A BRIEF HISTORY OF LEAN MANUFACTURING
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U.S. manufacturers have always searched for efficiency strategies that help reduce costs, improve output, establish competitive position, and increase market share. Early process oriented, mass production manufacturing methods common before World War II shifted afterwards to the results-oriented, output-focused, production systems that control most of today's manufacturing businesses.

Japanese manufacturers re-building after the Second World War were facing declining human, material, and financial resources. The problems they faced in manufacturing were vastly different from their Western counterparts. These circumstances led to the development of new, lower cost, manufacturing practices. Early Japanese leaders such as the Toyota Motor Company's Eiji Toyoda, Taiichi Ohno, and Shingeo Shingo developed a disciplined, process-focused production system now known as the "Toyota Production System", or "lean production." The objective of this system was to minimize the consumption of resources that added no value to a product.

The "lean manufacturing" concept was popularized in American factories in large part by the Massachusetts Institute of Technology study of the movement from mass production toward production as described in The Machine That Changed the World, (Womack, Jones and Roos, 1990), which discussed the significant performance gap between Western and Japanese automotive industries. This book described the important elements accounting for superior performance as lean production. The term "lean" was used because Japanese business methods used less human effort, capital investment, floor space, materials, and time in all aspects of operations. The resulting competition among U.S. and Japanese automakers over the last 25 years has lead to the adoption of these principles within all U.S. manufacturing businesses.

WHAT IS LEAN MANUFACTURING?
Lean Manufacturing can be defined as:
"A systematic approach to identifying and eliminating waste (non-value-added activities) through continuous improvement by flowing the product at the pull of the customer in pursuit of perfection."

VALUE
In lean production, the value of a product is defined solely by the customer. The product must meet the customer's needs at both a specific time and price. The thousands of mundane and sophisticated things that manufacturers do to deliver a product are generally of little interest to customers. To view value from the eyes of the customer requires most companies to undergo comprehensive analysis of all their business processes. Identifying the value in lean production means to understand all the activities required to produce a specific product, and then to optimize the whole process from the view of the customer. This viewpoint is critically important because it helps identify activities that clearly add value, activities that add no value but cannot be avoided, and activities that add no value and can be avoided.

CONTINUOUS IMPROVEMENT
The transition to a lean environment does not occur overnight. A continuous improvement mentality is necessary to reach your company's goals. The term "continuous improvement" means incremental improvement of products, processes, or services over time, with the goal of reducing waste to improve workplace functionality, customer service, or product performance (Suzaki, 1987). Continuous improvement principles, as practiced by the most devoted manufacturers, result in astonishing improvements in performance that competitors find nearly impossible to achieve. Lean production, applied correctly, results in the ability of an organization to learn. As in any organization, mistakes will always be made. However, mistakes are not usually repeated because this is a form of waste that the lean production philosophy and its methods seek to eliminate.

CUSTOMER FOCUS
A lean manufacturing enterprise thinks more about its customers than it does about running machines fast to absorb labor and overhead. Ensuring customer input and feedback assures quality and customer satisfaction, all of which support sales.

PERFECTION
The concept of perfection in lean production means that there are endless opportunities for improving the utilization of all types of assets. The systematic elimination of waste will reduce the costs of operating the extended enterprise and fulfills customer's desire for maximum value at the lowest price. While perfection may never be achieved, its pursuit is a goal worth striving for because it helps maintain constant vigilance against wasteful practices.

FOCUS ON WASTE
The aim of Lean Manufacturing is the elimination of waste in every area of production including customer relations, product design, supplier networks, and factory management. Its goal is to incorporate less human effort, less inventory, less time to develop products, and less space to become highly responsive to customer demand while producing top quality products in the most efficient and economical manner possible.
 Essentially, a "waste" is anything that the customer is not willing to pay for. Typically the types of waste considered in a lean manufacturing system include:

**Overproduction**: to produce more than demanded or produce it before it is needed. It is visible as storage of material. It is the result of producing to speculative demand. Overproduction means making more than is required by the next process, making earlier than is required by the next process, or making faster than is required by the next process. Causes for overproduction waste include:

- Just-in-case logic.
- Misuse of automation.
- Long process setup.
- Unlevel scheduling.
- Unbalanced work load.
- Over engineered.
- Redundant inspections.

**Waiting**: for a machine to process should be eliminated. The principle is to maximize the utilization/efficiency of the worker instead of maximizing the utilization of the machines. Causes of waiting waste include:

- Unbalanced work load
- Unplanned maintenance
- Long process set-up times
- Misuses of automation
- Upstream quality problems
- Unlevel scheduling

**Inventory or Work in Process (WIP)**: is material between operations due to large lot production or processes with long cycle times. Causes of excess inventory include:

- Protecting the company from inefficiencies and unexpected problems
- Product complexity
- Unleveled scheduling
- Poor market forecast
- Unbalanced workload
- Unreliable shipments by suppliers
- Misunderstood communications
- Reward systems

**Processing waste**: should be minimized by asking why a specific processing step is needed and why a specific product is produced. All unnecessary processing steps should be eliminated. Causes for processing waste include:

- Product changes without process changes
- Just-in-case logic
- True customer requirements undefined
- Over processing to accommodate downtime
- Lack of communications
- Redundant approvals
- Extra copies/excessive information

**Transportation**: does not add any value to the product. Instead of improving the transportation, it should be minimized or eliminated (e.g. forming cells). Causes of transportation waste include:

- Poor plant layout
- Poor understanding of the process flow for production
- Large batch sizes, long lead times, and large storage areas

**Motion**: of the workers, machines, and transport (e.g. due to the inappropriate location of tools and parts) is waste. Instead of automating wasted motion, the operation itself should be improved. Causes of motion waste include:

- Poor people/machine effectiveness
- Inconsistent work methods
- Unfavorable facility or cell layout
- Poor workplace organization and housekeeping
- Extra "busy" movements while waiting

**Making defective products**: is pure waste. Prevent the occurrence of defects instead of finding and repairing defects. Causes of processing waste include:

- Weak process control
- Poor quality
- Unbalanced inventory level
- Deficient planned maintenance
- Inadequate education/training/work instructions
- Product design
- Customer needs not understood
Underutilizing people: not taking advantage of people's abilities. Causes of people waste include:

- Old guard thinking, politics, the business culture
- Poor hiring practices
- Low or no investment in training
- Low pay, high turnover strategy

Nearly every waste in the production process can fit into at least one of these categories. Those that understand the concept deeply view waste as the singular enemy that greatly limits business performance and threatens prosperity unless it is relentlessly eliminated over time. Lean manufacturing is an approach that eliminates waste by reducing costs in the overall production process, in operations within that process, and in the utilization of production labor. The focus is on making the entire process flow, not the improvement of one or more individual operations.

SOME BASIC ELEMENTS OF LEAN MANUFACTURING

- Elimination of waste
- Equipment reliability
- Process capability
- Continuous flow
- Material flows one part at a time
- Less inventory required throughout the production process, raw material, WIP, and finished goods
- Defect reduction
- Lead time reduction
- Error proofing
- Stop the Line quality system
- Kanban systems
- Standard work
- Visual management
- In station process control
- Level production
- Takt Time
- Quick Changeover
- Teamwork
- Point of use storage

KEYS TO LEAN SUCCESS

Following are some considerations to successful lean implementation:

Prepare and motivate people

- Widespread orientation to Continuous Improvement, quality, training and recruiting workers with appropriate skills
- Create common understanding of need to change to lean

Employee involvement

- Push decision making and system development down to the "lowest levels"
- Trained and truly empowered people

Share information and manage expectations

Identify and empower champions, particularly operations managers

- Remove roadblocks (i.e. people, layout, systems)
- Make it both directive yet empowering

Atmosphere of experimentation

- Tolerating mistakes, patience, etc.
- Willingness to take risks

Installing "enlightened" and realistic performance measures, evaluation, and reward systems

- Do away with rigid performance goals during implementation
- Measure results and not number activities/events
- Tie improvements, long term, to key macro level performance targets (i.e. inventory turns, quality, delivery, overall cost reductions)

The need to execute pilot projects prior to rolling culture out across the organization

- After early wins in operations, extend across ENTIRE organization
Traditional vs. Lean manufacturing

For years manufacturers have created products in anticipation of having a market for them. Operations have traditionally been driven by sales forecasts and firms tended to stockpile inventories in case they were needed. A key difference in Lean Manufacturing is that it is based on the concept that production can and should be driven by real customer demand. Instead of producing what you hope to sell, Lean Manufacturing can produce what your customer wants...with shorter lead times. Instead of pushing product to market, it's pulled there through a system that's set up to quickly respond to customer demand.

Lean organizations are capable of producing high-quality products economically in lower volumes and bringing them to market faster than mass producers. A lean organization can make twice as much product with twice the quality and half the time and space, at half the cost, with a fraction of the normal work-in-process inventory. Lean management is about operating the most efficient and effective organization possible, with the least cost and zero waste.

OVERALL ORGANIZATIONAL CHARACTERISTICS:

<table>
<thead>
<tr>
<th>TRADITIONAL MASS PRODUCTION</th>
<th>LEAN PRODUCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Business Strategy</strong></td>
<td></td>
</tr>
<tr>
<td>Product-out strategy focused on exploiting economies of scale of stable product designs and non-unique technologies</td>
<td>Customer focused strategy focused on identifying and exploiting shifting competitive advantage.</td>
</tr>
<tr>
<td><strong>Customer Satisfaction</strong></td>
<td></td>
</tr>
<tr>
<td>Makes what engineers want in large quantities at statistically acceptable quality levels; dispose of unused inventory at sale prices</td>
<td>Makes what customers want with zero defect, when they want it, and only in the quantities they order</td>
</tr>
<tr>
<td><strong>Leadership</strong></td>
<td></td>
</tr>
<tr>
<td>Leadership by executive command</td>
<td>Leadership by vision and broad participation</td>
</tr>
<tr>
<td><strong>Organization</strong></td>
<td></td>
</tr>
<tr>
<td>Hierarchical structures that encourage following orders and discourage the flow of vital information that highlights defects, operator errors, equipment abnormalities, and organizational deficiencies.</td>
<td>Flat structures that encourage initiative and encourage the flow of vital information that highlights defects, operator errors, equipment abnormalities, and organizational deficiencies.</td>
</tr>
<tr>
<td><strong>External Relations</strong></td>
<td></td>
</tr>
<tr>
<td>Based on price</td>
<td>Based on long-term relationships</td>
</tr>
<tr>
<td><strong>Information Management</strong></td>
<td></td>
</tr>
<tr>
<td>Information-weak management based on abstract reports</td>
<td>Information-rich management based on visual control systems maintained by all employees</td>
</tr>
<tr>
<td><strong>Cultural</strong></td>
<td></td>
</tr>
<tr>
<td>Culture of loyalty and obedience, subculture of alienation and labor strife</td>
<td>Harmonious culture of involvement based on long-term development of human resources</td>
</tr>
<tr>
<td><strong>Production</strong></td>
<td></td>
</tr>
<tr>
<td>Large-scale machines, functional layout, minimal skills, long production runs, massive inventories</td>
<td>Human-scale machines, cell-type layout, multi-skilling, one-piece flow, zero inventories</td>
</tr>
<tr>
<td><strong>Operational capability</strong></td>
<td></td>
</tr>
<tr>
<td>Dumb tools that assume an extreme division of labor, the following of orders, and no problem solving skills</td>
<td>Smart tools that assume standardized work, strength in problem identification, hypothesis generation, and experimentation</td>
</tr>
<tr>
<td><strong>Maintenance</strong></td>
<td></td>
</tr>
<tr>
<td>Maintenance by maintenance specialists</td>
<td>Equipment management by production, maintenance and engineering</td>
</tr>
<tr>
<td><strong>Engineering</strong></td>
<td></td>
</tr>
<tr>
<td>&quot;Isolated genius&quot; model, with little input from customers and little respect for production realities.</td>
<td>Team-based model, with high input from customers and concurrent development of product and production process design</td>
</tr>
</tbody>
</table>
### MANUFACTURING METHODS:

<table>
<thead>
<tr>
<th></th>
<th>TRADITIONAL MASS PRODUCTION</th>
<th>LEAN PRODUCTON</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production schedules are based on…</td>
<td>Forecast — product is pushed through the facility</td>
<td>Customer Order — product is pulled through the facility</td>
</tr>
<tr>
<td>Products manufactured to…</td>
<td>Replenish finished goods inventory</td>
<td>Fill customer orders (immediate shipments)</td>
</tr>
<tr>
<td>Production cycle times are…</td>
<td>Weeks/months</td>
<td>Hours/days</td>
</tr>
<tr>
<td>Manufacturing lot size quantities are…</td>
<td>Large, with large batches moving between operations; product is sent ahead of each operation</td>
<td>Small, and based on one-piece flow between operations</td>
</tr>
<tr>
<td>Plant and equipment layout is…</td>
<td>By department function</td>
<td>By product flow, using cells or lines for product families</td>
</tr>
<tr>
<td>Quality is assured…</td>
<td>Through lot sampling</td>
<td>100% at the production source</td>
</tr>
<tr>
<td>Workers are typically assigned…</td>
<td>One person per machine</td>
<td>With one person handling several machines</td>
</tr>
<tr>
<td>Worker empowerment is…</td>
<td>Low — little input into how operation is performed</td>
<td>High — has responsibility for identifying and implementing improvements</td>
</tr>
<tr>
<td>Inventory levels are…</td>
<td>High — large warehouse of finished goods, and central storeroom for in-process staging</td>
<td>Low — small amounts between operations, ship often</td>
</tr>
<tr>
<td>Inventory turns are…</td>
<td>Low — 6-9 turns pr year or less</td>
<td>High — 20+ turns per year</td>
</tr>
<tr>
<td>Flexibility in changing manufacturing schedules is…</td>
<td>Low — difficult to handle and adjust to</td>
<td>High — easy to adjust to and implement</td>
</tr>
<tr>
<td>Manufacturing costs are…</td>
<td>Rising and difficult to control</td>
<td>Stable/decreasing and under control</td>
</tr>
</tbody>
</table>

### Benefits of Lean

All types of manufacturers are discovering the advantages of doing a Lean analysis and applying the principles of Lean Manufacturing to their own company. Perhaps you're faced with one, or many, of these challenges:

- Missed order dates
- High product cost relative to the competition
- Declining market share due to delivery time or cost problems
- Limited capacity

If so, Lean Manufacturing can have an immediate, positive impact on your company. Through the process of implementing Lean Manufacturing you will be able to find ways to achieve a number of benefits. Results will vary, but here are some typical savings and improvements:

**Reduce:**
- Manufacturing Lead Time 50 - 90%
- Floor Space Requirements 5 - 30%
- Work-in-Process 60 - 80%
Increase:
First-Pass Yields 50 - 100%
Throughput 40 - 80%
Productivity 75 - 125%

THE RELATIONSHIP OF WASTE TO PROFIT

Customer Focus

Leadership
Waste factor: Zero misalignment/Relationship to Profit: Direction and support for development improves cost, quality, and speed.

Lean Organization
Waste Factor: Zero bureaucracy/Relationship to Profit: Team-based operations reduce overhead by eliminating bureaucracy and ensuring information flow and cooperation.

Partnering
Waste Factor: Zero stakeholder dissatisfaction/Relationship to Profit: Flexible relationships with suppliers, distributors, and society improve quality, cost, and speed.

Information Architecture
Waste Factor: Zero lost information/Relationship to Profit: Knowledge required for operations is accurate and timely, thus improving quality, cost, and speed.

Culture of Improvement
Waste Factor: Zero wasted creativity/Relationship to Profit: Employee participation in eliminating operations waste improves cost, quality, and speed.

Lean Production
Waste Factor: Zero non-value-added work/Relationship to Profit: Total employee involvement and aggressive waste elimination promote speedier operations and eradicate inventories.

Lean Equipment Management
Waste Factor: Zero failures, zero defects/Relationship to Profit: Longer equipment life and design improvements reduce cost. Meticulous maintenance and equipment improvements increase quality. Absolute availability and efficiency increase speed.

Lean Engineering
Waste Factor: Zero lost opportunity/Relationship to Profit: Early resolutions of design problems with customers and suppliers significantly reduces cost, while improving quality and cycle time.

THE TRUE COSTS OF INVENTORY
Reducing inventory is an important goal of the lean organization. Carrying inventory has many costs associated with it. Obvious costs include: capital tied up in inventory and the associated loss of interest on that capital, loss due to material handling damage, increased labor costs for material handling, and increased space and storage requirement. A cost from excess inventory that is not so obvious is quality. In fact, many companies have seen quality improvements resulting from inventory reductions while not focusing on quality.

The reasoning is that if an upstream process is producing parts on a machine and defects occur halfway through the batch, in an organization with low levels of inventory the next downstream process will discover the defects sooner. An organization with low inventory levels can stop the process when the defect is discovered, throw out the defective inventory, and request the previous process to start another batch. The organization with lower inventory levels will also be more effective at determining what caused the defect because the batch that the defect occurred in is fresh in the minds of both production and maintenance.

OTHER BENEFITS
- Reduced scrap and waste
- Reduced inventory costs
- Cross-trained employees
- Reduced cycle time
- Reduced obsolescence
- Lower space/facility requirements
- High quality & reliability
- Lower overall costs
- Self-directed work teams
- Lead time reduction
- Fast market response
- Longer machine life
- Improved customer communication
- Lower inventories
- Improved vendor support and quality
- Higher labor efficiency and quality
- Improved flexibility in reacting to changes
- Allows more strategic management focus
- Increased shipping and billing frequencies

Glossary of Lean terms

A

Andon Board: A visual control device in a production area, typically a lighted overhead display, giving the current status of the production system and alerting team members to emerging problems.

Autonomation: Automation with a human touch. Refers to semi-automatic processes where the operator and machine work together. Autonomation allows man-machine separation. Also referred to Jidoka.

B

Balanced production: All operations or cells produce at the same cycle time. In a balanced system, the cell cycle time is less than takt time.

Batch-and-Queue: Producing more than one piece of an item and then moving those items forward to the next operation before that are all actually needed there. Thus, items need to wait in a queue.

Benchmarking: The process of measuring products, services, and practices against those of leading companies.

Bottleneck: Any resource whose capacity is equal to, or less than the demand placed on it.

Best-in-Class: A best-known example of performance in a particular operation. One needs to define both the class and the operation to avoid using the term loosely.

Blitz: A blitz is a fast and focused process for improving some component of business a product line, a machine, or a process. It utilizes a cross-functional team of employees for a quick problem-solving exercise, where they focus on designing solutions to meet some well-defined goals.

C

Capacity Constraint Resources: Where a series of non-bottlenecks, based on the sequence in which they perform their jobs can act as a constraint.

Catch-Ball: A series of discussion between managers and their employees during which data, ideas, and analysis are thrown like a ball. This opens productive dialogue throughout the entire company.

Cells: The layout of machines of different types performing different operations in a tight sequence, typically in a U-shape, to permit single piece flow and flexible deployment of human effort.

Chaku-Chaku: A method of conducting single-piece flow, where the operator proceeds from machine to machine, taking the part from one machine and loading it into the next.

Change Agent: The catalytic force moving firms and value streams out of the world of inward-looking batch-and-queue.
**Changeover:** The installation of a new type of tool in a metal working machine, a different paint in a painting system, a new plastic resin and new mold in an injection molding machine, new software in a computer, and so on.

**Constraint:** Anything that limits a system from achieving higher performance, or throughput.

**Continuous Flow Production:** Means that items are produced and moved from one processing step to the next one piece at a time. Each process makes only the one piece that the next process needs, and the transfer batch size is one. Also called "single-piece flow" or "one-piece flow."

**Covariance:** The impact of one variable upon others in the same group.

**Current State Map:** Helps visualize the current production process and identify sources of waste.

**Cycle Time:** The time required to complete one cycle of an operation.

**D**

**Dependent Events:** Events that occur only after a previous event.

**Error Proofing:** Designing a potential failure or cause of failure out of a product or process.

**F**

**Five S:** Five terms utilized to create a workplace suited for visual control and lean production. Sort means to separate needed tools, parts, and instruction from unneeded materials and to remove the latter. Simplify means to neatly arrange and identify parts and tools for ease of use. Scrub means to conduct a cleanup campaign. Standardize means to conduct Sort, Simplify, and Scrub at frequent intervals to maintain a workplace in perfect condition. Sustain means to form the habit of always following the first Ss.

**Flow:** A main objective of the lean production effort, and one of the important concepts that passed directly from Henry Ford to Toyota. Ford recognized that, ideally, production should flow continuously all the way from raw material to the customer and envisioned realizing that ideal through a production system that acted as one long conveyor.

**Functional Layout:** The practice of grouping machines or activities by type of operation performed.

**Future State Map:** A blueprint for lean implementation. Your organization’s vision, which forms the basis of your implementation plan by helping to design how the process should operate.

**H**

**Heijunka:** A method of leveling production at the final assembly line that makes just-in-time production possible. This involves averaging both the volume and sequence of different model types on a mixed-model production line.

**Hosin Planning (HP):** Also known as Management by Policy or Strategy Deployment. A means by which goals are established and measures are created to ensure progress toward those goals. HP keeps activities at all levels of the company aligned with its overarching strategic plans. HP typically begins with the "visioning process" which addresses the key questions: Where do you want to be in the future? How do you want to get there? When do you want to achieve your goal? And who will be involved in achieving the goals? HP then systematically explodes the whats, whos and hows throughout the entire organization.

**J**

**Just-in-Time (JIT):** Principles that are fundamental to Time-Based Competition waste elimination, process simplification, set-up and batch-size reduction, parallel processing, and layout redesign are critical skills in every facet of the lean organization. JIT is a system for producing and delivering the right items at the right time, in the right amounts. The key elements of Just-in-Time are Flow, Pull, Standard Work, and Takt Time.

**K**

**Kaizen:** Continuous, incremental improvement of an activity to create more value with less waste. The term Kaizen Blitz refers to a team approach to quickly tear down and rebuild a process layout to function more efficiently.

**Kanban:** A signaling device that gives instruction for production or conveyance of items in a pull system. Can also be used to perform kaizen by reducing the number of Kanban in circulation, which highlights line problems.

**L**

**Lead Time:** The total time a customer must wait to receive a product after placing an order. When a scheduling and production system is running at or below capacity, lead time and throughput time are the same. When demand
exceeds the capacity of a system, there is additional waiting time before the start of scheduling and production, and lead time exceeds throughput time.

**Lean:** Business processes requiring less human effort, capital investment, floor space, materials, and time in all aspects of operation.

**M Mistake Proofing:** Any change to an operation that helps the operator reduce or eliminate mistakes.

**Muda:** Anything that interrupts the flow of products and services through the value stream and out to the customer is designated Muda or waste.

**N Non-Value Added:** Activities or actions taken that add no real value to the product or service making such activities or action a form of waste.

**Operating Expenses:** The money required the system to convert inventory into throughput.

**Overproduction:** Producing more, sooner or faster than is required by the next process.

**PDCA (Plan, Do, Check, Act)**
- **Plan:** Senior management should use the visioning process in the context of it Business Plan. HP translates the Business Plans to action plans, meaningful to all levels of the organization.
- **Do:** Answer the what’s, how’s, and who’s for the total number of tiers for your organization; remember, the fewer the number of tiers, the better. Also, this is the time to bring management together and provide them with a basic understanding of HP mechanics.
- **Check:** On a periodic basis, review the measurements and note what you’ve learned that can help in the future.
- **Act:** Make the necessary adjustments to plans and priorities in order to ensure the success of the strategy breakthroughs.

**Perfection:** Always optimizing value-added activities and eliminating waste.

**Poka-Yoke:** A mistake-proofing device or procedure to prevent a defect during order taking or manufacture. An order-taking example is a screen for order input developed from traditional ordering patterns that question orders falling outside the pattern. The suspect orders are then examined, often leading to the discovery of inputting errors or buying based on misinformation. A manufacturing example is a set of photocells in parts containers along an assembly line to prevent components from progressing to the next stage with missing parts. A poka-yoke is sometimes called a baka-yok.

**Process:** The flow of material in time and space. The accumulation of sub-processes or operations that transform material from raw material to finished product.

**Process Kaizen:** Improvements made at an individual process or in a specific area. Sometimes called "point kaizen".

**Processing Time:** The time a product is actually being worked on in a machine or work area.

**Pull System:** One of the 3 elements of JIT. In the pull systems, the downstream process takes the product they need and pulls it from the producer. This customers pull is a signal to the producer that the product is sold. The pull system links accurate information with the process to minimize waiting and overproduction.

**Push System:** In contrast to the pull system, product is pushed into a process, regardless of whether it is needed. The pushed product goes into inventory, and lacking a pull signal from the customer indicating that it has been bought, more of the same product could be overproduced and put in inventory.
**Quality Function Deployment (QFD):** A visual decision-making procedure for multi-skilled project teams which develops a common understanding of the voice of the customer and a consensus on the final engineering specifications of the product that has the commitment of the entire team. QFD integrates the perspectives of team members from different disciplines, ensures that their efforts are focused on resolving key trade-offs in a consistent manner against measurable performance targets for the product, and deploys these decisions through successive levels of detail. The use of QFD eliminates expensive backflows and rework as projects near launch.

**Quick Changeover:** The ability to change tooling and fixtures rapidly (usually minutes), so multiple products can be run on the same machine.

**Queue Time:** The time a product spends in a line awaiting the next design, order processing, or fabrication step.

**Reengineering:** The engine that drives Time-Based Competition. To gain speed, firms must apply the principles of reengineering to rethink and redesign every process and move it closer to the customer.

**Resource Utilization:** Using a resource in a way that increases throughput.

**Sensei:** An outside master or teacher that assists in implementing lean practices.

**Sequential Changeover:** Also sequential set-up. When changeover times are within Takt time, changeovers can be performed one after another in a flow line. Sequential changeover assures that the lost time for each process in the line is minimized to one Takt beat. A set-up team or expert follows the operator, so that by the time the operator has made one round of the flow line (at Takt time), it has been completely changed over to the next product.

**Seven wastes:** Taiichi Ohno’s original catalog of the wastes commonly found in physical production. These are overproduction ahead of demand, waiting for the next processing stop, unnecessary transport of materials, over processing of parts due to poor tool and product design, inventories more than the absolute minimum, unnecessary movement by employees during the course of their work, and production of defective parts.

**Single Minute Exchange of Dies (SMED):** A series of techniques designed for changeovers of production machinery in less than ten minutes. Obviously, the long-term objective is always Zero Setup, in which changeovers are instantaneous and do not interfere in any way with continuous flow.

**Single-Piece Flow:** A situation in which products proceed, one complete product at a time, through various operations in design, order taking, and production, without interruptions, backflows, or scrap.

**Standards:** These involve comparison with accepted norms, such as are set by regulatory bodies.

**Standard Work:** A precise description of each work activity specifying cycle time, takt time, the work sequence of specific tasks, and the minimum inventory of parts on hand needed to conduct the activity.

**System Kaizen:** Improvement aimed at an entire value stream.

**Sub-Optimization:** A condition where gains made in one activity are offset by losses in another activity or activities, created by the same actions creating gains in the first activity.

**Takt Time:** The available production time divided by the rate of customer demand. For example, if customers demand 240 widgets per day and the factory operates 480 minutes per day, takt time is two minutes; if customers want two new products designed per month, takt time is two weeks. Takt time sets the pace of production to match the rate of customer demand and becomes the heartbeat of any lean system.

**Theory of Constraints:** A lean management philosophy that stresses removal of constraints to increase throughput while decreasing inventory and operating expenses.

**Throughput Time:** The time required for a product to proceed from concept to launch, order to delivery, or raw materials into the hands of the customer. This includes both processing and queue time.

**Total Productive Maintenance (TPM):** A series of methods, originally pioneered to ensure that every machine in a production process is always able to perform its required tasks so that production is never interrupted.
**Value**: A capability provided to a customer at the right time at an appropriate price, as defined in each case by the customer.

**Value-Added Analysis**: With this activity, a process improvement team strips the process down to its essential elements. The team isolates the activities that in the eyes of the customer actually add value to the product or service. The remaining non-value adding activities ("waste") are targeted for extinction.

**Value Chain**: Activities outside of your organization that add value to your final product, such as the value adding activities of your suppliers.

**Value Stream**: The specific activities required to design, order and provide a specific product, from concept to launch, order to delivery, and raw materials into the hands of the customer.

**Value Stream Mapping**: Highlights the sources of waste and eliminates them by implementing a future state value stream that can become reality within a short time.

**Visual Control**: The placement in plain view of all tools, parts, production activities, and indicators of production system performance so everyone involved can understand the status of the system at a glance.

**Waste**: Anything that uses resources, but does not add real value to the product or service.

**Work in Progress (WIP)**: Product or inventory in various stages of completion throughout the plant, from raw material to completed product.

**Yield**: Produced product related to scheduled product.

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**Frequently asked questions**

1. **How do we address the risks associated with changing the way we do business now?**

   **Answer**: Risk reduction is inherent in the process of lean implementation strategies through the following:
   1. Up front analysis for information gathering and the identification of potential savings
   2. Following a "road map" that targets big hits first, narrows the scope, and helps to save time and capital
   3. Accommodating for the training of workforce to help assure results
   4. Use of computer simulations to predict performance before implementation
   5. Phased implementation for control and manageability
   6. Benchmarking against others in industry
   7. Accommodating for milestone reviews
   8. Use of outside resources with flexible contract pricing
   9. Experiencing the start of payback in six months or less

2. **Isn't it true that lean manufacturing techniques only work in large, high-volume, repetitive manufacturing companies?**

   **Answer**: This is a common misconception. The truth is that lean manufacturing can be successful in many industries. The principles apply in both small and large manufacturing companies. This is good news since the large majority of all manufacturing companies have fewer than 500 employees.

3. **Can the workings of a "lean organization" that demands quick, cost-effective adaptability be compatible with the methodical, disciplined processes required by ISO 9001?**

   **Answer**: Forward thinking managers that truly understand the principles behind both concepts recognize that only a structured and disciplined approach, such as that provided by an ISO 9001 management system, will
allow them to successfully create a transformation within an organization. ISO 9001 clearly indicates that a management system is to be designed and implemented in such a manner as to meet the distinctive needs of the organization and its particular objectives, products, services, processes and practices. The decision to implement new techniques into the organization, that may or may not be addressed by ISO 9001, should be considered and incorporated into the formal management system as deemed most appropriate. The incorporation of these techniques into the formal management system ensure their implementation and continuity and provides for periodic monitoring so that management may evaluate ongoing effectiveness. An ISO 9001 management system is ideally suited to effectively implement lean programs. It provides for the success of such programs with provisions for:

- Management vision, direction, authorization and involvement
- Resource evaluation and application, inclusive of personnel qualification and training, processes, etc.
- Planning functions
- Qualification and control of designs, technologies, processes, materials, products and services
- Review and analysis of results, application of decision-making processes and initiation of needed changes

These are the tools provided by ISO 9001 that make it an ideal vehicle for management to achieve the changes needed in developing a "lean" organization.

5. **What is the difference between lean manufacturing and a lean enterprise?**

**Answer:** The first thing you will learn about lean manufacturing is that implementing it is a journey, not a quick fix. Many manufacturers eager for instant results try to steal the "quick fix" parts of lean manufacturing and force them into their existing plans to attack waste. Experts suggest that if you go lean, you have to be completely dedicated to it, adopt it wholeheartedly. Otherwise, you may experience some short-haul benefits, but you will most likely not be prepared for long-term challenges. Individual lean manufacturing practices often do not really make much of an impact. The only way to experience the full benefits of lean is through lean as a system, as a total system. To become a lean enterprise means that change has to occur at all levels from accounting, to upper management, to the shipping docks. Everyone in the organization has to accept lean as a lifestyle and be dedicated to the long term application and continuous improvements associated with it. Added to that you may also have to target suppliers and vendors and convince them to be lean. Everyone in the value chain needs to embrace and support lean principles to make ensure your long-term success as a lean enterprise.

6. **What effect has e-commerce had on companies considering lean improvements?**

**Answer:** More and more manufacturers are turning to lean because of new pressures for quicker response and shorter cycle times that e-commerce and e-manufacturing are imposing. As e-business puts more pressure on the plant, companies that weren't considering lean are now willing to adopt it because they have to. There is probably only one assumption we can guarantee about e-commerce and the Internet. Everything is going to change. Many feel that now is the time to consider implementing lean principles and strategies into their business to position themselves for a future of increasing customer requirements.

7. **Where should we start?**

**Answer:** MAMTC believes that the smartest way to begin your lean journey is through knowledge and education. You should experience and observe, through seminars, events and in-house training on lean manufacturing principles. In most cases, the next approach will be an analysis of your organization to identify wastes, areas of improvement, and to prioritize strategies to implement solutions. We recommend taking advantages of the benefits of a Value Stream mapping analysis to correctly evaluate your current state against your future state to determine how you will attain your goals.

8. **What’s next?**

**Answer:** Common lean "roadmaps" follow a path based on phases to guide you along your long-term improvement strategies. Individual strategies for implementation will vary, however a typical phased approach to implementation could look something like this:

**1. Plan**
Includes: Assessment, diagnosis, decision making, definition of goals, measures and milestones, policy making, determining teams, researching current conditions, conduct production assessments, determining visual management plans, training and education, communicating policy, awareness education, formally launching your initiative.

**2. Apply**
Includes: preparation and focus, scanning the workplace, applying 5S, team preparation, standardizing work, setting up cells, implementing area specific methods, applying quick changeover, applying visual controls, applying mistake proofing, applying maintenance methods, analyzing results, addressing safety issues, etc.
3. Deploy
Includes: improving implementation plan, applying advance one-piece flow, TPM, cycle time management, implementing production smoothing, analyzing results, applying a Kanban system, address system integration issues, schedules, interface with MRP systems, more analysis of results, etc.

4. Integrate
Includes: deploying lean throughout the value chain, continued education and involvement of employees, analyzing results, applying concurrent engineering principles, initiating supplier development programs, link to supply chain, apply QFD, link to customers, continued analysis of results, and strategy revisions, etc.

5. Excel (forever and always)
Includes: determining new ideas for future improvement, investing in R&D of new methods, analyzing and studying results, etc.

9. What is the best approach to making the distinction between "value-added" and "non-value added"?

Answer: When applied to a company or to an aggregate of companies, the concept of value-added is clear and quantitative. It is the difference between the price at which goods are sold and the cost of materials used to make them. In terms of individual manufacturing operations, processes can also be analyzed in terms of "value-added tasks" and "non-value added tasks", however at this level it becomes more challenging to try to quantify the difference. It is here that it becomes a question of not whether a task has a higher value-added than another, but whether it has any or none. Within the context of lean, tasks are usually non-value-added if they do not contribute to what the customer pays for. The concept of waste may be more operational. It is possible to identify what is waste and what isn't, and according to lean philosophies, waste needs to be eliminated.

10. Often times, "becoming lean" is interpreted as terminating employees to reduce costs. Is this true?

Answer: When evaluating "non-value added" activities it can be dangerous to categorize jobs into these categories. The connotation of "non-value" added sometimes is "should be eliminated", and it misleads many managers into concluding just that and acting accordingly. At closer inspection, some of the "non-value" added tasks are necessary and should be performed to make sure they don't slow-down production. They should also be performed efficiently to make sure they don't waste resources. Eliminating jobs is not a major goal of lean improvement strategies. When/if it becomes evident that a job is unnecessary and does contribute significantly to a waste, lean practitioners always suggest empowering individuals in those jobs with skills that will allow them to perform other tasks within the operation.

The Seven Deadly Wastes
(And How to Tame Them)

Waste elimination is one of the most effective ways to increase profitability in manufacturing and distribution businesses. In order to eliminate waste, it is important to understand exactly what waste is and where it exists in the factory or warehouse. While products differ in each factory, the typical wastes found in manufacturing environments are quite similar.

After years of work to eliminate waste, Toyota, the Japanese automobile manufacturer, identified the following seven types of waste as the most prominent ones:

1. Waste from overproduction
2. Waste of waiting time
3. Transportation waste
4. Processing waste
5. Inventory waste
6. Waste of motion
7. Waste from product defect
1. Overproduction

Waste from overproduction is one of the greatest wastes commonly found in manufacturing operations. It is created by producing more products than are required by the market. When the market is strong, this waste may not be very noticeable. However, when demand slackens, the overproduction creates a very serious problem with unsold inventory and all the by-products associated with it:

- Extra inventory
- Extra handling
- Extra space
- Extra interest charges
- Extra machinery and equipment
- Extra defects
- Extra overhead
- Extra people
- Extra paperwork

Overproduction usually begins by getting ahead of the work required. More raw materials are consumed and wages paid than necessary, resulting in extra inventory. This situation requires additional material handling, storage space and interest paid on money used to carry the inventory. Additional staff, computers, and equipment may be needed to monitor the extra goods. But as serious as these problems are, even more critical is the confusion about what the priorities are (or should be). People are distracted and unable to focus on immediate goals, which results in additional production control staff. Since the overproduction causes the machinery and operators to seem busy, additional equipment may be purchased and labor hired, under the assumption that they are necessary.

Since overproduction creates difficulties that often obscure more fundamental problems, it is considered one of the most serious types of waste and should be eliminated as promptly as possible. The elimination lies in the understanding that machines and operators do NOT have to be fully utilized to be cost efficient, as long as market demands are met. Unfortunately this concept is difficult for many people to grasp. It is helpful for the operator at each stage of production to think of the next stage of the process as his or her "customer". Only the amount required by this customer should be produced, meeting the requirements of high quality, lowest cost and correct timing.

2. Waiting

Unlike waste from overproduction, waste from waiting is usually readily identifiable. Idle workers who have completed the required amount of work, or employees who spend much time watching machines but are powerless to prevent problems are two examples of the waste of waiting and are easy to spot. By completing only the amount of work required, the capacity - both speed and volume - of each work station can be monitored. This will result in using only the machinery and personnel required for the minimum amount of time to meet production demands, thereby reducing waiting time.

3. Transportation

The transportation and double or triple handling of raw and finished goods are commonly observed wastes in many factories. Often the culprit of this type of waste is a poorly conceived layout of the factory floor and storage facilities, which can mean long distance transportation and over-handling of materials. This situation is aggravated by such factors as temporary storage, or frequent changes of storage locations. In order to eliminate transportation waste, improvements must be made in the areas of layout, process coordination, methods of transportation, housekeeping and general organization or the operation.

4. Processing
The processing method may be another source of waste. In observing this type of waste, one often finds that maintenance and manufacturability are keys to eliminating it. If fixtures and machinery are well-maintained, they may require less labor on the part of the operator to produce a quality product. Regular preventative maintenance may also reduce defective pieces produced. When the principles of design for manufacture (DFM) are employed and manufacturability is taken into consideration in product design, processing waste can be reduced or eliminated before production even begins.

5. Inventory

Inventory waste is closely connected with waste from overproduction. That is, the overproduction creates excess inventory which requires a list of extras including handling, space, interest charges, people, and paperwork. Because of the often substantial cost associated with extra inventory, rigorous measures should be taken to reduce inventory levels.

☐ Disposal of obsolete materials
☐ Production only of the number of items required by the subsequent process
☐ Purchase of required amounts of materials -- savings achieved through volume discounts must be carefully weighed against inventory and storage costs
☐ Manufacture of products in required size lots -- measure set up and changeover costs against inventory carrying costs to achieve the most appropriate size

It is important to understand that in many operations, inventory covers a myriad of other problems. As levels are reduced, these problems will surface and they must be corrected before inventory levels can be reduced to their optimum levels:

☐ Poor scheduling
☐ Machine breakdown
☐ Quality problems
☐ Long transportation time of raw materials and/or finished goods
☐ Vendor delivery times
☐ Line imbalance
☐ Lengthy set up time
☐ Absenteeism
☐ Lack of housekeeping or factory organization
☐ Communication problems within the organization, with suppliers and with customers

6. Motion

Waste of motion can be defined as whatever time is spent NOT adding value to the product or process:

Movement ≠ Work

This type of waste is most often revealed in the actions of the factory workers. It is clearly evident in searching for tools, pick and place of tools and parts kept out of immediate reach of the work station, and especially by the walking done by one operator responsible for several machines. All of these can be eliminated by carefully planned layout and fixture selection.

7. Product Defects

Waste from product defects is not simply those items rejected by quality control before shipment, but actually causes other types of waste throughout the entire manufacturing process.
· Waiting time is increased in subsequent processes, increasing costs and lead times
· Rework may be required to make the part usable, increasing labor costs
· Additional labor may be required for disassembly and reassembly
· Additional materials may be needed for replacement parts
· Sorting the defective from acceptable parts requires additional labor
· Scrapping the defective pieces wastes both the materials and the work already added

All of the above are serious, but pale in comparison to the results when customers discover defects. Not only are extra warranty and delivery costs incurred, but customer dissatisfaction may result in loss of future business and market share.

To eliminate product defect waste, a system must be developed to identify the defects (or the conditions that cause the defects) so that anyone present may take corrective action. Without this preventive system in place, other time-saving efforts are futile.

**There is no advantage in using a highly automated machine to make defective parts faster.**

The first step to eliminating the seven deadly wastes is to identify each one within the operation. After that, measures can be taken to correct the situation and eliminate the problems. Such action may require simple, inexpensive solutions to a single work station or may involve changes as massive as a new layout of the factory floor with more efficient machinery. The appropriate solutions require careful study of the operation, clearly defined objectives, and thorough investigation of the benefits to be gained by each change.

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**Checklist for Workstation Assessment**

This checklist is intended to provide you with basic information so that you can check the current set up of your furniture and equipment. **It may help to reduce your risk of repetitive strain injury from working at a computer.**

The first column describes the recommended posture, set up, or work practice. Place a check mark in the “yes” column if you have or do what is listed, and in the “no” column if you do not. If you check “no”, take the action listed in the last column.

**It is your responsibility to notify your immediate supervisor if you have any health concerns you may attribute to your computer use. Your supervisor will notify the Occupational Health Nurse and request a workstation assessment.**
<table>
<thead>
<tr>
<th>Preferred Posture/Set Up/Work Practice</th>
<th>Yes</th>
<th>No</th>
<th>If No, Action Required</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. CHAIR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| a. Elbows at 90° and forearms parallel to floor when using keyboard | Yes | No | • Raise or lower chair  
• Raise or lower workstation height  
• Raise or lower keyboard height |
| b. Thighs parallel to floor           |     |    | • Add/subtract footrest |
| c. Feet flat on floor and ankles at 90° |     |    | • Add/subtract footrest  
• Limit shoe heel height |
| d. Adequate back support              |     |    | • Adjust chair back  
• Obtain proper chair  
• Obtain lumbar roll |
| e. Shoulders relaxed and level        |     |    | • Adjust or eliminate armrests |
| f. Two inch space between back of knee and front edge of seat pan | Yes | No | • Use foot rest  
• Obtain chair with shorter or adjustable seat pan |
| **2. DESK**                           |     |    |                        |
| a. Seated elbow height equals desk height | Yes | No | • Raise/lower chair  
• Raise/lower desk height |
| b. Adequate space:                   |     |    | • Organize desk surface  
• Remove clutter on and under desk  
• Arrange other furniture and equipment (e.g., cabinets, printers) to minimize body twisting  
• Arrange or eliminate furniture and equipment to create adequate space |
| - items used most often should be within an arm length or envelope of reach  
- items used less frequently can be placed outside of the envelope of reach |     |    |                        |
| c. Minimal reaching above shoulder    |     |    | • Stand to reach overhead items  
• Place frequently used items on desk within easy reach |
| d. Minimal reaching below shoulder    |     |    | • Raise items  
• Use proper body mechanics |
| **3. KEYBOARD POSTURE**               |     |    |                        |
| a. Relaxed arm position during keyboarding (elbows at 90°; forearms parallel to floor) | Yes | No | • Recheck chair height and raise or lower, as needed |
| b. Wrists not flexed nor extended     |     |    | • Lower or remove keyboard tilt  
• Obtain wrist rest to prevent resting palms or wrists on the edge of desk. |
| c. Wrists not bent to either side (i.e., no side deviation) |     |    | • Review typing skills and habits  
• Adjust keyboard position to minimize deviation  
• Obtain different keyboard (e.g., split) |
| d. Relaxed fingers and hands          |     |    | • Use light touch  
• Perform relaxation exercises |
| f. Eliminate slouching of upper body  |     |    | • Move closer to keyboard  
• Sit up straight  
• Perform different activity (i.e., mini break)  
• Take scheduled breaks |
| **4. MOUSE**                          |     |    |                        |
| a. Position of mouse allows for proper arm posture (i.e., arm not extended) | Yes | No | • Move chair closer to work surface  
• Place mouse close to keyboard and at same level (If necessary, obtain longer keyboard tray) |
| b. Wrists in neutral posture (i.e., no flexion, extension, nor side deviation) | Yes | No | • Recheck mouse placement (i.e., close to keyboard and at same level)  
• Obtain mouse pad with wrist rest |
| c. Full arm motion used when using mouse | Yes | No | • Adjust height of arm rests so that proper arm position and movement are not impeded  
• If unable to adjust, armrests are in the way, and arm support is not needed, remove armrests  
• If added support is needed, obtain armrest(s) |
| **5. MONITOR AND DOCUMENT HOLDER**    |     |    |                        |
| a. Head in neutral position           |     |    | • Raise or lower monitor (Top of viewing area should be at or slightly below eye level unless screen is viewed through lower part of glasses [bifocals] and neck is extended, then monitor should be lower.) |
• Orient monitor directly in front of body
• Use document holder
• Place document holder right beside monitor and at same height as viewing screen

b. Monitor at arm’s length
• Adjust distance of monitor

c. Upper torso relaxed against chair backrest
• Sit back in the chair and adjust posture
• Sit close to the desk and keep your back supported by the backrest at all times
• Raise or lower the chair backrest

d. Document holder and monitor are equal distance from eyes
• Adjust monitor and/or document holder distance

e. Document holder and monitor are at the same height
• Adjust monitor and/or document holder
• Obtain different document holder

f. Glare minimized
• Tilt monitor slightly downward
• Adjust monitor brightness
• Close window coverings
• Obtain anti-glare screen or hood
• Contact Facilities Management for lighting assessment or to decrease overhead lighting
• Ideally, the window should be at the side of the monitor

6. TELEPHONE
a. Neck centered and in neutral position
• Adjust posture
• Hold handset with hand (i.e., no cradling between head and shoulder)
• Obtain headset if required

b. Telephone within easy reach
• Move telephone closer to eliminate reaching

7. WORK AND PERSONAL HABITS
a. Visual rest every 20 minutes
• Perform eye exercises (see provided Eye exercise sheet)

b. Regular stretch break
• Pace work activities
• Take scheduled breaks
• Perform office exercises 4 times per shift (see provided Exercise sheet)

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Sincerely yours-

Engr. Ansari

General Manager; Operations
MK Fashions Ltd.
Lecturer, BUFT
Trainer & Consultant, BDJOBS Training
Trainer and consultant, Prothom-Alo Jobs training
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Right First Time
Respect for peoples

The true sign of intelligence is not knowledge but imagination