product quality by maximizing equipment effectiveness.
It embraces the concept of continuous improvement and total participation by all employees and by all departments."

TPM is the philosophy and practice of preventing the loss of productive time and poor quality of service due to:

- Breakdowns
- Minor Stoppages
- Idling
- Operating at less-than-planned-for cycle times

- Changeovers/Set-ups
- Unacceptable quality

It is an organization-wide equipment improvement strategy with a systematic focus on eliminating the major equipment-related losses. TPM is an approach that trains and holds all workers accountable for proper operations and proper maintenance. It is a strategy assuring that all critical equipment is reliable by focusing on improving overall equipment effectiveness.

Finally, it should be viewed as a culture change led by top management with very clear business expectations.

The main aims associated with TPM are as follows:

- Establish a corporate culture that will maximize production system effectiveness
- Implement a practical shop floor system to prevent losses before they occur throughout the entire production life cycle, with a view to achieving zero accidents, zero defects, and zero breakdowns
- Involve all the functions of an organization including production, development, management, and key equipment suppliers
- Aim for zero losses through the activities of ‘overlapping’ small groups

TPM has numerous associated benefits, including:

- Improved quality through equipment that produces/processes parts with reduced variation
- Improved productivity by eliminating equipment downtime, stoppages, and reduced line speed
- Improved delivery due to improved schedule attainment
- Reduced inventory from reduction in buffers designed to accommodate equipment downtime
- Improved employee satisfaction through successful production
- Increased plant capacity

- Lower maintenance and production costs
- Increased return on investment

TPM typically involves the entire organization in identifying, monitoring, and correcting the root causes of each of the losses outlined above. The philosophy relies on the thinking worker, waste reduction, and being simple and visible. For TPM to be successfully implemented in any organization, the management team should carry out an audit on a regular basis. In addition, steering teams should be in place. These teams should consist of both direct and indirect staff, with representatives from all departments.

A successful and sustainable TPM implementation requires long term top management commitment as well as commitment from the staff involved in its deployment. The deployment itself should be undertaken by a flexible cross- trained team led and coordinated by a suitable Project Champion.

4.1. Pillar 1: Autonomous Maintenance

Autonomous maintenance is focused on preparing operators to close the gap between themselves and the maintenance staff, therefore making it easier for both to work as one team. Equipment should be modified or adapted so that operators can identify any abnormal conditions and measure deterioration before it affects the process or leads to a failure. The pillar is focused on ensuring that operators can set optimal equipment conditions and ensure they are able to maintain those conditions.

The following seven steps should be implemented to progressively increase operators' knowledge, participation, and responsibility for their equipment:

1. Perform initial cleaning and inspection
2. Implement counter measures for the causes and effects of dirt and dust
3. Establish cleaning and lubrication standards
4. Conduct general inspection training
5. Carry out equipment inspection checks

6. Implement appropriate workplace management and control
7. Practice continuous improvement on an ongoing basis

4.2. Pillar 2: Focused Improvement

The objective of this pillar is to maximize efficiency by eliminating waste and manufacturing losses. In order to do this, manufacturing losses should be first categorized and quantified so that they can be prioritized and addressed accordingly.

Manufacturing losses can be categorized in terms of equipment, manpower, and material.

EQUIPMENT LOSSES | MANPOWER LOSSES | MATERIAL LOSSES

Equipment losses can be broken down as follows:

- Downtime loss through equipment failure/breakdown, set-ups, and adjustments
- Loss of speed through minor stoppages and idling
- Loss of quality through process errors and rework

EQUIPMENT LOSSES | MANPOWER LOSSES | MATERIAL LOSSES

Manpower losses can be incurred through:

- Waiting for materials
- Waiting for instructions

- Waiting for quality confirmation/assurance

EQUIPMENT LOSSES | MANPOWER LOSSES | MATERIAL LOSSES

Material losses can manifest as:

- Material yield
- Energy
- Consumables

Equipment losses can be categorized in according to how effectively a piece of equipment is operating. Calculating Overall Equipment Effectiveness (OEE) helps establish this. OEE figures are determined by combining the availability and performance of equipment with the quality of parts made. It measures the efficiency of the machine during its planned loading time. Planned downtime does not affect the OEE figure. It is a composite measure of the ability of a process to carry out value-adding activity.

OEE is calculated by **multiplying the % availability by the % output achieved by the % perfect output.**

The following diagram outlines the elements that contribute to each of the percentages outlined above.

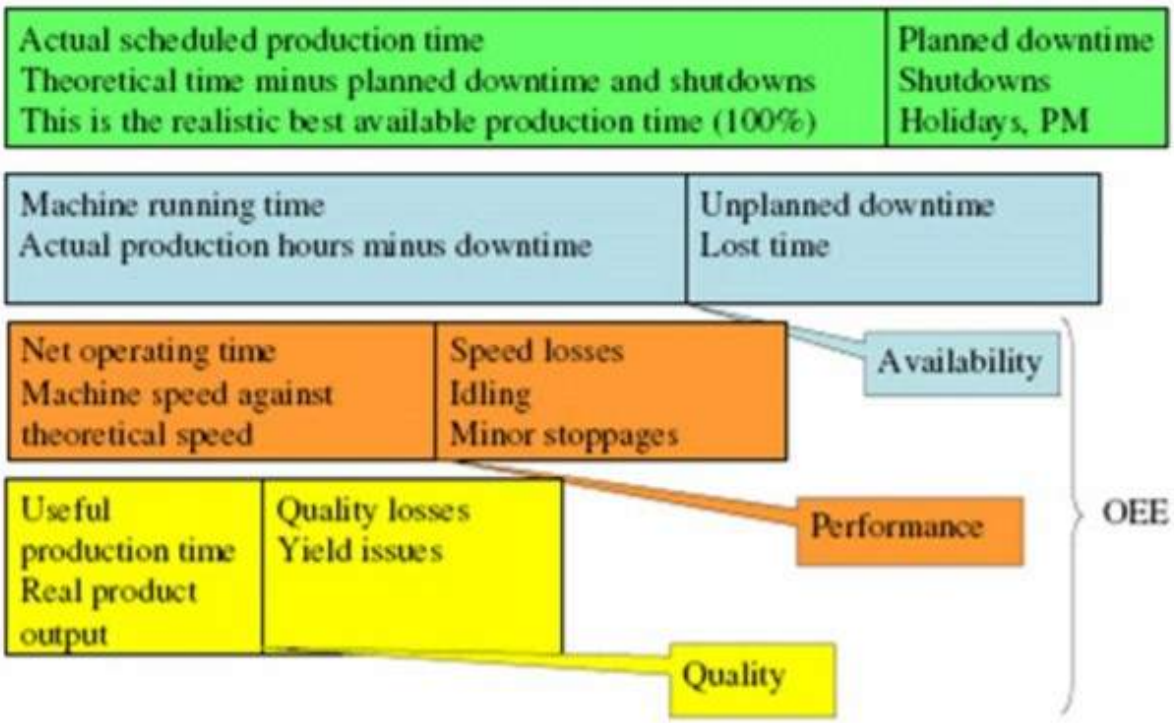


Figure 2. OEE Elements

An example of how OEE is calculated is provided below.

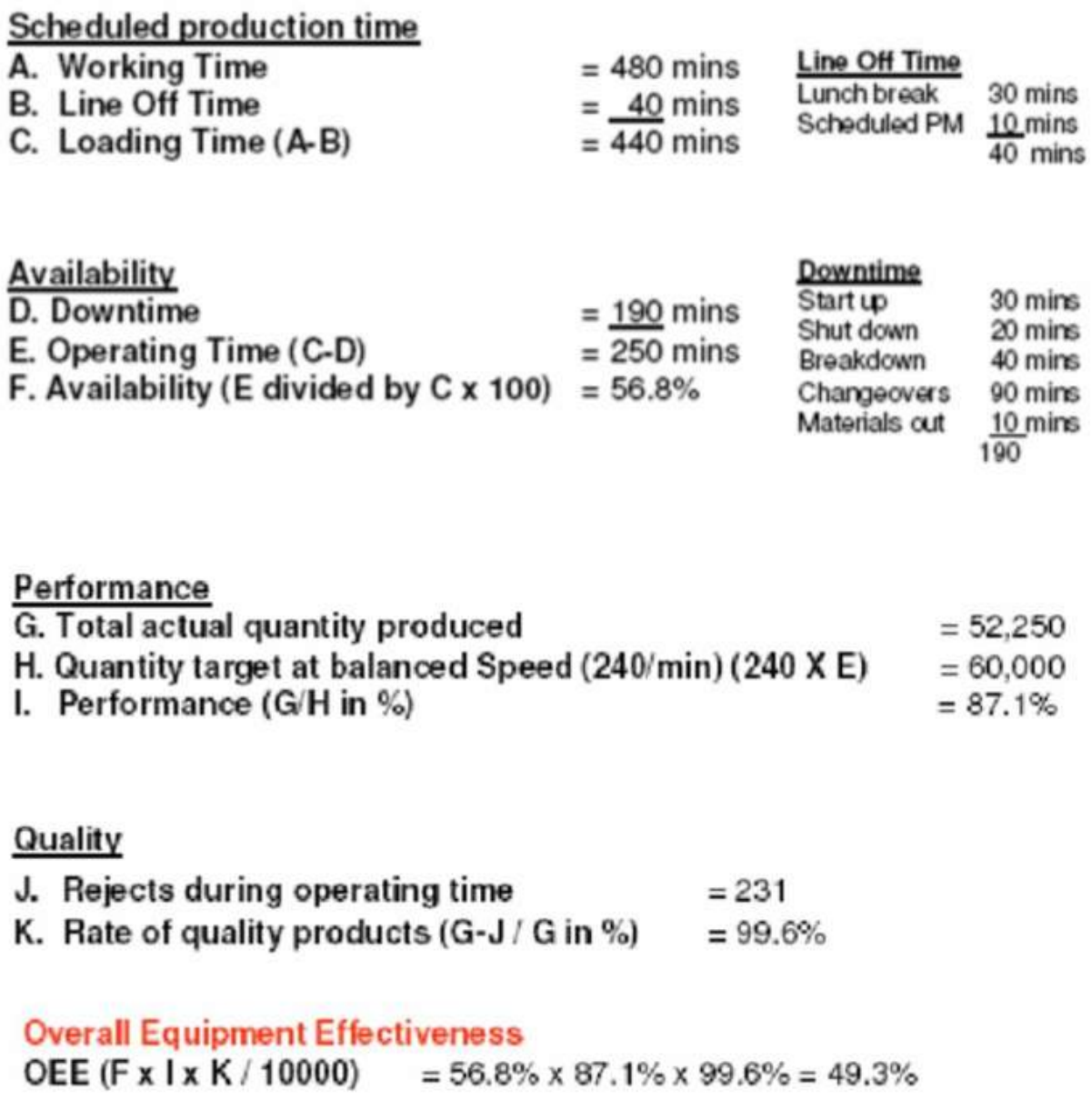


Figure 3. OEE Calculation

4.3. Pillar 3: Preventive and Predictive Maintenance

This pillar is focused on establishing preventative and predictive maintenance systems for equipment and tooling. Preventive maintenance is time-based, interval or run-based maintenance that is aimed at periodically inspecting, servicing, cleaning, or replacing parts to

prevent sudden failure. Maintenance activities are performed on a calendar or operating time interval basis to extend the life of the equipment and prevent failure.

The diagram below depicts how preventive maintenance is typically carried out.

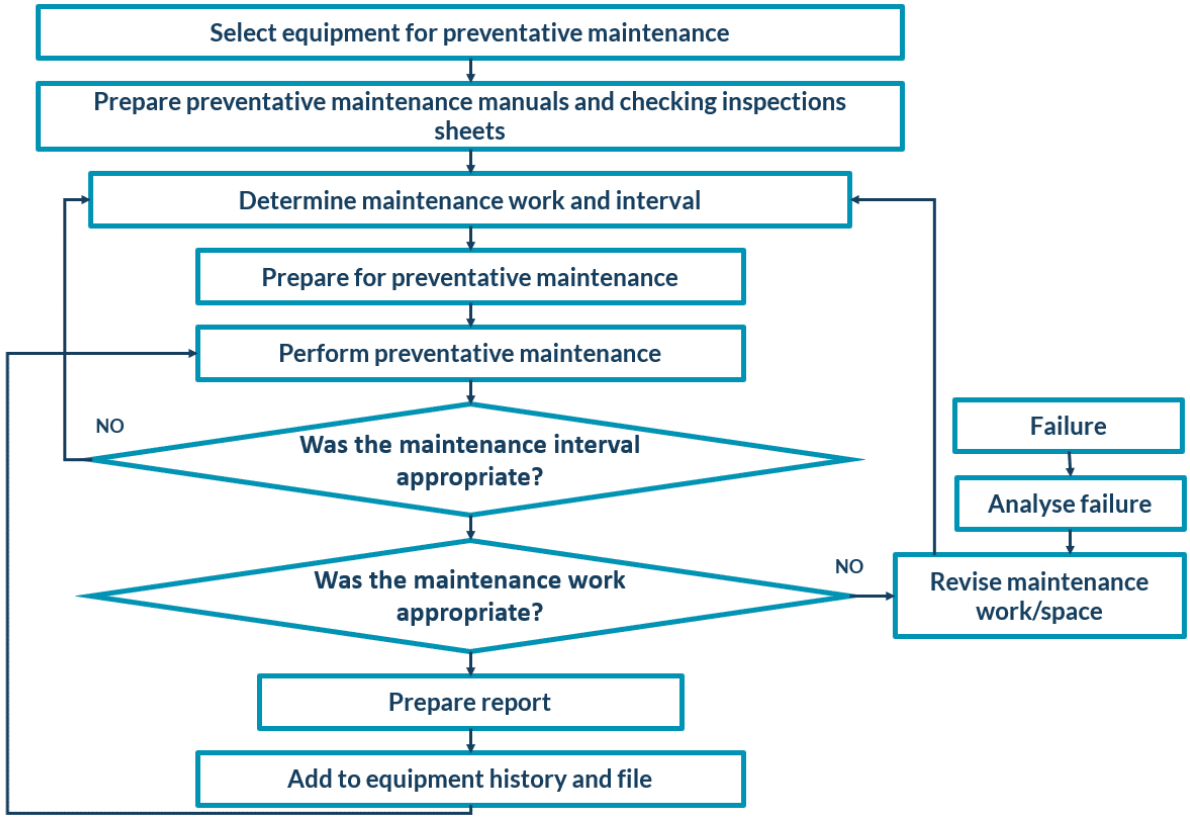


Figure 4. Preventive Maintenance Flow Diagram

Predictive maintenance uses monitoring equipment coupled with historical data to predict the life cycle of components. Also known as condition-based maintenance, it uses non-intrusive testing techniques as well as visual inspection and performance data to assess machinery condition. It replaces arbitrarily timed maintenance tasks with maintenance that is scheduled when warranted by equipment condition. Predictive maintenance can also incorporate on-line monitoring of equipment in order to use important/ expensive parts to the limit of their serviceable life.

Predictive maintenance has a number of associated advantages. It:

- Helps reduce costs and improve reliability
- Improves mean-time-to-repair due to prediction of failure
- Reduces inventory levels due to the avoidance of premature parts replacement and the ability to predict parts requirements
- Decreases maintenance resource requirements and provides reduced overtime levels due to reduced emergency maintenance
- Provides the engineer/technician with an insight into the location and cause of the impending failure thereby reducing diagnosis time

Equipment on-line monitoring methods include intrusive and non-intrusive approaches:

- Vibration analysis
- Lubricant examination
- Thermal imaging and temperature measurement
- Flow measurement
- Electrical testing and motor current analysis
- Leak detection
- Valve operation
- Corrosion monitoring
- Process parameters
- Visual observations

The diagram below depicts how predictive maintenance (PdM) is typically carried out.

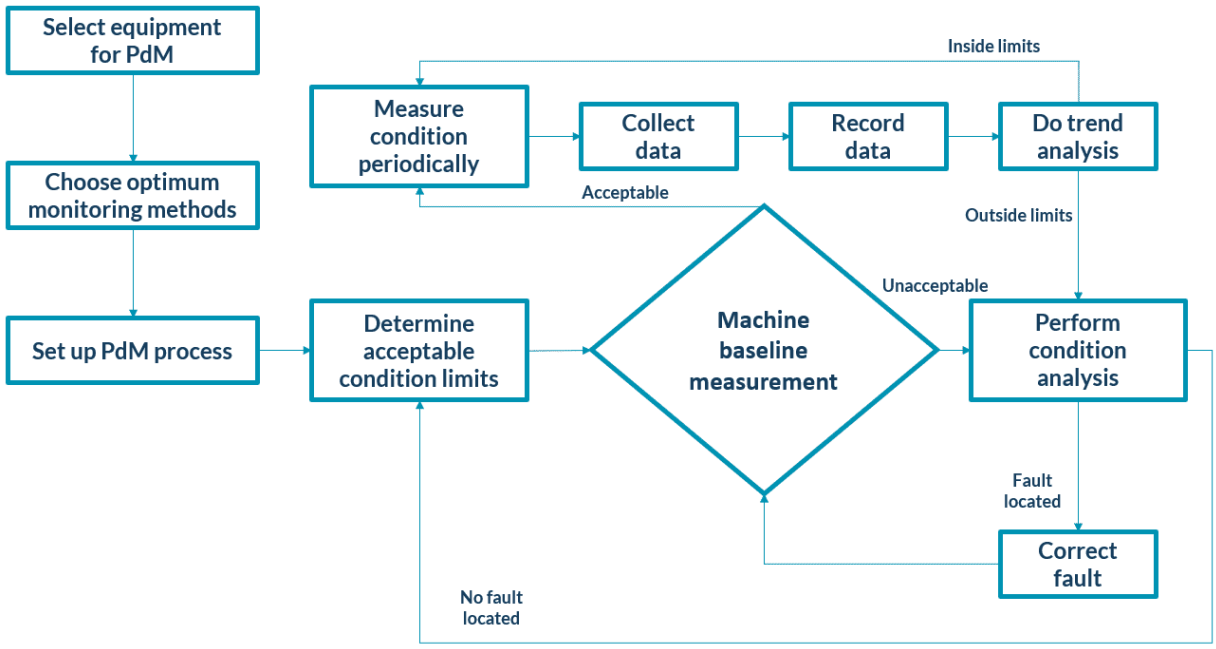


Figure 5. Predictive Maintenance

Predictive and preventive maintenance should be aimed at realizing the natural life cycle of individual machine elements through:

- Implementing correct operation and set-up procedures
- Carrying out regular cleaning and lubrication
- Retightening on a regular basis
- Providing informative feedback in relation to the repair of any defects
- Purchasing spare parts that are of a high quality

4.4. Pillar 4: Early New Equipment Management

The objective of this pillar is to establish systems to reduce new product or equipment development and decrease start- up, commissioning, and stabilization time for quality and efficiency. To achieve this objective, new equipment needs to:

- Be easy to operate
- Be easy to clean
- Be easy to maintain and reliable
- Have quick set-up times
- Operate at the lowest life cycle cost

4.5. Pillar 5: Process Quality Maintenance

This pillar is focused on creating a process for controlling the condition of those equipment components that affect variability in product quality. The objective of the pillar is to set and maintain conditions to accomplish zero defects. It is based on the idea that the quality rate of any product is directly co-related with the following:

- Material conditions
- Equipment precision
- Production methods
- Process parameters

4.6. Pillar 6: TPM in Support Departments

This pillar is focused on the idea that administrative and support departments can be seen as process plants whose principal tasks are to collect, process, and distribute information. In order to optimize the performance of these areas, effective process analysis should be applied to help streamline information flow.

4.7. Pillar 7: Education and Training

TPM should be viewed as a continuous learning process. In order to embed TPM fully and effectively into the organization, two major training components need to be considered:

- **Soft skills training:** How to work as teams, diversity training, and communication skills
- **Technical training:** Upgrading problem solving and equipment-related skills

4.8. Pillar 8: Safety and Environmental Management

Ensuring safety and preventing adverse environmental impacts should be important priorities in any TPM effort. The other pillars of TPM work to strengthen this pillar:

- Faulty or unreliable equipment is a source of danger to the operator and the environment
- Autonomous maintenance teaches equipment operators how to properly operate equipment and maintain a clean, safe, and organized workstation
- TPM-trained operators have a better understanding of their equipment and processes and are able to quickly detect and resolve abnormalities that might result in unsafe conditions

The operation of equipment by unqualified operators is eliminated through effective deployment of TPM. Operators accept responsibility for safety and environmental protection at their workstations.

Properly maintaining equipment and systems helps reduce the defects that result from a process. Reducing defects helps decrease waste and negative environmental impacts in 3 key ways:

1. A decrease in the number of products that need to be scrapped
2. Elimination of the raw materials, energy, and resulting waste associated with scrap
3. A decrease in the amount of energy, raw material, and wastes that are used or generated to fix defective products that can be re-worked

TPM can increase the longevity of equipment, thereby decreasing the need to purchase and/or make replacement equipment. This, in turn, reduces the environmental impacts associated with raw materials and the manufacturing processes needed to produce new equipment. TPM

often attempts to decrease the number and severity of equipment spills, leaks, and upset conditions. This typically reduces the solid and hazardous wastes – for example, contaminated rags and adsorbent pads - that may emerge as the result of spillages, leaks, and their associated clean-up.

4.9 TPM Roadmap

The following diagram outlines a road map for implementing TPM in the organization.

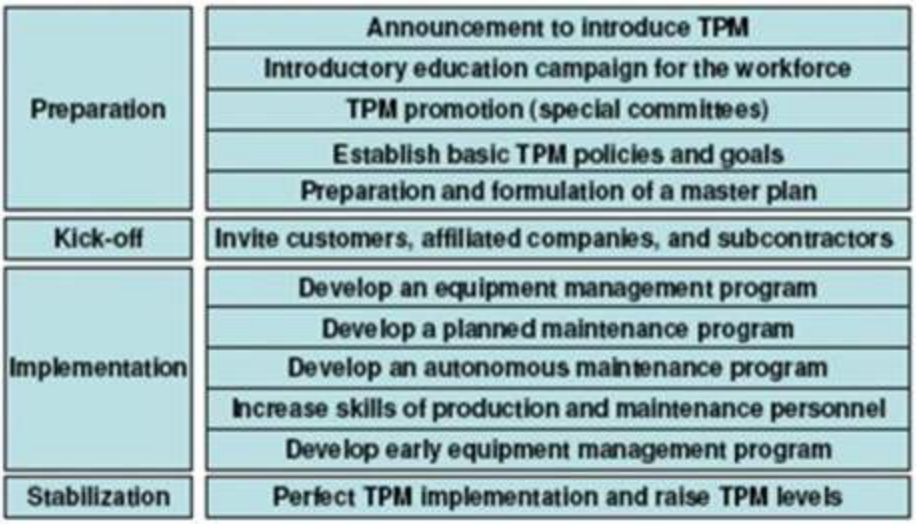
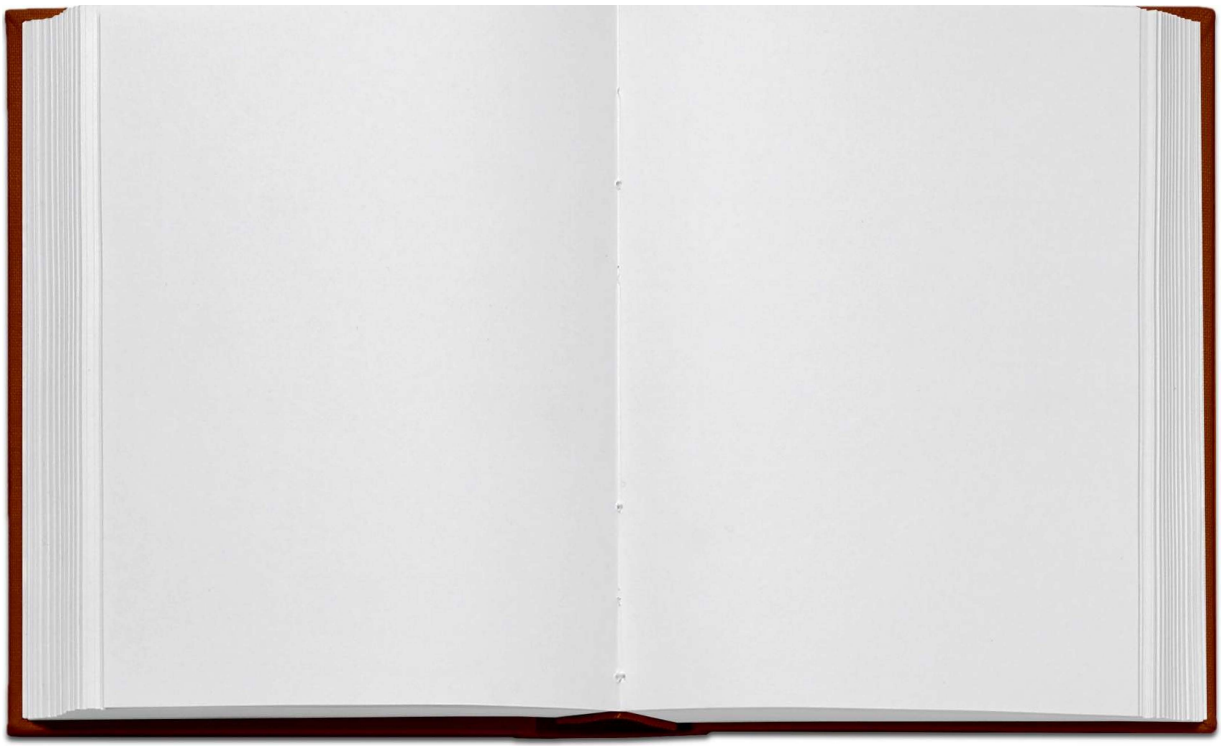


Figure 6. TPM Roadmap

Video Tutorial: Total Productive Maintenance (TPM)

This tutorial describes ways that TPM is beneficial to organizations and shows how to calculate overall equipment effectiveness (OEE).

Video Notes:



Required Reading

- **John Bicheno and Matthias Holweg,** *The Lean Toolbox: The Essential Guide to Lean Transformation*, **pp.129-134**

5

5. Single Minute Exchange of Dies (SMED)

Single Minute Exchange of Dies (SMED) is focused on reducing the time taken up through changeovers or set-ups. Set- up or changeover time can be defined as the amount of time taken to change over a piece of equipment from the end of the last piece of production to the completion of the next production lot.

Changeover time can be reduced through:

- Increasing machine capacity
- Reducing optimal batch size
- Reducing production
- Increasing flexibility

A reduction of a changeover is achieved through the following steps:

1. Recording and timing the current changeover process
2. Differentiating between ‘internal’ and ‘external’ activities
3. Transforming ‘internal’ activities to ‘external’ where possible
4. Reducing and eliminating remaining ‘internal’ and ‘external’ activities

5. Standardizing the new changeover procedure

5.1. Internal vs. External Activities

Before progressing any further, we should define ‘internal’ and ‘external’ activities. Internal activities incorporate elements in the changeover that can only be carried out when the machine is stopped, while external activities incorporate elements that can be performed when the machine is running.

An example of an internal activity would be a tire change where one needs to ensure that the tire has the correct air pressure before installing it on the car. Other examples of internal activities include:

- Coordination of items required for a set-up
- Cleaning and sharpening tools
- Pre-setting gauges
- Transporting and sequencing material
- Re-positioning tools/fixtures

Examples of external activities include:

- Forming dress grinding wheels
- Heating up molds
- Inserting dies/tools
- Making adjustments to machines, tools, and equipment

Reduction of a Changeover Process

1

Recording and timing the current changeover process

This stage incorporates a team comprising of a Recorder, Timer, and Fact Collector. The Recorder takes note of the overall changeover duration from the last product to the first product. They then describe the changeover – what is being changed to what – and they take note of the equipment used. Timers record the time that each step takes, and the Fact Collectors break down each step into as many actions as possible.

Ideally the same changeover should be recorded on video a number of times, with the recording analyzed to note the following details:

- Date and start/finish times of the changeover
- Details of those workers involved in the changeover - number of workers involved, respective roles and responsibilities, etc.
- The machine or item of equipment that is being set up or is the target of the changeover
- Nature of the set-up or changeover
- Steps involved in the changeover - order and duration of each and any relevant comments relating to the work carried out

  The observation teams could also use a spaghetti diagram to provide a top-level view of the target area or process and allow the observation team to plot the movement of the items and workers involved in the changeover activity. The team can use the spaghetti diagram to assess if there is scope to reduce or eliminate any unnecessary motion.

2

Differentiating between ‘internal’ and ‘external’ activities

Each internal step and procedure is analyzed to see if it can be made external so that setups and changeovers can still be carried out when machines are running. This enables production to carry on with minimal disruption.

3

Transforming internal activities to external where possible

Any remaining internal steps are analyzed further to see if they can be made external. In doing this, one needs to focus on the actual function of each step.

4

Reducing and eliminating remaining internal and external activities

Each step or activity is analyzed further, with a view to improving it further. For example, with regard to adjustments, the following could be considered:

- Standardizing spacer and fixture heights
- Pre-setting stops, gauges, limit switches, and tools
- Adding center lines and reference planes
- Pre-setting locations to eliminate measurement
- Using gauges so that adjustment can be pre-set without producing any defective parts
- Color-coding set-up locations per part numbers
- Using V-notch and pin locators for dies
- Using quick release clamps (one-turn/one-motion)

In relation to bolts used on machines and equipment, the following should be considered:

- Using hinged bolts with wing nuts
- Using U-shaped washers
- Use pear shaped holes
- Cutting down screw threads to 3 turns
- Finding alternatives to bolts whenever possible - quick clamps, lever or cam fasteners, auto-clamps, cassette-type replacement jigs, etc.

Workplace order and organization should be introduced to incorporate the following:

- Clearly identified storage locations
- Items arranged according to frequency of use
- Use of color coding

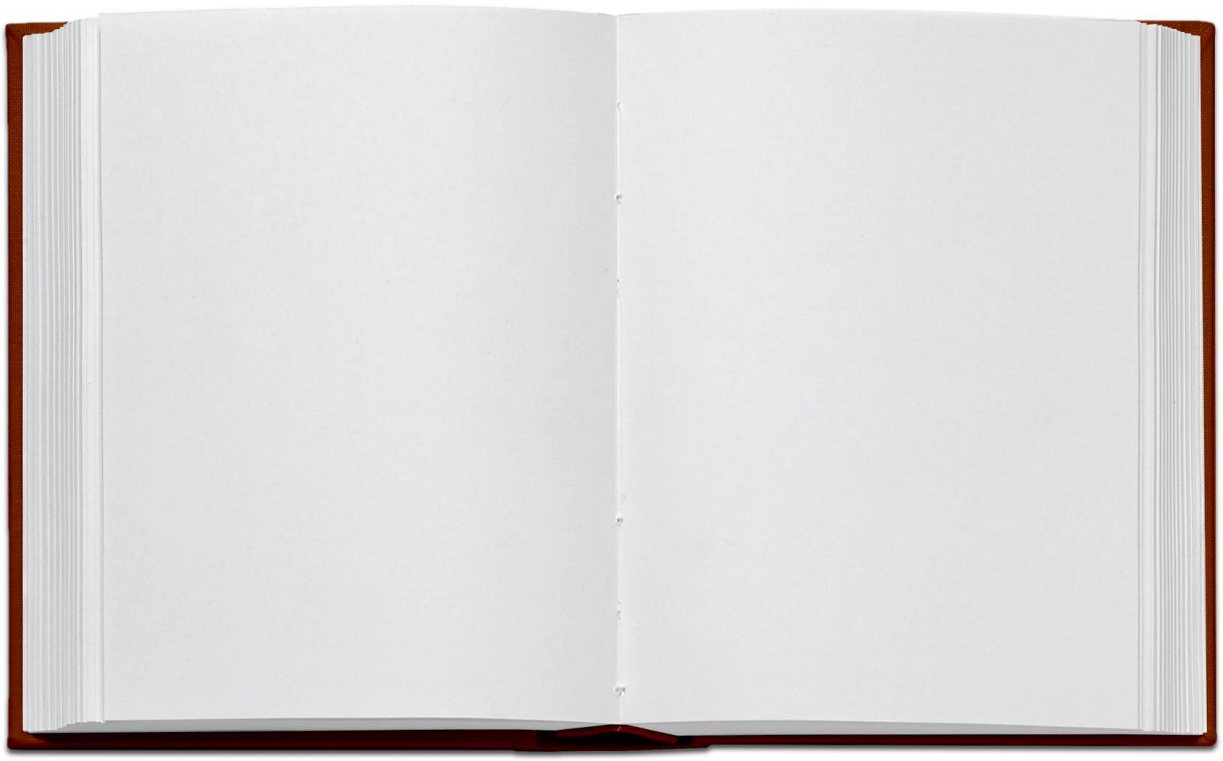
5

Standardizing the new changeover procedure

In this stage, the new internal and external procedures are documented, and an action sheet is developed to ensure that the new procedures can be achieved. The following should also be considered:

- Designing and building special changeover carts
- Creating a checklist
- Sequencing changeovers carefully
- Developing a Standardized Work Chart
- Standardizing terminology

Procedures should be detailed and documented in such a way that they are clearly understood by all who read them. Documented procedures should be reviewed on a regular basis and updated where necessary. Training on equipment use and changeover procedures should be well designed and provided for all relevant workers. This training should be part of an overall training plan for employees.



Required Reading

- **John Bicheno and Matthias Holweg,** *The Lean Toolbox: The Essential Guide to Lean Transformation*, **pp.148-151.**

References

1. http://www.strategosinc.com/jidoka.htm2
2. http://lssacademy.com/2007/04/09/jidoka-forgotten-pillar/
3. http://www.bizbodz.com/Business-Improvement/Lean/quality-filter-mapping-how-to-guidepart-2.asp
4. www.superfactory.com

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6. Workplace Organization

Module Overview

This module outlines and explains how to sustain and standardize an organized, clean, high-performance workplace, thereby ensuring that time isn't wasted looking for necessary materials, files, equipment etc. Everything needed at each step of the process is easily available and all areas are tidy, hygienic, and safe. The module explains the 6S methodology and how to sustain and standardize it. The module outlines how to implement a visual control system that eliminates the need to search for items, reduces the risk of errors occurring, increases productivity, improves quality and safety levels and increases staff morale.

Modules Objectives

On successful completion of this module, you will be able to:

- Identify the steps involved in planning a typical 6S implementation
- Identify and distinguish between the stages of the 6S philosophy
- Identify how each of the 6S stages should be implemented
- Suggest a suitable strategy for sustaining and standardizing 6S in a specific target area
- Establish the components of an effective visual management system
- Outline a suitable approach for implementing a visual management system for a specific work area or target process
- Implement a standardized work procedure for a specific process

Required Reading

- **Bichero J and Holweg M 2016,** *The Lean Toolbox: The Essential Guide to Lean Transformation, PICSIE, 5th edition.* **Pages 136-140.**

Module Topics

The topics that will be covered in this module are:

1. 6S
2. Visual Management

Reflection and Self-assessment

At the end of this module you will be asked to answer two self-assessment questions related an initiative in your own organization.

1

1. 6S

6S (originally and in a lot of places “5S”) is a methodology and philosophy developed as a part of the Toyota Production System (TPS) shortly after the end of World War II. It provides a number of techniques and activities aimed at removing waste from the workplace by means of improved workplace organization, visual communication and overall cleanliness. The activities are focused on cleaning and organizing the workplace to enable workers to carry out their daily tasks in as efficient a manner as possible.

6S is aimed at eliminating waste and hazards associated with:

- Waiting for tools
- Looking for tools
- Creating variation
- Defective equipment, tools, and machinery
- Uncontrolled processes

6S eliminates these types of waste by removing any workplace items that are in the way and by identifying an appropriate location to store any items that are deemed necessary. This helps reduce the time that is wasted by workers continually trying to find a document, supply or tool.

By establishing an order in the workplace, 6S helps improve conditions for employees by making things tidier, cleaner, brighter and safer. This, in turn, helps develop a more pleasant work environment for employees, improving morale and, as a consequence, productivity and quality.

The 6S methodology is based on five stages or pillars derived from the Japanese words – Seiri, Seiton, Seiso, Seiketsu and Shitsuke. These stages and the order in which they should be implemented are outlined as follows:

1. **Stage 1: Sort** -This stage is focused on eliminating any unnecessary materials from the workplace.
2. **Stage 2: Set-in-order** - This stage is focused on organizing the workplace to ensure that there is a place for everything.
3. **Stage 3: Shine** - This stage is focused on cleaning and inspecting the workplace to eliminate any harmful substances and to safeguard against any defects or faults in tools, equipment or machinery.
4. **Stage 4: Standardize** - This stage is aimed at making all workplaces consistent with each other.
5. **Stage 5: Sustain** - This is stage is ongoing. It is aimed at maintaining continued compliance of the 6S standards and practices that have been developed.
6. **A Sixth S: Safety** - One of the main benefits associated with the philosophy is the creation of a workplace that is clean, orderly, and safe. A safe workplace is of utmost importance, and for this reason safety itself should be considered as a sixth S in the system, and should be adhered to in particular as part of the Shine, Standardize and Sustain stages

1.1. Implementing and sustaining 6S

6S can be implemented in many ways but, in general, organizations should aim to adhere to the following steps:

1. Identify and select the project team
2. Outline a suitable plan for each of the stages
3. Announce the initiative
4. Develop and provide any necessary training
5. Implement a preliminary program/initiative
6. Implement each stage on an overall basis
7. Analyze and evaluate the results of 5S
8. Carry out any necessary adjustments or improvements and implement more widely

Senior executives and management need to demonstrate their full support and commitment to 6S and allow for the availability of suitable resources to achieve its successful implementation. Once the entire workforce sees that there is a managerial involvement in the 6S initiative, they are more likely to embrace and support the concept. It is vital that everyone in the organization is fully supportive and willing to participate in its implementation.

Management need to be familiar with all aspects of the methodology before committing fully to the concept. All relevant managers should receive appropriate preparation or training on:

- The aims of 6S
- The various stages of 6S
- 6S implementation methods
- The role of the team and management itself in implementing 6S

Once management is sufficiently familiar with 6S, it should outline appropriate dates and time frames for the initiative. It should then select a suitable leader and a cross-functional work group or team with responsibility for its implementation. This group should typically consist of existing supervisors and team leaders such as clinical nursing managers or lead nurses. The team also needs to have representation from departments that will be involved in making changes. This team should then be trained in the same way as upper management. However, this training should also cater for 6S team leadership.

Once training for the implementation team has been completed, the organization should aim to implement a preliminary program as a practice run for the overall implementation itself. The preliminary program should typically be administered and organized by a Lean Black Belt with the support of a Green Belt. This program can then be used as the basis for the overall, organization-wide implementation. Based on the results of the preliminary program, the implementation team can develop and refine a suitable plan for overall implementation. 6S should be implemented over a gradual period of time – on a module, process or departmental basis.

Each stage needs to be completed successfully before the next begins. 6S is not only applicable to the actual hospital, clinic or laboratory floor, it should be implemented across all areas including personal offices. This helps encourage everyone in the organization to implement it and make it an everyday part of the working life.

6S should be administered and managed like any project. It should have clear objectives, targets and milestones. To develop these elements, it is important that the group responsible for 6S carry out a thorough observation of the workplace to:

- Clearly define the target area for 6S
- Identify the purpose and function of that target area
- Develop a map of the area
- Document supply, information, people and equipment flow

- Photograph problem areas
- Clarify ownership and differentiate areas of responsibility
- Define accountability for 6S audits along with clear improvement and recognition plans

By observing the area closely and determining its purpose and function, the team can gain an understanding of the wastes that exist in there. This will help form the basis of what the aims and objectives of the 6S implementation will be. These will be the foundation on which the 6S approach is built.

After the first three stages, work areas should be well-organized and cleaned appropriately, so the aim of the fourth stage is to develop a system or set of procedures to ensure that the changes implemented over the previous stages of 6S remain in place.

Despite the obvious need for 6S to be sustained forever, organizations can lose sight of the need for sustaining 6S. There a number of reasons why this occurs:

- Training has not been properly addressed. New hires can be left out
- Little real empowerment is given to employees
- The organization is too successful and complacent
- The organization fails to address fundamental questions
- Senior management is not visibly committed
- 6S regarded as a “program” – not a way of life

The 6S implementation team should work in conjunction with all staff members from the target area to develop these procedures and standards. Involving those who work in the area will help to develop standards that can be easily and regularly implemented. It also gives the workers a sense of responsibility and ownership for them. These standards should be documented so that each person in the area knows their specific responsibility, what they

need to do and when they need to do it. The standards should be outlined on labels, signs, posters and message boards, and should be posted throughout the work area.

Each employee's particular responsibility in relation to 6S should be added to their job description. Responsibilities should be assigned based on that employee's experience and skill level. For example, employees that are experienced in operating in a particular area should be responsible for the regular cleaning of that area. Tasks and schedules should be posted at relevant locations in each work area. Each area should have daily checklists that outline each employee's task and when it should be completed. For example, each checklist will outline who is responsible for each area. The checklist may include a list of all necessary consumables or medical supplies needed as well as minimum stocking levels. It may also include the tasks for cleaning the area. The checklists should be varied so that each employee gets to carry out as many tasks as are relevant to their role and experience in the work area. It should be the responsibility of each employee in the area to carry out each task and tick it off each day on the checklist. If a task hasn't been completed, all of the other workers can see who has not completed it.

It is important to continually analyze the effectiveness of the standards and procedures that have been developed. The aim should be to make them as easy to implement and maintain as possible. In that way, one can be assured that they will be carried out. The implementation team should always be on the lookout for ways to modify and improve standards and procedures to make them more efficient.

The fifth stage of a 6S implementation is ongoing once the first four have been implemented. It is the most difficult, since it requires ongoing attention within the business. It is a means of ensuring that the standards and procedures developed are maintained to the highest levels and that workers do not revert to the old way of doing things. It is aimed at setting up a support system to ensure that all employees continue to implement such standards and practices. The Sustain stage focuses on developing methods that can be used to ensure that the standards, procedures and best practices are continually adhered to. These methods can include:

- 6S conceptual training and briefing

- 6S system of communication that outlines tasks, schedules, updates and changes
- Before and after photos that emphasize the effect that 6S has had and to remind workers of the original state that an area was in
- Visual standards and procedures
- Daily 10-15-minute 6S activities
- Weekly 6S application
- Monthly and yearly 6S audits

The fifth stage is very much a continuation of the tail end of the Standardize stage, where the implementation team needs to develop a suitable system for continually analyzing, evaluating and updating the system that has been put in place. This is important in that certain standards and procedures may require change in accordance with any modifications that may occur in the work area's process, files, supplies, equipment, tools and worker roles/responsibilities. Cleaning rotas, inspection schedules and daily tasks should be modified based on any of the aforementioned modifications. Any updates to 6S standards and procedures then need to be communicated as early as possible to all employees. All existing signs, labels, posters and banners should be updated accordingly.

Any new employees should be trained in the processes that are in place as well as the 6S principles that underpin them. Refresher training for existing employees should also be organized on a regular basis. This training can be used to outline any updates or to simply re-emphasize the existing standards and procedures and the objectives behind them. 5S has numerous benefits in terms of increased quality, safety and efficiency. It helps decrease costs as well as waiting and queue times. By ensuring that the 6S process is implemented and maintained on a regular basis going forward, the organization, its customers and its staff will reap these benefits for years to come.

The organization should carry out a 6S audit based on pre-defined scoring every few months to ensure that standards are being maintained. The audit should be scored based on aspiring

to and maintaining an agreed future state for the target area. A 6S audit checklist should be used to carry out such an audit. The checklist should be constructed based on what is required to reach the future state through the implementation of each of the stages of 6S. Each stage should incorporate items and required score criteria based on how close the area is to attaining the future state. One checklist should be used for each area that has been audited.

As teams improve their 6S initiatives across various areas and become more 'Lean' through continuous improvement efforts, audit scores can actually decrease. The decrease typically occurs because employees may be scoring themselves too easily at the outset and have to decrease their scores on follow-up audits even through the 6S has improved. This can send the wrong message, so it is important to define scores and requirements as clearly and accurately at the outset when constructing checklists for different areas.

The following graphic illustrates a structured audit to ensure effective and standardized implementation.

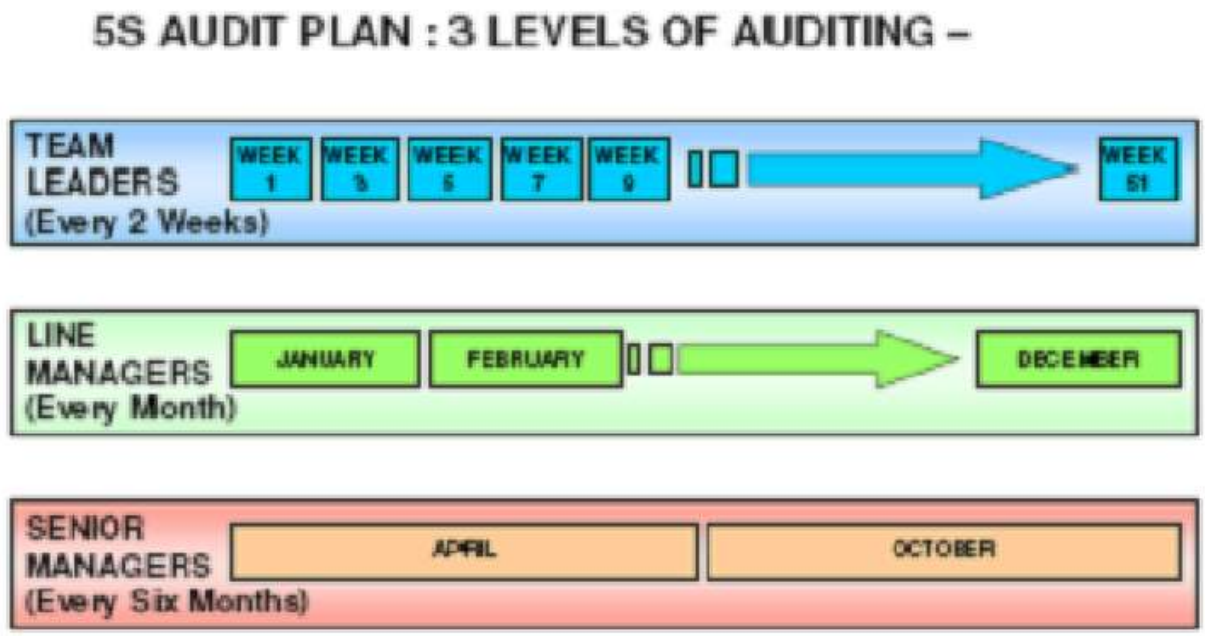

Figure 6.1: 6S structured audit

2. Visual Management

Visual management systems enable anyone to immediately assess the current status of a procedure, activity, or process at a glance, regardless of their knowledge of the process or area.

Visual management and 5S are frequently mentioned together mainly because the need for visual management is so often the result of wanting to effectively implement a sustaining 5S method. The whole point of visual management is that it is used to better implement other procedures that may otherwise be too tedious or complicated to understand.

The main elements of visual management or control systems are:

- Visual controls that are used to control the actions of the group members
- Visual displays that relate safety, business and work-related information and data to employees and customers in the area
- Visual documentation of processes

Visual control methods aim to increase the effectiveness of a process by making the steps involved more visible and obvious. It is based on the idea that is something is clearly visible or in plain sight, it is easier to remember.

There are many different techniques that are used to apply visual control in the workplace. Some organizations use visual control as a method for storing materials and supplies. A clearly labeled storage board lets the employee know exactly where a supply, piece of equipment or document belongs and what is missing from a storage area. Another simple

example of a common visual control is to have reminders posted on corridors, wards, storage areas etc.

Visual signs and signals communicate information that is needed to make effective decisions. These decisions may be safety-oriented or they may give reminders as to what steps should be taken to resolve a problem.

Visual controls are designed to make the control and management of processes as simple as possible. This involves making problems, abnormalities or deviations from standards visible to all. When these deviations are visible and apparent, corrective action can immediately be taken. Visual controls are meant to clearly display the operating or progress status of a given process. A visual control system must have an action component associated with it in the event that the represented procedures are not being followed in the real process. Therefore, visual controls must also have a component where immediate and relevant feedback is provided.

The whole purpose behind implementing visual control techniques is to expose abnormalities in a process that could ultimately end up creating waste or inefficiencies. When visual control is effective at helping employees recognize abnormalities, then corrective action can be taken. An added benefit is that many of the visual controls used can reduce the need to verbally communicate instructions or requirements, thereby reducing or eliminating the waste associated with miscommunication due to different methods of verbal communication.

With visual controls you can create a process that is self-regulating and self-explanatory. Employees are happier because they understand clearly what is expected of them and managers/owners are happy because all employees can perform tasks consistently without variation. Customers are ultimately the beneficiaries of such efficiency when they receive a high quality and consistent service.

Visual displays could consist of charts, metrics, and process/procedure documentation. Process indicators such as painted floor areas and direction of flow could also be used as part of a visual management system. Color coding is a form of visual display often used to prevent errors.

2.1 Implementing a Visual Management System

The following steps should be considered when implementing a "visual management system:

1. Select a target are of focus for the system.
2. Form a cross functional and representative team who will be responsible for developing a system and a budget for that system.
3. Develop a map identifying the "access ways" (aisles, entrances, walkways, etc.) and the "action" areas.
4. Perform any necessary realignment of walkways, aisles, entrances, etc.
5. Assign an address to each of the major action areas.
6. Mark off the walkways, aisles, and entrances from the action areas.
7. Apply flow direction arrows to aisles and walkways.
8. Perform any necessary realignment of action areas.
9. Mark-off inventory locations.
10. Mark-off equipment/machine locations.
11. Mark-off storage locations (cabinets, shelves, tables).
12. Color code floors and respective action areas.
13. Once the system is developed an announcement and introduction as to the start of the program needs to be delivered.
14. Train and support employees until they can be comfortable with the new system.

15 Once everyone feels comfortable with the training that they have received subsequent target areas should be chosen for further roll-out.

16 After closely observing the actual application of the visual control plan, evaluations need to be made regarding its effectiveness and corrective actions need to take place if there are inefficiencies.

Module 6 Self Assessment

1. Analyze a 6S initiative that has already taken place in your organization and assess how sustainable and standardized it as become. Suggest modifications where appropriate.
2. Select a target area and outline an approach for the development of a visual management system. In doing so, outline the components of such a system, the participants required for its implementation and the steps involved in its deployment.