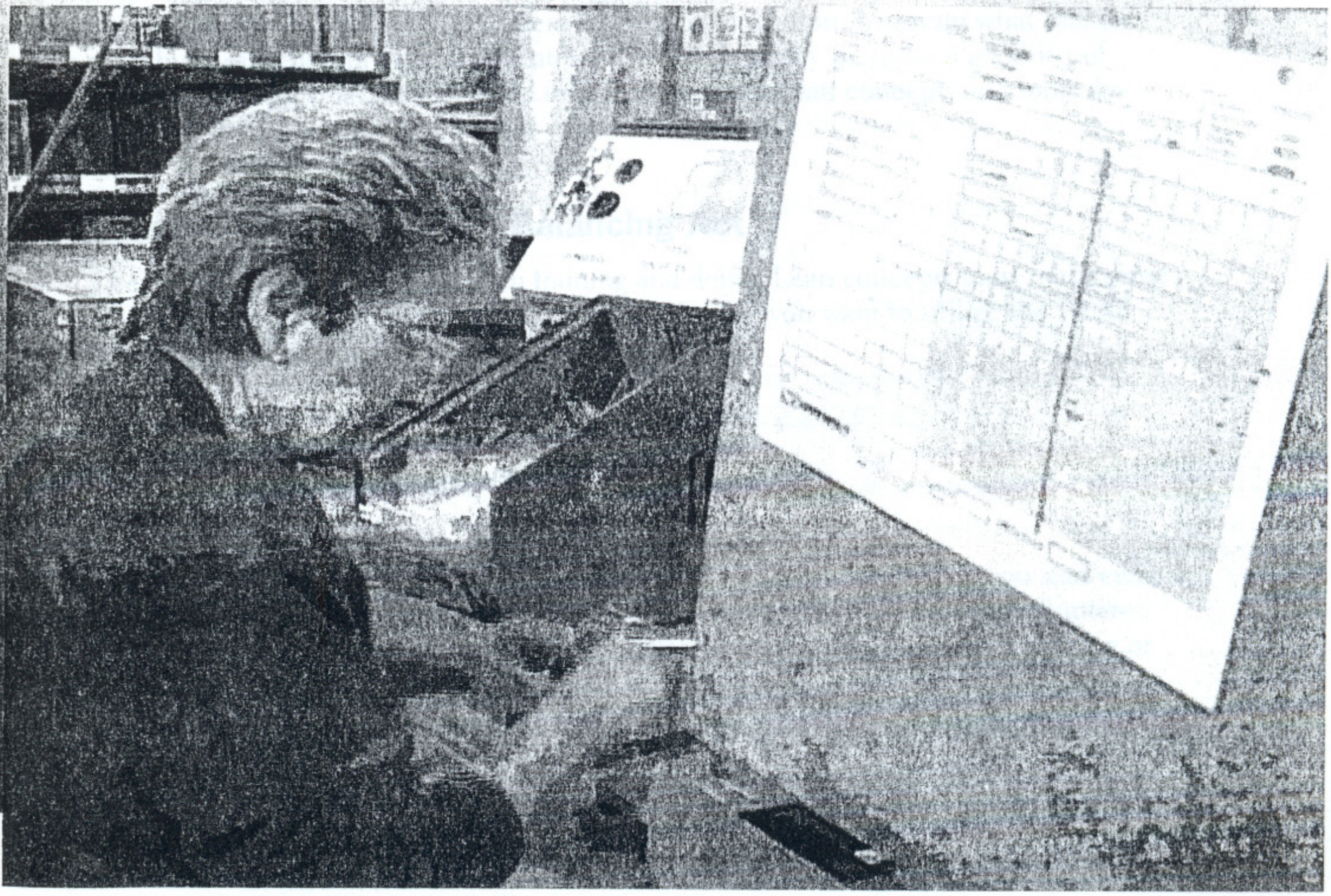
3. Learn about Lean



Step 3. Learn about Lean

In Steps 1 and 2 of Value Stream Management, you gained management commitment, formed a core implementation team, and identified the value stream targeted for lean conversion. However, before you can map the current state (Step 4), determine lean metrics (Step 5), and plan the future state (Step 6), you must gain a firm understanding of lean concepts. The purpose of Step 3 is to ensure that everyone has this understanding. After you learn about lean, you will start applying your knowledge by identifying non-lean conditions in the current state and entering them on the storyboard.

This step covers some key points on how to approach training and reviews the lean concepts that should be conveyed during training. As you read about each concept or tool, keep in mind that this is but one avenue or approach to learning about lean. The learning and implementation process differs for every organization. Integrate what makes good business sense for your organization. The bibliography includes a good list of resources that provide more detailed information on the lean concepts and tools discussed in this chapter.

Training and Doing—The Balancing Act

There is a delicate balance between training and doing. Lean concepts must make sense *now*, before you proceed with the next step. But ideally, you want to utilize the LEAP approach to all training:

LE**arn . . . and then . . . *AP*****ply**

The faster *AP* follows *LE*, the better the results. You will learn much once you start creating and implementing. But if people are not asking questions, or if they seem disinterested, reconsider the approach immediately, before you go any further. More training or explanation on lean concepts and tools may be necessary.

Remember that the goal of learning is to get to the *doing* in Step 8. The point of a lean manufacturing transformation is to drive waste from the value stream. If you put a great deal of effort into planning a transformation that never actually occurs, all the time and effort that went into that process gets wasted.

Learning to Ride

Learning the Toyota Production System is a lot like learning to ride a bicycle. It cannot be done entirely in a classroom or by reading a book. You can draw a bicycle on a white board and tell people where to place their hands, where to sit, and where to put their feet. But this explanation is not enough to teach them how to ride. To become proficient at riding a bike, you must *learn by doing.* You may need some assistance at first, because you haven't yet learned how to balance. After several attempts and falls, however, you start to develop a sense or feel for riding.

Understanding and implementing the Toyota Production System is very similar. You can read material about the system and attend workshops and conferences on the subject. This will help, but like riding a bicycle, you must learn by doing. You will need some assistance in the beginning from people who have implemented lean before. They can help you keep your balance. As you begin to change your workplace with kaizen events, you will make mistakes. Don't give up when that happens. Pick yourself up and try again.

The Training Plan

All companies aspiring to become lean must place a premium on education and training. To get the core implementation team up to speed, develop a training plan based on the following five steps:

1. Determine the required skills and knowledge.
2. Assess current skill and knowledge levels of team members.
3. Determine the gap between present skills and knowledge and required skills and knowledge.
4. Schedule the training.
5. Evaluate the effectiveness of the training.

Be sure to document the plan, making a specific agenda of activities, listing who will participate, and setting target completion dates.

The knowledge for the training should come from a variety of sources. Some good options for training include:

- Conducting a simulation that ties together all the lean concepts. This can be accomplished by attending a public workshop, or by using materials your training department may supply.
- Benchmarking another facility that is using some of the tools (see sidebar).
- Demonstrating a successful in-house project.
- Using internal resources to conduct just-in-time lean training sessions that are quickly followed by actual application of the concepts.
- Using a consultant to facilitate the learning as it relates to the value stream.
- Using books and videos combined with group discussion of the content.

The more you learn and do regarding lean, the more you *will be able to* learn and do. As with everything, true learning is cumulative; the way to gain experience with lean manufacturing is progressively, step by step. Build from what works and move on.

Benchmarking

Benchmarking is a structured approach to identifying a world-class process, then gathering relevant information and applying it within your own organization to improve a similar process.

Benchmarking Guidelines

❑ **Be specific in defining what you want to improve.** You may want to improve your entire manufacturing organization, but you also may want to see specifically how a company uses supermarkets and kanbans.

❑ **Be willing to share.** Identify an area you think may be world class in your organization, if you can, and present that to the potential benchmark site as something you are willing to share with them.

❑ **Attempt to make it a win-win experience.** Identify what's in it for the benchmark company! Offer something. Let them know that you are sincere.

❑ **Know the site.** Ensure that the benchmark team is familiar with some aspects of the company you will benchmark (products, size, whether it's a union shop, etc.).

❑ **Send questions.** Fax or e-mail specific questions in advance to the benchmark company's point person.

❑ **Don't go alone.** Do not benchmark in isolation. It is always better to have a minimum of two members on the benchmarking team.

❑ **Document.** Document and take notes as needed.

❑ **Respect privacy.** If some information is proprietary and cannot be released, respect that and move on.

❑ **Dress appropriately.** Be sure to discuss attire prior to the visit. Most companies have a "business-casual" dress code, but make sure you never underdress.

❑ **You can call.** Consider a conference call if an on-site visit is not practical.

❑ **Say "thanks!"** Show appreciation to the benchmark company. Consider offering appropriate gifts (i.e., t-shirts, hats, golf balls) to the people you will be visiting.

❑ **Follow up.** Follow up with a letter to the host facility detailing what you found helpful. Again, offer to be a benchmark site for them at any time in the future.

Key Concepts of Lean

What should be covered in the training? What are the key concepts people will need to be aware of as they work through the Value Stream Management process? The remainder of this chapter provides a brief overview of the concepts and tools people need in order to assess the current state and plan the future state effectively:

- The cost reduction principle.
- The seven deadly wastes.
- Two pillars of TPS:
  - JIT (just-in-time) production.
  - Jidoka (also known as autonomation).
- The 5S System.
- Visual workplace.
- Three stages of lean application:
  - Demand.
  - Flow.
  - Leveling.

The Cost Reduction Principle

Management is constantly under pressure from customers to reduce costs and lead times and to maintain the highest quality. Traditional thinking dictates that you set your sale price by calculating your cost and adding on a margin of profit. But in today's economic environment this is a problem. The market is so competitive that there is always someone ready to take your place. The customer can often set the price, and you don't have the luxury of adding a margin of profit.

Under these circumstances, the only way to remain profitable is to eliminate waste from your value stream, thereby reducing costs. This is the *cost reduction principle*. Determine the price customers are willing to pay, and subtract your cost to determine what your profit will be (profit = price – cost) (see Figure 3-1). Not only do customers often set the price, but also they often demand price reductions. This is why eliminating waste is so important—it's the primary means of maximizing profits.

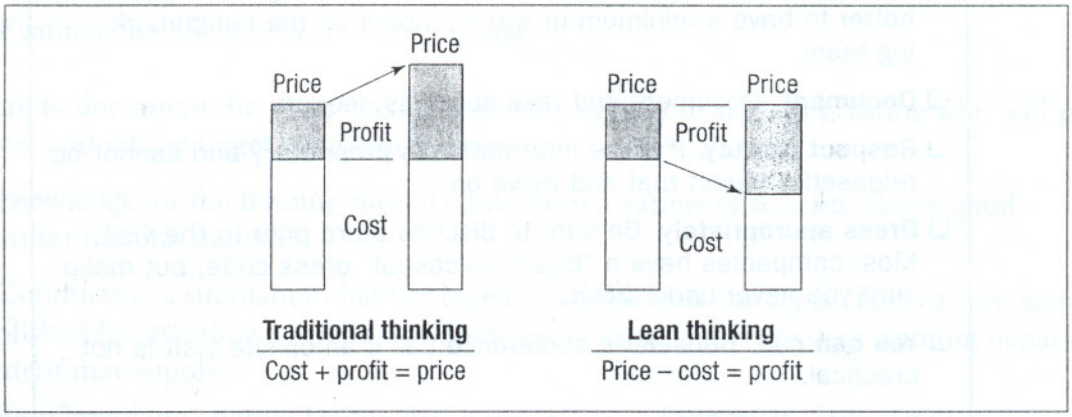


Figure 3-1. Cost plus versus price minus

Implementing lean has become a survival strategy in a manufacturing environment where mandatory cost reductions are a fact of life. An organization's resources should be focused on installing the proper systems to achieve cost reductions and the highest standards for quality and on-time delivery. Value Stream Management will allow you to deliver those results, provided you have a plan to ensure that resources are committed in the right places at the right times.

The Seven Deadly Wastes

The ultimate lean target is the total elimination of waste. Waste, or *muda*, is anything that adds cost or time without adding value. Over the years, seven deadly wastes have been identified (see Figure 3-2):

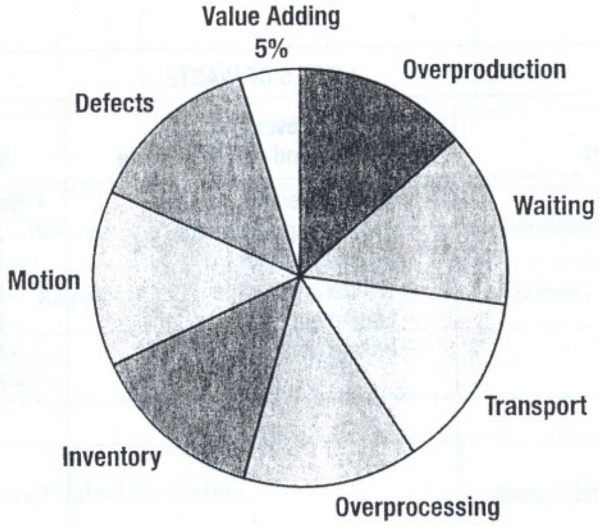


Figure 3-2. The seven deadly wastes

1. Waste of *overproducing*: producing components that are not intended for immediate use or sale.
2. Waste of *waiting*: idle time between operations or during an operation due to missing material, an unbalanced line, scheduling mistakes, etc.
3. Waste of *transport*: moving material more than necessary. This is often caused by poor layout.
4. Waste of *processing*: doing more to the product than necessary. This is the single most difficult type of waste to identify and eliminate. Reducing such waste often involves eliminating unnecessary work elements (including inspection through implementation of jidoka).
5. Waste of *inventory*: excess stock in the form of raw materials, work-in-process, and finished goods.
6. Waste of *motion*: any motion that is not necessary to the successful completion of an operation. Obvious forms of motion waste include back-and-forth movement in a workstation and searching for parts or tools. A more subtle form of motion waste involves any change in a worker's center of gravity. Thus, any time a worker stretches, bends, or twists, it is a waste of motion.

7. Waste of *defects and spoilage*: producing defective goods or mishandling materials. This includes the waste inherent in having to rework parts not made correctly the first time through. It also includes productivity losses associated with disrupting the continuity of a process to deal with defects or rework.

Within these seven categories are many more specific types of waste. To further define waste and understand how to address it, it is helpful to think of three different levels. Level one is gross waste, or low-hanging fruit. Specific wastes at this level are relatively easy to spot, and dealing with them can have a big impact. Level two is process and method waste, and level three is microwaste within processes. Clear away the lower-level wastes first to expose the higher-level wastes.

LEVELS OF WASTE		
Level One **Gross waste**	**Level Two** **Process and method waste**	**Level Three** **Microwaste within process**
• Work-in-progress – Poor plant layout – Rejects – Returns – Rework – Damaged product – Container size – Batch size – Poor lighting – Dirty equipment – Material not delivered to point of use	• Long changeover – Poor workplace design – No maintenance – Temporary storage – Equipment problems – Unsafe method	• Bending and reaching – Double handling – Excess walking – Look for stock – Paperwork – Speed and feed – No SOP

The Two Pillars of the Toyota Production System

The most highly developed lean system in existence is the Toyota Production System. In fact, the terms "lean manufacturing" and "Toyota Production System" are interchangeable; and most if not all of the lean concepts discussed in this book were perfected at Toyota.

Two pillars support the Toyota Production System (see Figure 3-3):

- Just-in-time (JIT) production—the ideal state of continuous flow characterized by the ability to replenish a single part that has been "pulled" by the customer.
- Jidoka (autonomation)—the practical use of automation to mistake-proof the detection of defects and free up workers to perform multiple tasks within work cells.

The foundation on which these pillars rest is *people,* and the critical role they play in eliminating waste from manufacturing and business processes.

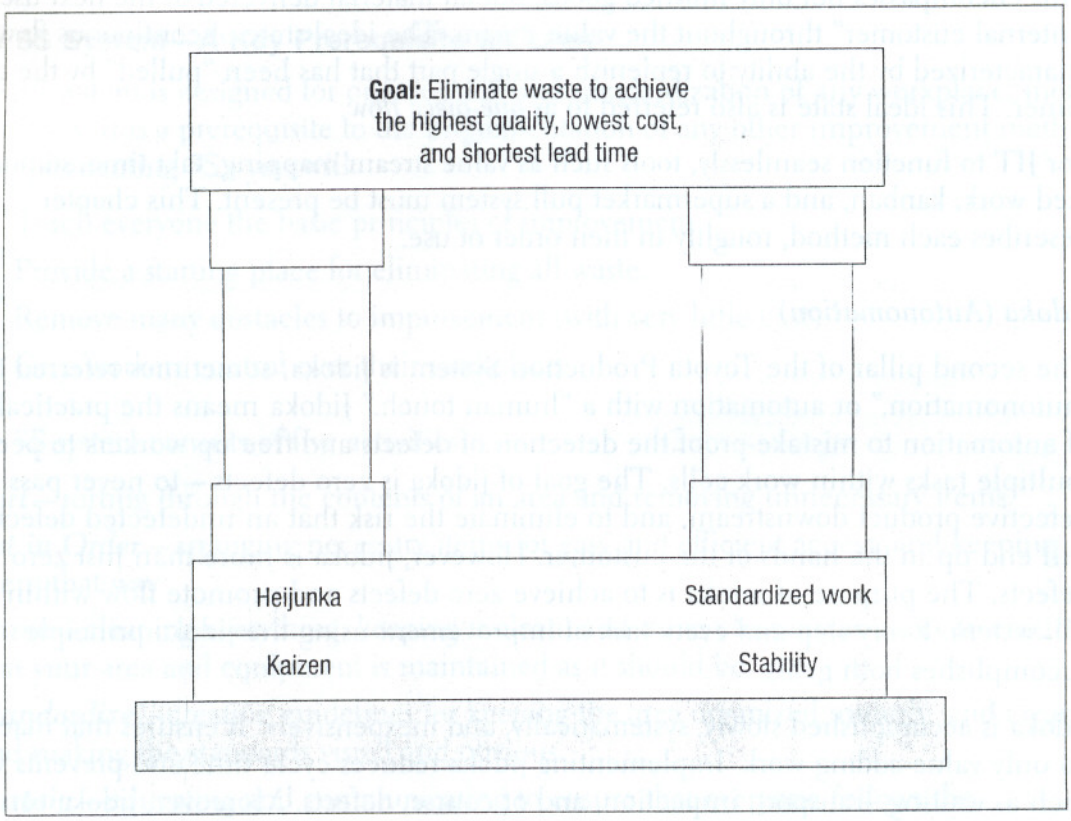


Figure 3-3. The Toyota Production System

> ***People and Kaizen***
>
> At Toyota, employees are encouraged to make positive contributions toward improving their own work areas. Through kaizen events, teams meet for a short period to analyze conditions, recommend improvements, and implement them. The word *kaizen* comes from the Japanese characters "kai," or take apart, and "zen," or make good. Toyota is best known for the many informal kaizen ideas generated each day. As people at your site learn about and apply lean tools and concepts, their increased knowledge and awareness will result in increasing returns in the ongoing effort to eliminate waste from your manufacturing and business processes.

JIT (Continuous Flow Production)

The first Toyota Production System pillar represents just-in-time (JIT) production. JIT is synonymous with continuous flow production, the goal of which is to provide every customer with the highest quality products while meeting highly specific order and delivery requirements:

- *only* those units ordered;
- *just when* they are needed; and
- in the *exact amount* needed.

This encompasses not only finished goods, but all material delivered to the next user or "internal customer" throughout the value stream. The ideal state of continuous flow is characterized by the ability to replenish a single part that has been "pulled" by the customer. This ideal state is also referred to as *one-piece flow*.

For JIT to function seamlessly, tools such as value stream mapping, takt time, standardized work, kanban, and a supermarket pull system must be present. This chapter describes each method, roughly in their order of use.

Jidoka (Autonomation)

The second pillar of the Toyota Production System is jidoka, sometimes referred to as "autonomation," or automation with a "human touch." Jidoka means the practical use of automation to mistake-proof the detection of defects and free up workers to perform multiple tasks within work cells. The goal of jidoka is zero defects—to never pass a defective product downstream, and to eliminate the risk that an undetected defect will end up in the hands of the customer. However, jidoka is more than just zero defects. The purpose of jidoka is to achieve zero defects and promote flow within a JIT system. Every step and every task of improvement using the jidoka principle accomplishes both goals.

Jidoka is accomplished slowly, systematically, and inexpensively. It ensures that machines do only value-adding work. Implementing jidoka reduces cycle time and prevents wastes such as waiting, transport, inspection, and of course, defects. Moreover, jidoka can be applied to virtually any production process you have created.

The Three Functions of Jidoka

1. Separate human work from machine work.
2. Develop defect-prevention devices.
3. Apply jidoka to assembly operations.

Jidoka uses automation in such a way as to promote *flow*. By contrast, in traditional manufacturing operations, automated equipment has done little to promote the flow of goods. Instead, manufacturers often get stuck with extremely expensive, sophisticated, and *unreliable* equipment that will not operate continuously and make quality parts consistently. What's worse, such equipment often has been installed to improve a specific operation rather than a process. To improve flow, you must consider how the parts of the process relate to the whole and use automation *judiciously* to achieve your objectives.

Understanding the principles of jidoka will help you understand how to use automation to promote a smooth, defect-free process flow.The concepts and tools behind *poka-yoke* (mistake-proofing) and the statistical methodologies of Six Sigma will assist in this area immensely.

The 5S System—A Key Prerequisite for Lean

The 5S system is designed for organization and standardization of any workplace, including offices. It is a prerequisite to the implementation of any other improvement method. By implementing 5S , you will:

- ✓ Teach everyone the basic principles of improvement.
- ✓ Provide a starting place for eliminating all waste.
- ✓ Remove many obstacles to improvement (with very little cost).
- ✓ Give workers control over their workplace.

The 5S system consists of five activities:

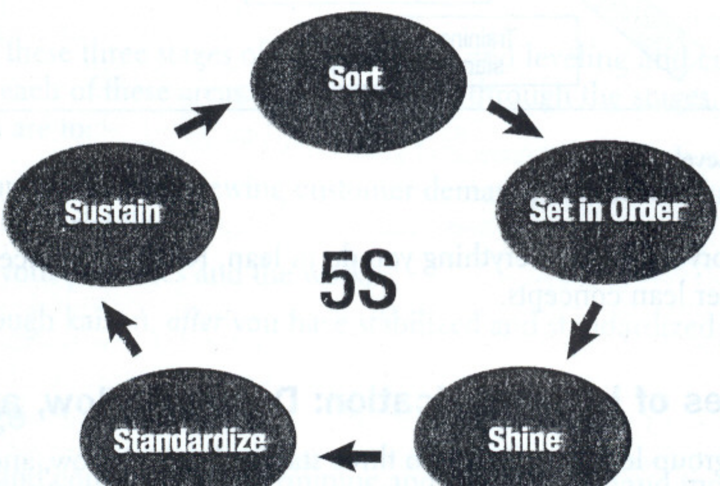
Sort—sorting through the contents of an area and removing unnecessary items.

Set in Order—arranging necessary items for easy and efficient access, and keeping them that way.

Shine—cleaning everything, keeping it clean, and using cleaning as a way to ensure that your area and equipment is maintained as it should be.

Standardize—creating guidelines for keeping the area organized, orderly, and clean, and making the standards visual and obvious.

Sustain—educating and communicating to ensure that everyone follows the 5S standards.



Although 5S activities seem like "good things to do," they aren't carried out for that reason. The 5S system is not merely housekeeping. It will have a positive impact on performance that will be reflected in the following metrics:

- ✓ Reduced total lead time.
- ✓ Elimination of accidents.
- ✓ Shorter changeover times.

✓ Improved worker attendance.

✓ Value-added activities.

✓ More improvement ideas per worker.

Visual Workplace

A visual workplace or visual factory begins with one simple premise: "One picture is worth a thousand words." If that picture is available exactly when you need it, where you need it, with just the right amount of information, then it's worth several thousand words. For that reason, the essence of the visual factory is "just-in-time information."

On the shop floor, the goal of a visual factory is to give people control over the workplace. There are several levels of control that apply (see Figure 3-4).

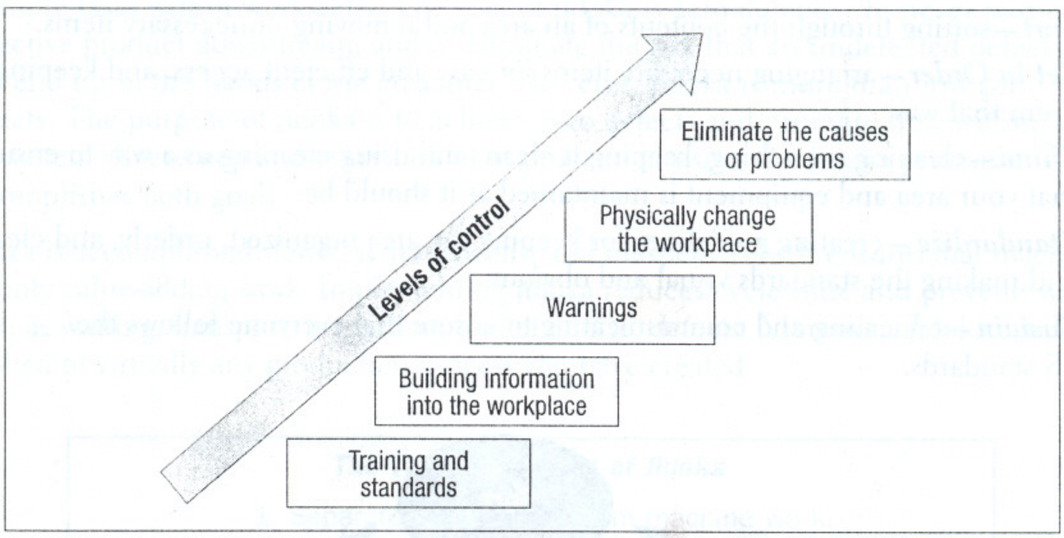


Figure 3-4. Levels of control

The visual factory is part of everything you do in lean. Keep this concept in mind as you learn about other lean concepts.

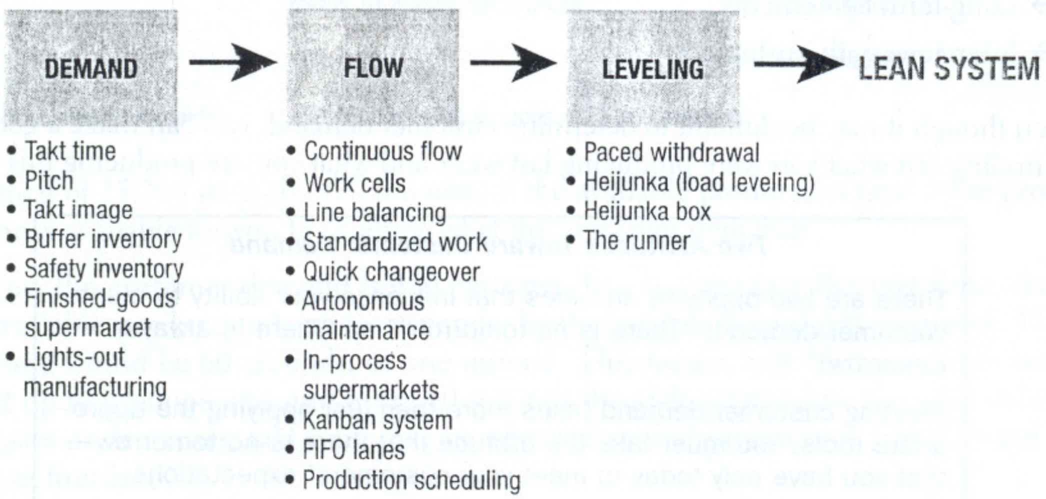
Three Stages of Lean Application: Demand, Flow, and Leveling

It is helpful to group lean concepts into three stages: demand, flow, and leveling. We will clearly define the tools and techniques within each stage, then outline a logical methodology for applying lean to the value stream.

1. Customer demand stage—understanding customer demand for your products, including quality characteristics, lead time, and price.
2. Flow stage—implementing continuous flow manufacturing throughout your plant so that both internal and external customers receive the right product, at the right time, in the right quantity.

3. Leveling stage—distributing work evenly, by volume and variety, to reduce inventory and WIP and to allow smaller orders by the customer.

We recommend that you implement these stages in the same order as we examine them here. One of the main reasons why lean transformations fail to be sustained is that people "cherry pick" their implementation tools-including popular kaizen and value stream mapping workshops. Understanding the demand, flow, and leveling stages of application, along with the guidelines for implementing VSM, will give you the solid approach required not only for implementing, but also for sustaining, lean improvements.



Think in terms of these three stages of demand, flow, and leveling and conduct kaizen events focused in each of these areas. As you proceed through the stages, the common principles or goals are to:

- ❑ **Stabilize** your processes, reviewing customer demand, equipment capabilities, labor balance, and material flow.
- ❑ **Standardize** your processes and the work.
- ❑ **Simplify** through kaizen, *after* you have stabilized and standardized processes.

Demand Stage

The various tools and concepts for determining and meeting demand include

- Takt time.
- Pitch.
- Takt image.
- Buffer and safety inventories.
- Finished-goods supermarket.
- Lights-out manufacturing.

Understand Customer Ordering Patterns

The first and primary concept of lean is to determine what you need to produce specifically in terms of quantity and delivery requirements; in other words, determine the actual number of parts you need to produce each day. This is not just a calculation; it means understanding your customers' ordering patterns. There are many sources for this information, including:

- ➔ Sales forecasts.
- ➔ Previous three months' actual production.
- ➔ Current production forecasts.
- ➔ Long-term agreements.
- ➔ Interviews with customers.

Even though it may be difficult to determine customer demand, you can make a good start by finding out what you were producing last week and what you are producing this week.

> ***Two Attitudes Toward Customer Demand***
>
> There are two opposite attitudes that influence your ability to meet customer demand: "There is no tomorrow!" or "There is always tomorrow!"
>
> Meeting customer demand takes more than just applying the appropriate tools. You must take the attitude that there is no tomorrow—that you have only today to meet your customers' expectations.
>
> The alternative is the attitude that prevails in many organizations today—the attitude that "we can get most of it done today, and finish it tomorrow." Such an attitude results in organizations achieving no better than 90 percent on-time delivery.
>
> Which attitude will prevail at your factory?

Takt Time

From the data you collect on customer demand, you will determine your *takt time*, or the pace of customer demand. "Takt" is a German word for a musical beat or rhythm. Just as a metronome keeps the beat for music, takt time keeps the beat for customer demand. Takt time is the rate at which a company must produce a product to satisfy customer demand. Producing to takt means synchronizing the pace of production with the pace of sales.

To calculate takt time for a particular product family or value stream, divide the available production time by the total daily quantity required.

Takt time formula

$$\text{Takt time} = \frac{\text{Available production time}}{\text{Total daily quantity required}} \text{ or } \frac{\text{Time}}{\text{Volume}}$$

Note: Calculate takt time in seconds for high-volume value streams.

Let's say a manufacturing operation is open eight hours a day. To get the available production time, you must subtract from eight hours (the total available production time) the regularly scheduled planned downtime occurrences (for example, the time for lunch, breaks, or beginning-of-shift meetings).

Available production time calculation:

Available production time:	8 hours x 60 minutes	=	480 minutes
	minus two 10-minute breaks	=	−20 minutes
	minus one 10-minute shift start meeting	=	−10 minutes
	minus 30-minute lunch break	=	−30 minutes
	480 − 60	=	420 minutes
To convert to seconds:	420 minutes X 60 seconds = 25,200 seconds		

The total of 25,200 seconds (420 minutes) is the available production time—the production time available for you to produce what the customer demands.

Let's say the customer demand is 420 parts per day. To calculate the takt time, divide the available production time (in seconds) by the total daily quantity required. The takt time would be 60 seconds, or one minute. This means that your processes must be set up to produce one unit every 60 seconds throughout the day. As order volume increases or decreases, takt time may be adjusted so that production and demand are synchronized.

Takt time calculation:

Takt time = available production time / total daily quantity required

Takt time = 25,200 seconds / 420 parts required = 60 seconds

> ***Operational Takt Time***
>
> Another approach or adaptation of takt is a concept referred to as *operational takt time*. This is a time that is *faster* than takt time; it is used to balance the line to accommodate a chronic system failure such as equipment downtime, absenteeism, or a sudden customer demand change.
>
> For example, if your takt time was 60 seconds but you knew of system problems that could affect production, you might try to work to an operational takt time that was 10 percent faster, or 54 seconds. This would help ensure that you could meet the true customer demand of the 60-second takt time.
>
> Don't be satisfied with continually maintaining operational takt. Focus your kaizen activities to reduce system problems so you can move toward the 60-second takt that represents the true customer demand.

Pitch

The ideal state in any pull system is to eliminate all waste and create one-piece flow through the entire production system, from shipping back through raw material. However, we know that customers will not usually order product one piece at a time, but in a standard pack-out quantity shipped in a container of some sort. When this occurs, we must convert our takt time into a unit called *pitch*.

Pitch is the amount of time—based on takt—required for an upstream operation to release a predetermined pack-out quantity of work in process (WIP) to a downstream operation. Pitch is therefore the product of the takt time and the pack-out quantity.

Pitch formula:

Pitch = takt time × pack-out quantity

Note: Takt time is customer driven. Pack-out quantity may or may not be.

For example, if your takt time is 60 seconds and you want to move 20 pieces at a time, you would set a pitch of 20 minutes:

Pitch calculation:

Pitch = 60 seconds (takt time) × 20 pieces (pack-out quantity) = 1,200 seconds = 20 minutes

For high-volume, low-product-mix lines, pitch will normally be between 12 and 30 minutes, depending on customer requirements and any internal constraints.

Calculating pitch is a compromise between producing in large batches and implementing one-piece flow. For a variety of reasons, it is not always practical to produce to takt one piece at a time, but it is possible to produce a small batch of something in some multiple of the takt time based on the quantity produced. If your takt time is 0.5 seconds per part, for example, you are unlikely to achieve one-piece flow; you will have to settle for producing in small lots.

Advantages of Pitch

There are a number of advantages to producing in small batches based on pitch instead of producing large batches:

- ✓ A forklift is less necessary because you are working with smaller lots.
- ✓ Safety improves because workers are lifting smaller quantities.
- ✓ Inventory control improves.
- ✓ Problems can be identified immediately.
- ✓ You can react to a problem in a much shorter time than with large batches.

An advantage of working in pitch increments is that you can react to a problem in a much shorter time than if you were working in large batches. Pitch allows you to release a predetermined, manageable amount of work to the floor to meet customer demand and ensure that problems are detected quickly. If, for some reason, parts are not available at the specified pitch increment, it's important to notify the supervisor or team leader so that corrective action can be taken.

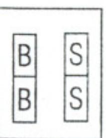
Takt Image: Visualize One-Piece Flow

To maintain the true spirit of lean, you must believe in and strive for the ideal state of one-piece flow, and challenge each compromise you make for practical reasons. You must ensure that you are doing everything possible to continuously improve so that you can meet the expectations of this ideal state. This vision of the ideal state is called *takt image*.

> ***Takt Image***
>
> *Takt image* is the *vision* of an ideal state in which you have eliminated waste and improved the performance of the value stream to the point that you have achieved one-piece flow based on takt time.

Takt image challenges the entire organization to reach a higher level. Let's say that you are trying to improve a five-step process with a 60-second takt time. To achieve continuous flow in such a process with multiple operations—regardless of whether you are producing piece-by-piece or in small batches—each operation must be completed in 60 seconds or less. If the last of five operations in the process is an assembly operation that cannot presently produce one unit in 60 seconds or less, your ability to meet customer demand could be compromised. However, a clear understanding of takt image will motivate everyone to make the improvements necessary to achieve a faster assembly cycle time. Without a clear takt image, you run the risk that people will develop the attitude that "there is always tomorrow."

Buffer and Safety Inventories



As soon as you have determined customer demand, you must make the commitment to meet it—now. You do not want to wait until the future state is completed, as that may take months. However, if you cannot confidently meet demand with current production processes, you can use the tools of *buffer and safety inventory*. These are temporary measures that allow you to meet demand while you are planning and implementing improvements.

Buffer inventory is used when customer demand suddenly increases and your production process is not capable of meeting a lower (faster) takt time. Safety inventory, on the other hand, protects you from internal problems (labor power issues, quality problems, equipment reliability problems, power outages, and the like) that could prevent you from meeting demand.

By establishing buffer and safety inventories, you can meet demand without having to schedule overtime sporadically. But remember that buffer and safety inventories are compromises on the journey to your ideal state. Excess inventories are waste. As customer

Buffer and Safety Inventories

Buffer Inventory Finished goods available to meet customer demand when customer ordering patterns, or takt time, varies.

Safety Inventory Finished goods available to meet customer demand when internal constraints of inefficiencies disrupt process flow.

Note: These inventories should be stored and tracked separately. They exist for two distinct reasons.

demand becomes more stable and you improve the reliability of your operations and processes, you should periodically review these inventories and minimize or eliminate them, if possible (see Figure 3-5).

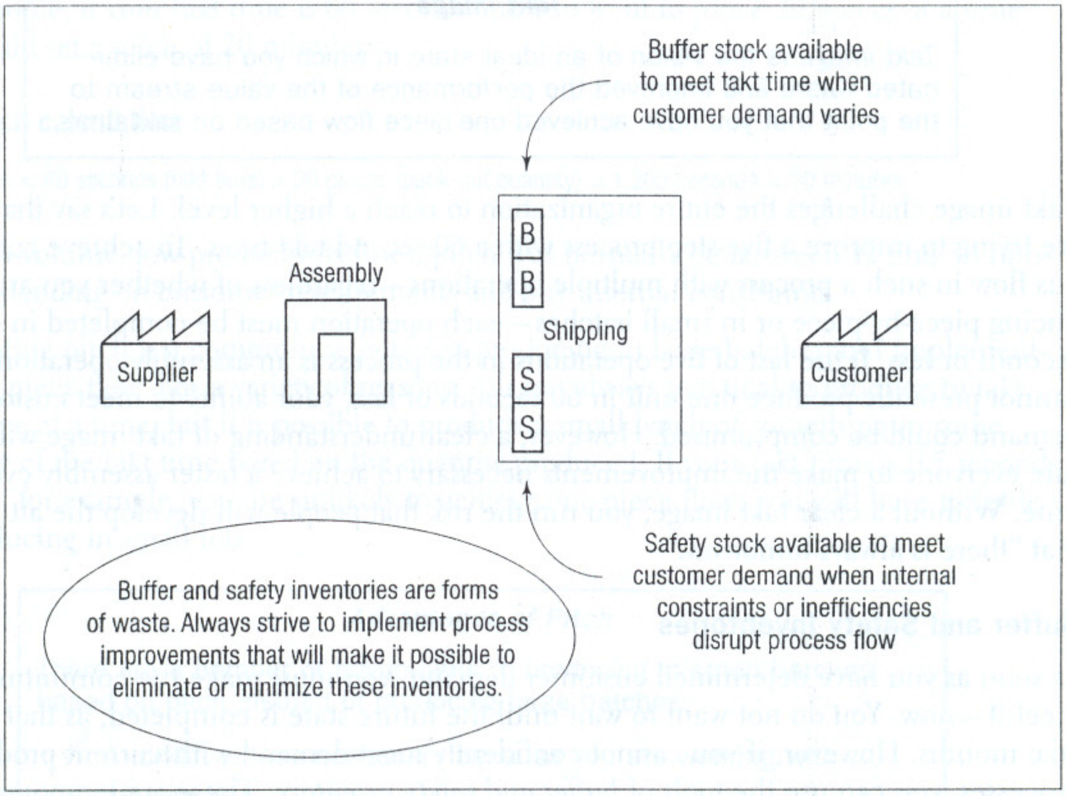


Figure 3-5. Buffer and safety inventories

Finished-Goods Supermarket

Next you must determine *where* customer demand is to be met within your value stream. While shipping personnel are responsible for ensuring that products are shipped, *everyone* throughout the value stream is responsible for meeting customer demand. Shipping must be able to withdraw finished goods for shipment either from the end of the line or from a holding area or finished-goods warehouse.

We refer to such a holding area as a *finished-goods supermarket*—probably because the inspiration for Toyota's just-in-time pull system was the modern supermarket. Taiichi Ohno, who invented JIT, was fascinated by the idea that the physical flow of product culminated with its placement on supermarket shelves. He observed that once customers picked product off the shelves, the grocer replenished inventory by *pulling* from suppliers exactly what was needed to replenish inventory.

Similarly, in a finished-goods supermarket, items are not replaced until they are removed; they are removed when a customer orders them. This is the beginning of a pull system in which items are replenished by upstream operations as they are removed from shipping or the finished-goods supermarket. We will explain this unique withdrawal and replenishment system in more detail later when we discuss continuous flow and kanbans.

> ***Finished-Goods Supermarket***
>
> A system used in the shipping part of the value stream to store a set level of finished goods and replenish them as they are "pulled" to fulfill customer orders. Such a system is used when it is not possible to establish pure, continuous flow.
>
> **Note:** the inventory level in the supermarket does not include buffer and safety inventories.

Supermarkets are not just for finished goods. They can also be used—and in fact may be required to store—work-in-process in other parts of the value stream. We will cover the use of in-process supermarkets in our discussion of the flow stage.

Lights-Out Manufacturing

Lights-out or unattended manufacturing can be considered a means of meeting customer demand. It is allowing an automated machine to run when the operator is not present. This will increase the amount of product that can be manufactured. It is a fairly new concept that can work successfully, but you must consider the following:

- ❑ *Determine process capability*. The process must have a demonstrated C_{pk} (process capability index) of 1.63, or even 2.0.
- ❑ *Review type of material*. Some materials must be monitored closely to ensure product/equipment reliability.
- ❑ *Review part complexity*. Parts that are extremely complex are not good candidates for lights-out machining.
- ❑ *Determine the appropriate lot size*. The lot size should be consistent with one-pitch increments.

You must also consider the potential problems associated with lights-out machining:

- ✗ Operators may be reluctant to let a machine run when they are not there.
- ✗ If a quality problem occurs, it may occur throughout the entire lot.
- ✗ Time may be required to inspect the output.

> ***Lights-Out Manufacturing***
>
> Lights-out manufacturing or "unmanned" machining is a method for meeting customer demand by making it possible for automated machines to run unattended for stretches of time-breaks, lunch, etc. This increases available production time, thus increasing capacity.

Lights-out manufacturing can increase production, but you must weigh the advantages against the concerns and the costs involved in order to decide whether the strategy makes good business sense.

Flow Stage

Once you have stabilized demand and devised a system for ensuring that you can meet it, you will turn your attention toward establishing a *flow* to ensure that customers receive the right parts at the right time in the correct amounts. The tools and concepts necessary to establish flow include

- Continuous flow—one-for-one manufacturing.
- Work cells.
- Line balancing.
- Standardized work.
- Quick changeover.
- Autonomous maintenance.
- In-process supermarkets.
- Kanban system.
- First-in, first-out (FIFO) lanes.
- Production scheduling

Continuous Flow

Continuous flow can be summarized in a simple statement: "move one, make one" (or "move one small lot, make one small lot"). Understanding continuous flow is critical to the just-in-time philosophy of ensuring that an upstream operation never makes more than is required by a downstream operation, so that a value stream never produces more than a customer requires (Figure 3-6).

Continuous flow processing means producing or conveying products according to three key principles:

- Only what is needed,
- Just when it is needed,
- In the exact amount needed.

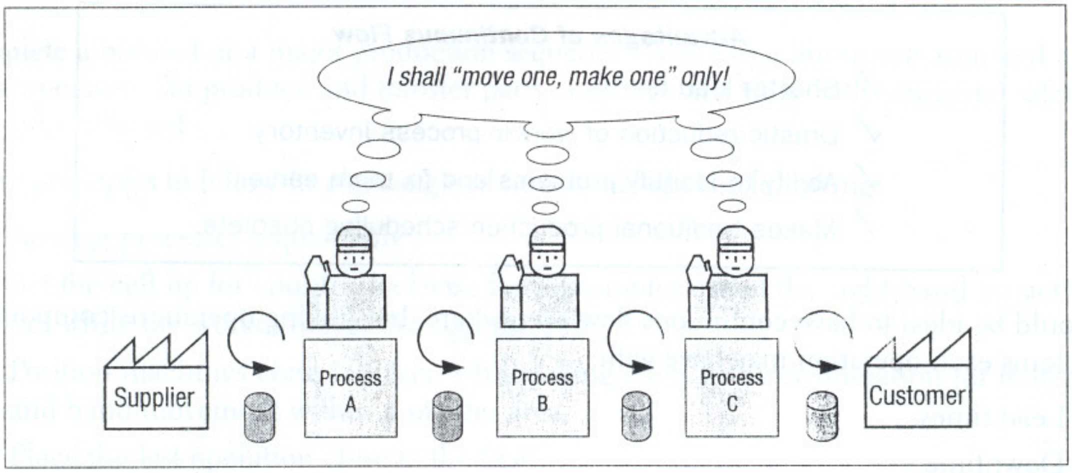


Figure 3-6. Continuous flow—"move one, make one"

One piece or one small batch is produced upstream only *after* a piece or a small batch is moved or "pulled" downstream. This is also called a *pull system* of production. Pull production is faster than batch or "push" production (see Figure 3-7). A pull system controls the flow between operations and eliminates the need for traditional production scheduling.

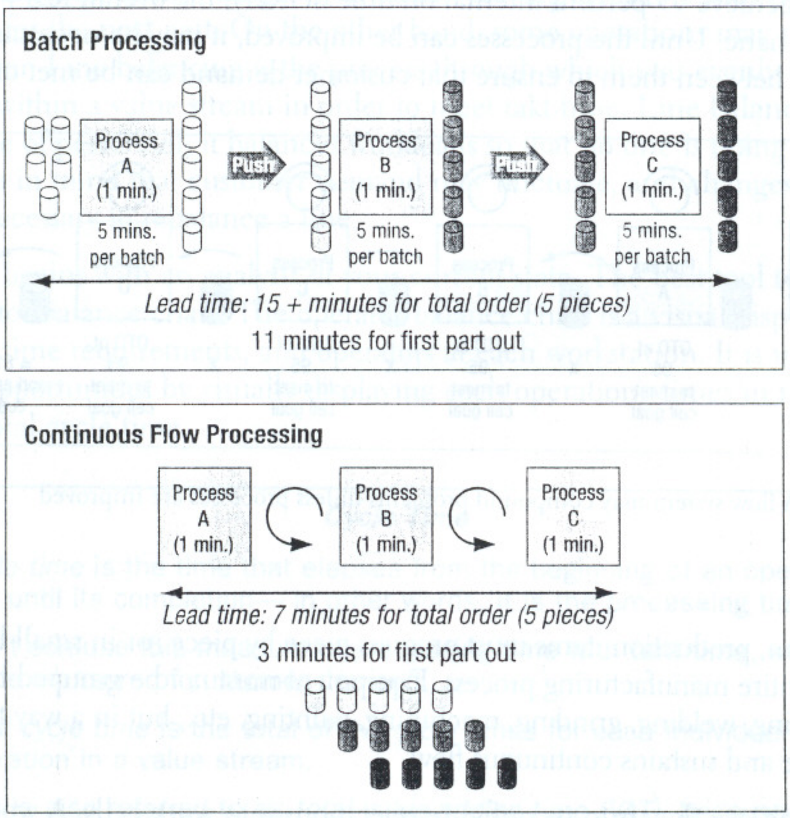


Figure 3-7. Push versus pull production system

Advantages of Continuous Flow

- ✓ Shorter lead times.
- ✓ Drastic reduction of work-in-process inventory.
- ✓ Ability to identify problems and fix them earlier.
- ✓ Makes traditional production scheduling obsolete.

It would be ideal to have continuous flow everywhere, but linking operations compounds problems each operation may have with:

- ✗ Lead times.
- ✗ Downtime.
- ✗ Changeover.

Other obstacles to continuous flow include poor plant layout and varying speed of processes.

➔ For example, consider a value stream consisting of four operations, each with a demonstrated 95 percent on-time delivery rate to its internal customer downstream. The cumulative effect would be an 81.4 percent on-time delivery rate (see Figure 3-8). If any of these operations were to have additional problems that further diminished the ability to achieve 95 percent internal on-time delivery, the overall loss would be even more dramatic. Until the processes can be improved, it may be necessary to use safety inventory between them to ensure that customer demand can be met on time.

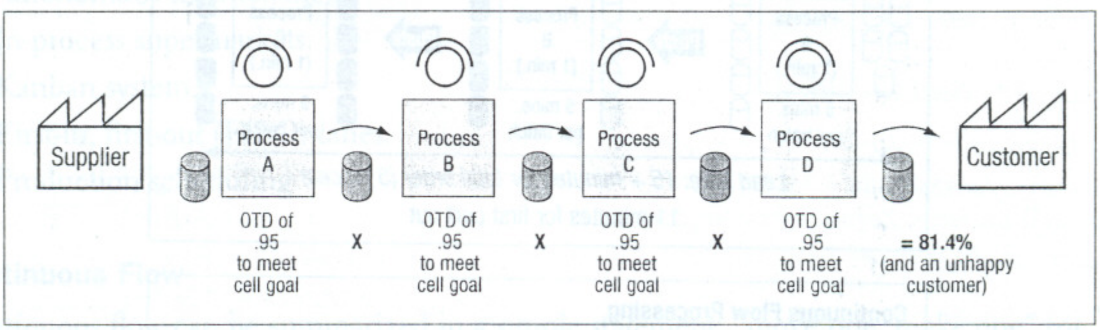
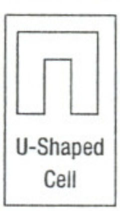


Figure 3-8. A flow system may compound problems unless processes are improved

Work Cells



In a flow system, production items must progress piece by piece (or in small batches) through the entire manufacturing process. Equipment must *not* be grouped by categories such as stamping, welding, grinding, machining, painting, etc., but in a way that minimizes transport waste and sustains continuous flow.

One way to achieve flow is to reconfigure operations into work cells. A work cell is a self-contained unit that includes several value-adding operations. The cell arranges equipment and personnel in process sequence and includes all the operations necessary to complete a product or a major production sequence. When operations are arranged into cells, operators can produce and transfer parts one piece at a time with improved safety and reduced effort.

Some principles to follow in planning cell layout include the following:

- Arrange processes sequentially.
- Set the cell up for counterclockwise flow (promotes use of the right hand for activities while the worker moves through the cell).
- Position machines close together, while taking safety into consideration for material and hand movement within a smaller area.
- Place the last operation close to the first.
- Create U- or C-shaped, or even L-, S-, or V-shaped cells, depending on equipment, constraints, and resource availability.

Keep the product demand and mix in mind when designing the cell layout. The cell must be able to adapt to customers' changing demands (Figure 3-9).

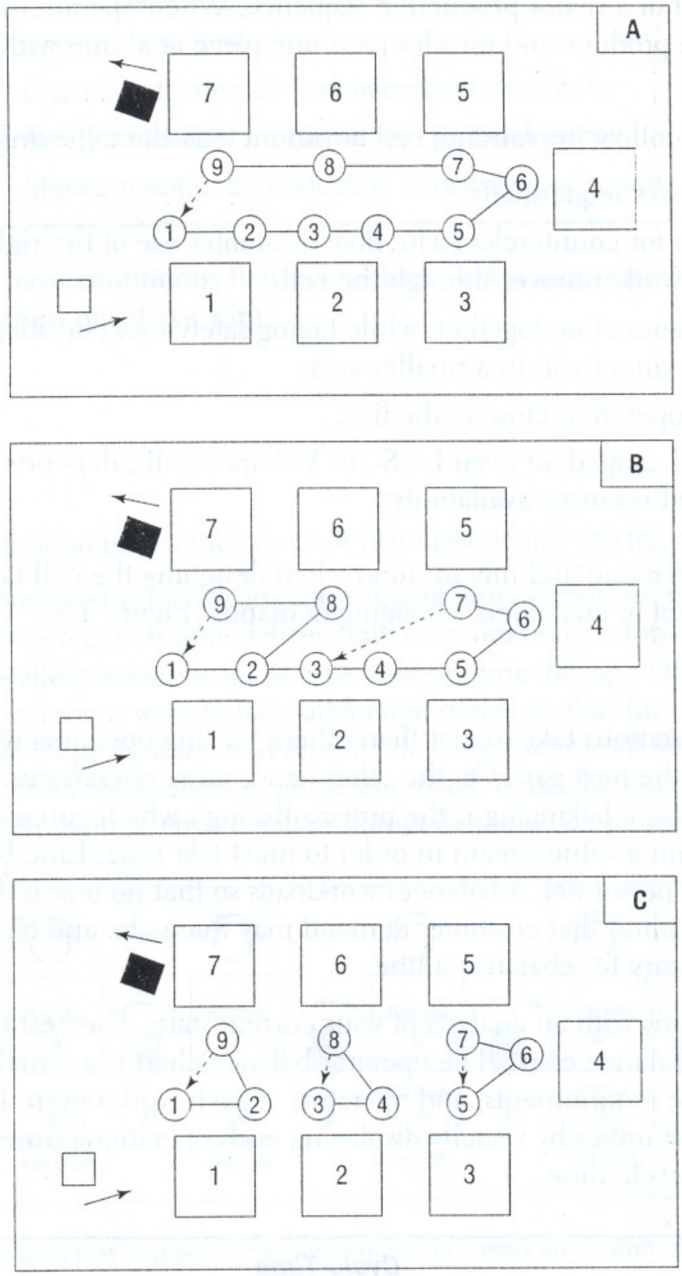
Line Balancing

Operator

Typically, some operations take longer than others, leaving operators with nothing to do while they wait for the next part. On the other hand, some operations may need more than one operator. Line balancing is the process through which you evenly distribute the work elements within a value stream in order to meet takt time. Line balancing helps optimize the use of personnel; it balances workloads so that no one is doing too little or too much. Keep in mind that customer demand may fluctuate, and changes in takt time often make it necessary to rebalance a line.

Line balancing begins with an analysis of your current state. The best tool to perform this task is an operator balance chart. The operator balance chart is a visual display of the work elements, time requirements, and operators at each workstation. It is used to show improvement opportunities by visually displaying each operation's times in relation to takt time and total cycle time.

> ***Cycle Time***
>
> *Cycle time* is the time that elapses from the beginning of an operation until its completion— in other words, it is the processing time.
>
> Don't confuse this measure of processing time with takt time, which is the measure of customer demand.
>
> *Total cycle time* is the total of the cycle times for each individual operation in a value stream.
>
> This is also referred to as *total value-adding time (VAT)*, because this is the time during which value is actually being added to the material as it flows through the process.

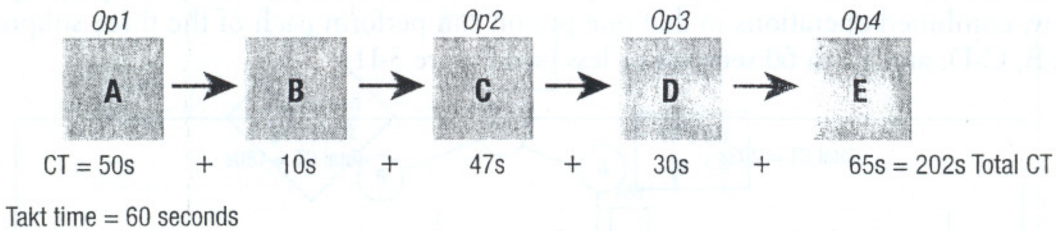


	Customer Demand	Total Product Cycle Time	Daily Available Time	Takt Time	Number of Operators Required
A	500	60S	30,000S	60S	1
B	1,000	60S	30,000S	30S	2
C	1,500	60S	30,000S	20S	3

Figure 3-9. U-shaped cell increases flexibility

The steps for creating an operator balance chart follow:

1. Determine current cycle times and work element assignments. For example consider the following process, which has five operations (A-E), four operators, a takt time of 60 seconds, and a total cycle time of 202 seconds:



2. Create a bar chart that gives a better visual representation of the condition (see Figure 3-10). This current-state bar chart clearly shows a line that is out of balance, and where the imbalance exists.

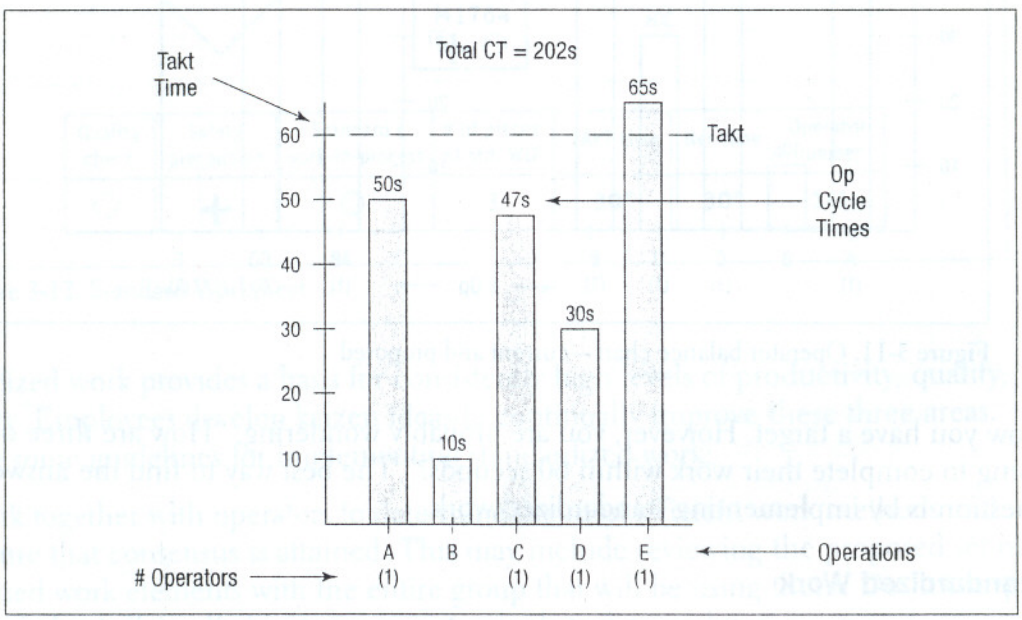


Figure 3-10. Operator balance chart—current state

3. Determine the number of operators needed by dividing total product cycle time by takt time:

$$\text{\# Operators needed} = \frac{202\ (\text{TCT})}{60\ (\text{takt time})} = 3.36$$

A requirement of 3.36 means that you do not really have enough work to keep four workers busy, but there is presently more work than three people can handle. This fact represents a problem, of course. But it also presents an opportunity to design an improved future state.

If you can eliminate enough waste in the process so that only three operators are required, you will reduce your direct labor cost per part and be able to re-deploy the fourth worker elsewhere. The conventions of lean thinking suggest that a decimal less than or equal to 0.5 (in this case, 0.36) is a good indicator that this is a realistic goal. In the improved process, each of the three remaining operators must do their share of what is necessary to make one part within the 60-second takt time (or a small batch within the time calculated for *pitch*). Thus, total cycle time must be less than or equal to 180 seconds.

One solution would be to combine operations A and B, and C and D, simplifying the new, combined operations so that one person can perform each of the three subprocesses (A-B, C-D, and E) in 60 seconds or less (see Figure 3-11).

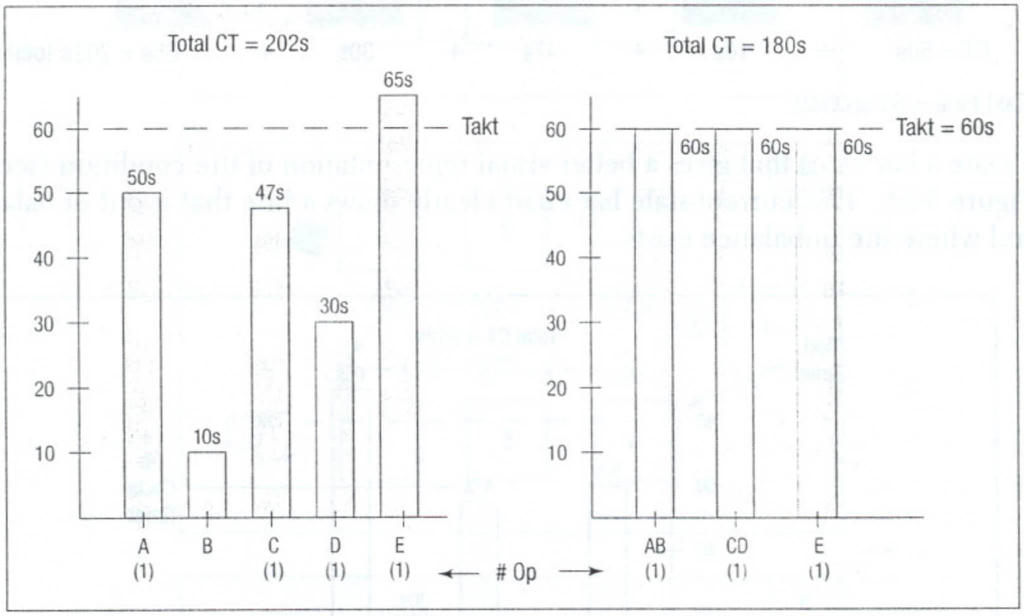


Figure 3-11. Operator balance chart—current and proposed

Now you have a target. However, you are probably wondering, "How are three operators going to complete their work within 60 seconds?" The best way to find the answer to this question is by implementing standardized work.

Standardized Work

For consistent flow to occur within the manufacturing value stream, workers must be able to produce to takt time and achieve consistent cycle times for the work elements assigned. You do not want one individual achieving a 45-second cycle time and a coworker achieving a 60-second cycle time for the same operation. You want to standardize to the 45-second cycle time and see to it that everyone does the same work the same way. This is accomplished by implementing standardized work.

Standardized work is an agreed-upon set of work procedures that establishes the best method and sequence for each manufacturing and assembly process. You can use a Standard Worksheet to illustrate the sequence of operations within a process, including operation cycle times (see Figure 3-12). This worksheet should be posted in the work area.

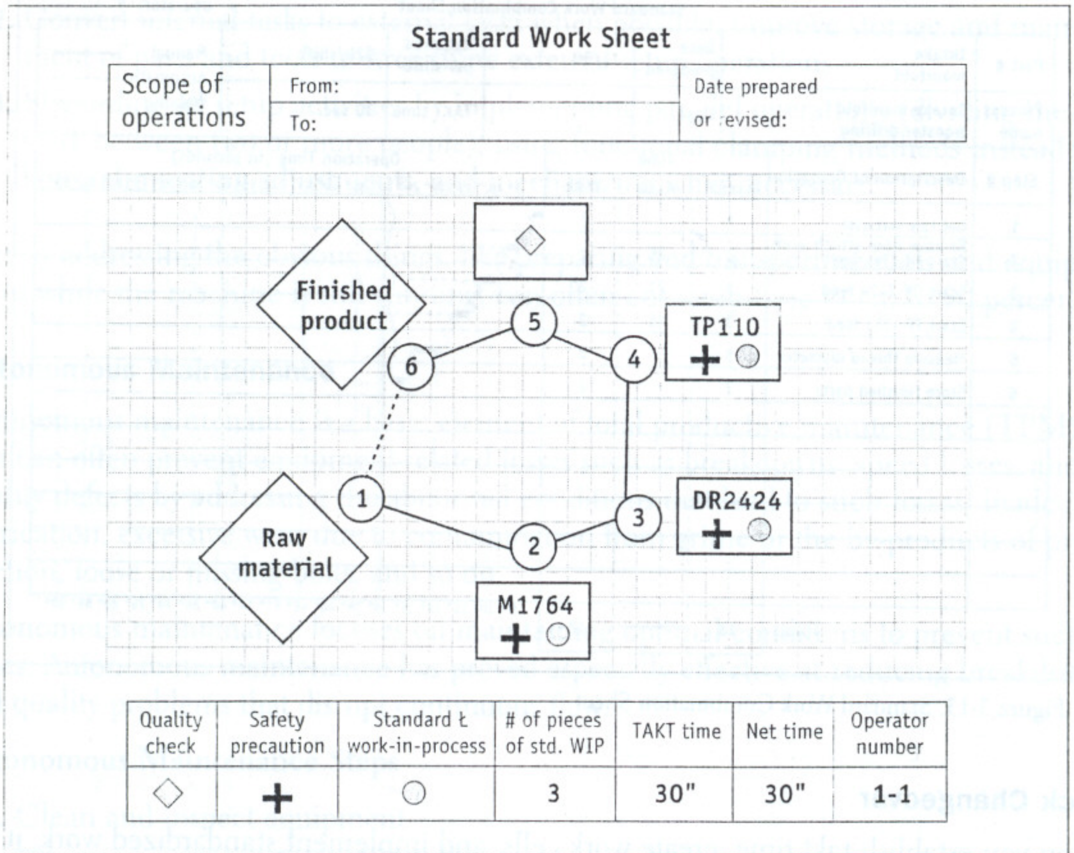


Figure 3-12. Standard Worksheet

Standardized work provides a basis for consistently high levels of productivity, quality, and safety. Employees develop kaizen ideas to continually improve these three areas. Here are some guidelines for implementing standardized work:

- ❑ Work together with operators to determine the most efficient work methods and ensure that consensus is attained. This may include reviewing the proposed set of revised work elements with the entire group that will be using them. Do not surprise people by unilaterally imposing new standards and procedures.
- ❑ Use the Standard Work Combination Sheet (Figure 3-13) to understand how process cycle time compares with takt time. This document displays the material and human workflow for a process. It specifies the exact time for each sequence within an operation, including walk time. If cycle time is longer than takt time, the operation can be "kaizened" (improved) to meet takt. This may include allocating some of the work elements into an operation that cycles faster than takt.
- ❑ Adhere to takt time, a critical unit of measurement for standardized work. Do not attempt to accommodate changes in takt time by making substantial changes in individual workloads. When takt time decreases, streamline the work and add employees as necessary. When takt time increases, assign fewer employees to the process.

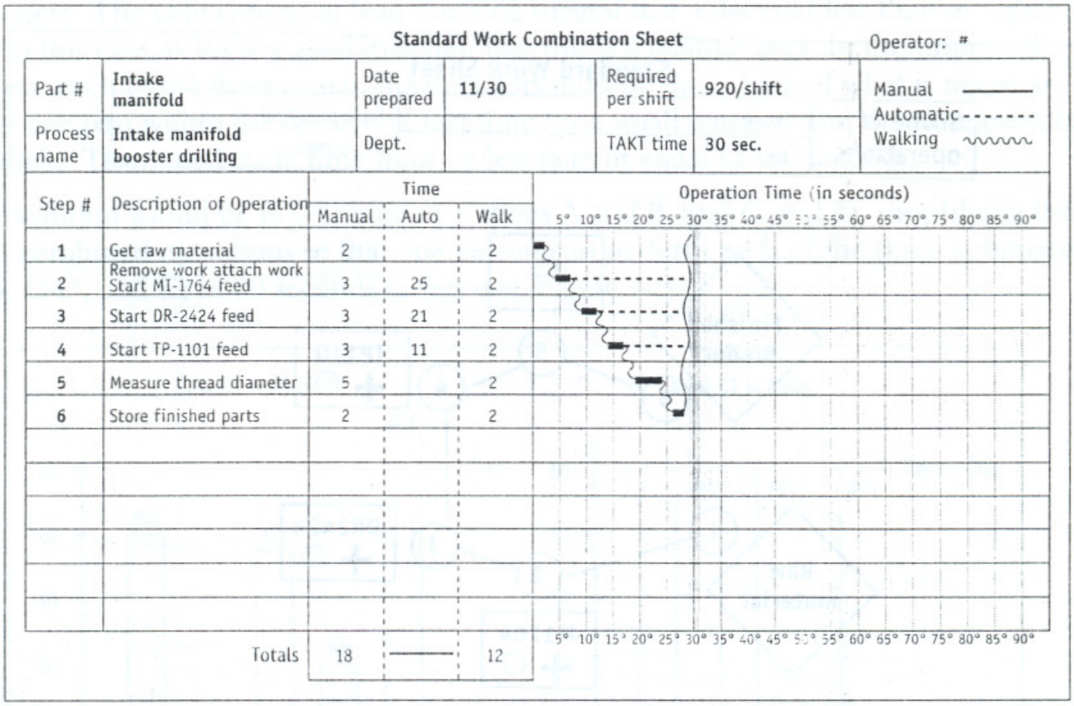


Figure 3-13. Standard Work Combination Sheet

Quick Changeover

When you establish takt time, create work cells, and implement standardized work, it is likely that you will also want to increase the variety of products flowing through the cells. Such flexibility requires tooling changes that do not disrupt continuous flow. The means for achieving this goal is the quick changeover (QCO) method. QCO originates from a methodology called single-minute exchange of die (SMED) that was developed by Shigeo Shingo at Toyota.

> ***When to Implement QCO***
>
> The need for QCO usually becomes obvious at one of two stages—or at both of the following stages:
>
> 1. Demand stage: slow changeover times present a major obstacle to meeting customer demand.
> 2. Continuous flow stage: implementing standardized work underscores the need for faster changeover times to reduce total cycle time and help balance operations.

SMED is a theory and set of techniques that makes it possible to set up or change over equipment in less than 10 minutes. SMED begins with a thorough analysis of current setup procedures. It is applied in three sequential stages:

1. Distinguish between *internal setup* tasks that can be performed only while the machine is shut down and *external* setup tasks that can be performed while the machine is running.

2. Convert internal tasks to external tasks when possible; improve storage and management of parts and tools to streamline external setup operations.
3. Streamline all setup activities by implementing parallel operations (dividing the work between two or more people), using functional clamping methods instead of bolts, eliminating adjustments, and mechanizing when necessary.

Merely addressing the obvious things, like preparing and transporting tools and equipment while the machine is still running, can often cut setup time by up to 50 percent.

Autonomous Maintenance

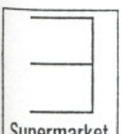
Autonomous maintenance is a basic element of total productive maintenance (TPM). You can often prevent equipment-related losses such as breakdowns, speed losses, and quality defects by addressing the abnormal conditions that lead to such losses: inadequate lubrication, excessive wear due to contamination from grime or the by-products of production, loose or missing bolts, and so on.

Autonomous maintenance focuses on maintaining optimal conditions to prevent such losses. Autonomous maintenance has proved especially effective at reducing breakdowns and quality problems that disrupt continuous flow.

Autonomous Maintenance Steps

1. Clean and inspect equipment.
2. Eliminate sources of contamination.
3. Lubricate components and establish standards for cleaning and lubrication.
4. Train operators in general inspection of subsystems (hydraulics, pneumatics, electrical, etc.).
5. Conduct regular general inspections.
6. Establish workplace management and control.
7. Perform advanced improvement activities.

In-Process Supermarkets

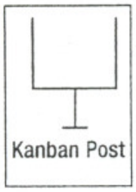


Where obstacles to continuous flow exist, you can use an in-process supermarket system. A supermarket of work-in-process may be necessary to ensure that flow is possible. It is used when there are multiple demands made on a machine or a process.

Toyota found the supermarket to be the best alternative for scheduling upstream processes that cannot flow continuously. As you improve flow, the need for supermarkets may decrease. Remember that supermarkets are a compromise to the ideal state, as are pitch, buffer inventory, and safety inventory. You will not achieve your ideal state overnight, but keep the takt image alive and continually work toward that ideal state.

The supermarket system works best when there is a high degree of commonality between parts. Refer to the PQ analysis or part-routing matrix you created in Step 2 to examine part families.

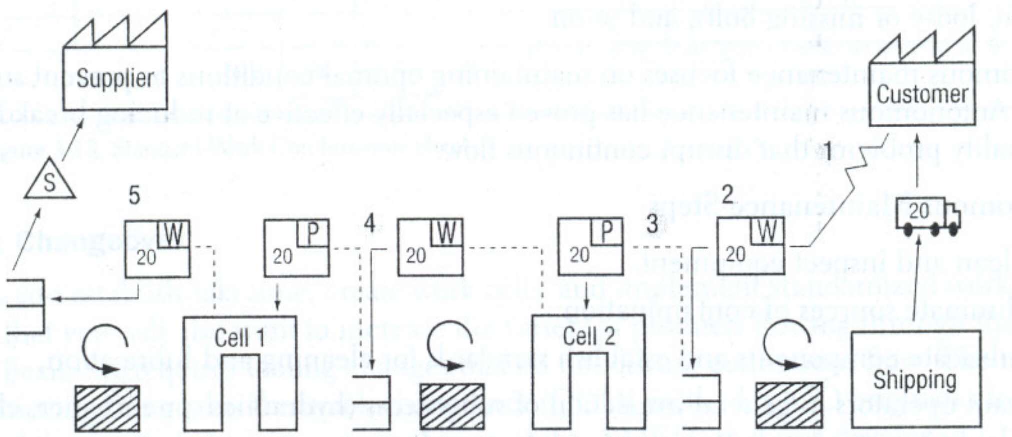
Kanban System



Kanban is at the heart of a pull system. Kanbans are cards attached to containers that store standard lot sizes. When the inventory represented by that card is used, the card acts as a signal to indicate that more inventory is needed. In this way, inventory is provided only when needed, in the exact amounts needed.

> ***The Origin of Kanban***
>
> In Japanese, *kanban* means "card," "billboard," or "sign." Kanban refers to the inventory control card used in a pull system. Kanban also is used synonymously to refer to the inventory control system developed for use within the Toyota Production System.

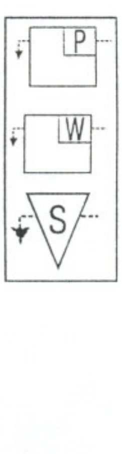
Kanbans manage the flow of material in and out of supermarkets. lines, and cells. They can also be used to regulate orders from the factory to suppliers (see Figure 3-14).



1. Customer orders 20 units (electronic transaction).
2. Withdrawal kanban for 20 units taken to finished goods supermarket.
3. After shipper withdraws 20 units from the supermarket, takes production kanban for 20 units and drops it off at Cell 2.
4. Cell 2 operator uses withdrawal kanban to pull 20 units of WIP from in-process supermarket. pulls production kanban from container, and drops off at Cell 1.
5. Cell 1 operator uses withdrawal kanban to pull 20 units of raw material from raw material supermarket, pulls signal kanban from container and places it in a holder to be collected by supplier's truck driver.

Figure 3-14. How a kanban system controls material flow

There are three types of kanban:



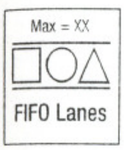
- A *production kanban* is a printed card indicating the number of parts that need to be processed to replenish what customers have pulled.
- A *withdrawal kanban* is a printed card indicating the number of parts to be removed from a supermarket and supplied downstream.
- A *signal kanban* is a printed card indicating the number of parts that need to be produced at a batch operation to replenish what has been pulled from the supermarket downstream.

You can think of kanbans as a factory's automatic nervous system. To work properly, a few rules must always be followed:

Kanban Rules

- ❑ Downstream operations or cells withdraw items from upstream operations or cells.
- ❑ Upstream operations or cells produce and convey only if a kanban card is present and only the number of parts indicated on the kanban.
- ❑ Upstream operations send only 100-percent defect-free products downstream.
- ❑ Kanban cards move with material to provide visual control.
- ❑ Continue to try to reduce the number of kanban cards in circulation to force improvements.

FIFO Lanes



If you lack a high degree of commonality between parts and cannot use an in-process supermarket system, then you can work with the concept of a first-in, first-out (FIFO) lane. First-in-first-out (FIFO) is an inventory control method used to ensure that the oldest inventory (first-in) is the first to be used (first-out). FIFO lanes are useful in situations where multiple value streams meet before product customization, and before large-batch operations where dissimilar parts go through an operation such as anodizing, welding, stamping, or painting (see Figure 3-15).

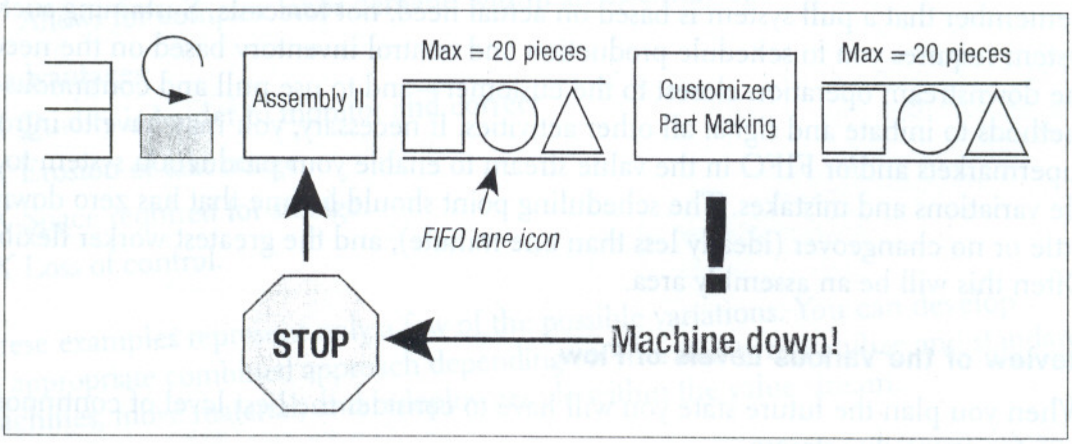


Figure 3-15. FIFO lanes

A FIFO lane has the following characteristics:

- ❑ Holds a designated number of parts between two processes and is sequentially loaded.
- ❑ Is created in such a way that it is difficult—if not impossible—to draw anything other than the oldest inventory first.
- ❑ Uses a signal to notify the upstream process to stop producing when the lane is full, preventing overproduction (one of the seven deadly wastes).

- ❑ Requires sequencing rules and procedures for upstream and downstream processes to ensure that neither overproduces and that time is not wasted.
- ❑ Requires discipline by the workforce to ensure FIFO integrity.

Note that even though in-process supermarkets and FIFO lanes are used in different situations, in both cases product should be pulled in FIFO *order*. Standardize processes for pulling product from in-process racks and for replenishing it so that FIFO order is maintained.

> ***FIFO Lane Example***
>
> An upstream operation cuts steel rods for a cell that makes three slightly different but related products. One product starts with a 3-inch diameter rod that is 8 inches long, the second product starts with a 4-inch diameter rod that is 10 inches long, and the third product starts with a 5-inch diameter rod that is 12 inches long. Since the cell requires three different-sized rods, you could establish a FIFO lane to ensure that the rods are processed downstream in the order that they were cut.
>
> On the other hand, if each of the three products were made from the same-sized steel rod, you could establish an in-process supermarket from which parts could be pulled when needed.

Production Scheduling

Remember that a pull system is based on actual need, not forecasts. Sustaining such a system requires you to schedule production and control inventory based on the needs of the downstream operation closest to the customer—and to use pull and continuous flow methods to initiate and signal all other activities. If necessary, you may have to introduce supermarkets and/or FIFO in the value stream to enable your production system to handle variations and mistakes. The scheduling point should be one that has zero downtime, little or no changeover (ideally less than one minute), and the greatest worker flexibility. Often this will be an assembly area.

Review of the Various Levels of Flow

When you plan the future state you will have to consider the best level of continuous flow for your value stream.

Flow in the Ideal State (One-Piece Flow)

Advantages:

- ✓ Absolute control over processes.
- ✓ Instant feedback on quality and safety issues.
- ✓ Balanced workload.
- ✓ Immediate reaction to system failure (machine, people, material).
- ✓ True takt image that can be clearly seen.

Disadvantages:

✗ None, assuming you have eliminated problems with downtimes, changeovers, etc.

Flow Using Supermarkets

Advantages:

✓ Allows for flow when using shared equipment.

✓ Better use of capital equipment when state-of-the-art technology has not risen to small, more lean-oriented machines.

✓ Potential for enhanced labor balance.

Disadvantages:

✗ Quality is harder to monitor and correct when producing in small batches.

✗ Erosion of takt image.

✗ Space required for storage.

✗ Loss of control.

Flow Using FIFO Lanes

Advantages:

✓ Allows for flow when potential for chronic failure of upstream process exists.

✓ Allows for flow during tool changes.

✓ Allows for complex labor demand within an assembly operation.

Disadvantages:

✗ Quality is harder to monitor and correct.

✗ Erosion of takt image.

✗ Space required for storage.

✗ Loss of control.

These examples represent only a few of the possible variations. You can develop an appropriate combined approach depending on your ability to stabilize and standardize machines, move material, and redeploy people within the value stream.

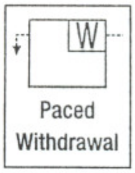
Leveling Stage

After you have determined demand and established flow, you will work on *leveling* production. Leveling involves evenly distributing over a shift or a day the work required to fulfill customer demand. The concepts and tools used to level production include

- Paced withdrawal.
- Heijunka.
- Heijunka box.
- The runner.

To maintain a takt image, you must establish a method by which you can balance the pace of production against the pace of sales or takt time. There are two ways to accomplish this: paced withdrawal and heijunka.

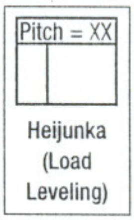
Paced Withdrawal



Paced withdrawal is a system for moving small batches of a product from one operation or process to the next, at time intervals equal to the pitch. Paced withdrawal is used when you have no product variety in the value stream, meaning that all pitch increments will be identical.

Remember that the ideal state is one-piece flow. However, customers usually want products in containers that hold a standard pack-out quantity. Paced withdrawal levels production by dividing the total requirement for a shift or day into batches equal to a pack-out quantity. The pitch determines the frequency with which containers are released to shipping.

Heijunka (Load Leveling)



Heijunka is a sophisticated method for planning and leveling customer demand by volume and variety over the span of a day or shift. If there is little or no product variation, you may not need this level of sophistication. As you move toward smaller lots or pure, continuous, one-piece flow, the demand for parts is subject to sudden peaks and valleys. Large orders may immediately deplete inventory, making it difficult to manage.

Heijunka may be the key to establishing a true lean pull system in your facility—if your product mix warrants it. Heijunka uses paced withdrawal based on pitch, but breaks it into units based on the volume and variety of product being manufactured. For example, consider a value stream that makes five related products in standard-pack quantities of 25, as shown in the table below.

Product	A	B	C	D	E
Daily requirement	300	200	200	50	50
Pack-out quantity	25	25	25	25	25
# of kanbans	12	8	8	2	2

In each case, the number of kanbans is determined by dividing the daily requirement by the pack-out quantity. The total daily requirement is 800 units, and the available production time over two shifts is 52,800 seconds. This means that takt time equals 66 seconds and pitch equals 1,650 seconds (27.5 minutes):

Takt time = Available production time / Total daily quantity required
Takt time = 52,800 seconds / 800 units
Takt time = 66 seconds

Pitch = Takt time X Pack-out quantity
Pitch = 66 seconds per unit X 25 units per container
Pitch = 1,650 seconds or 27.5 minutes

So, every 27.5 minutes, 25 units must be released to shipping. Now the question is: "25 units of which product?" Over the course of the day, the value stream must turn out 12 containers of A, 8 containers each of *B* and C, and 2 containers each of *D* and *E*. In other words, the ratio of A : *B* : C : *D* : *E* is 12 : 8 : 8 : 2 : 2. Reduced to its smallest terms, the ratio is 3 : 2 : 2 : 0.5 : 0.5—*or*, for every three containers of product *A* produced, two containers each of products *B* and *C* and 0.5 containers each of products *D* and *E* must be produced. The levelled production ratios are managed through distribution of kanbans using a heijunka box, explained in the next section.

Implementing heijunka clearly requires a sound understanding of customer demand and the effects of this demand upstream. Heijunka is not something that you can put in place with a cosmetic lean effort: it requires strict attention to the principles of stabilization and standardization.

Heijunka Box

The heijunka box, or leveling box, is a physical device used to manage levelled production volume and variety over a specified time period. The load is leveled with consideration for the most efficient use of people and equipment. Kanban cards are placed in slots corresponding to the pitch increments in which products are to be released to shipping and subsequently replenished.

In the heijunka example above, we determined that level production could be achieved based on the following ratio:

$$A : B : C : D : E = 3 : 2 : 2 : 0.5 : 0.5$$

Figure 3-16 represents a heijunka box. The left column shows 32 pitch increments, and the right column shows which product is staged for shipment and subsequently replenished during each 27.5-minute period.

Note that the heijunka box is loaded in a way that approximately reflects the ratio shown above:

- Product A is made during the first three pitch periods.
- Product *B* is made during the next two periods.
- Product C is made during the following two periods.
- Since production is based on pitch, it would be impractical to make a half container of product *D*. Instead, it would make good sense to run A-the high runner-for three more pitch periods before running *D*. This helps sustain flow by minimizing changeovers.
- After running *D*, you would dedicate the next four pitch periods to running two more containers of *B* and C respectively.
- Product *E* is made during the final pitch period of the first shift.
- The pattern established above repeats during the second shift.

Pitch Increment	Product
6:30 — 6:40	Beginning of 1st Shift Meeting and Operator PM Checks
6:40:00 — 7:07:30	A
7:07:30 — 7:35:00	A
7:35:00 — 8:02:30	A
8:02:30 — 8:30:00	B
8:30 — 8:40	Break—No Production
8:40:00 — 9:07:30	B
9:07:30 — 9:35:00	C
9:35:00 — 10:02:30	C
10:02:30 — 10:30:00	A
10:30 — 11:00	Lunch—No Production
11:00:00 — 11:27:30	A
11:27:30 — 11:55:00	A
11:55:00 — 12:22:30	D
12:22:30 — 12:50:00	B
12:50 — 1:00	Break—No Production
1:00:00 — 1:27:30	B
1:27:30 — 1:55:00	C
1:55:00 — 2:22:30	C
2:22:30 — 2:50:30	E
2:50:30 — 3:00:00	End of 1st Shift 5S
3:00 — 3:10	Beginning of 2nd Shift Meeting and Operator PM Checks
3:10:00 — 3:37:30	A
3:37:30 — 4:05:00	A
4:05:30 — 4:32:30	A
4:32:30 — 5:00:00	B
5:00 — 5:10	Break—No Production
5:10:00 — 5:37:30	B
5:37:30 — 6:05:00	C
6:05:30 — 6:32:30	C
6:32:30 — 7:00:00	D
7:00 — 7:30	Lunch—No Production
7:30:00 — 7:57:30	A
7:57:30 — 8:25:00	A
8:25:00 — 8:52:30	A
8:52:30 — 9:20:00	B
9:20 — 9:30	Break—No Production
9:30:00 — 9:57:30	B
9:57:30 — 10:25:00	C
10:25:00 — 10:52:30	C
10:52:30 — 11:20:00	E
11:20 — 11:30	End of 2nd Shift 5S

Figure 3-16. Heijunka box—pitch increment

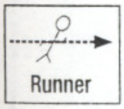
	6:40 - 7:07:30	7:07:30 - 7:35	7:35 - 8:02:30	8:02:30 - 8:30	8:40 - 9:07-30	9:07:30 - 9:35	9:35 - 10:02:30	10:02:30 - 10:30	11:00 - 11:27:30	11:27:30 - 11:55	11:55 - 12:22:30	12:22:30 - 12:50	1:00 - 1:27:30.	1:27:30 -
A	1	1	1					1	1	1				
B				1	1							1	1	
C						1	1							
D											1			
E														

Figure 3-17. Heijunka box—kanbans

Note that by the end of the day, production requirements have been met. Twelve containers of *A*, eight containers each of *B* and *C*, and two containers each of *D* and *E* have been produced.

We created the table for the preceding example to show in a simple way on one page how the production of a variety of different products is distributed in a balanced way over an entire day. A heijunka scheme is more commonly represented as shown in Figure 3-17 (in reality, you might fabricate a box with slots in which you place kanbans or a board on which the kanbans are posted).

The Runner



In a lean transformation you often discover in the course of performing line balancing that you can eliminate a worker from a target value stream and redeploy that person elsewhere. Sometimes you can redeploy a displaced operator as a runner, or material handler, provided that he or she is qualified to assume that role (see "Runner Qualifications").

The runner ensures that pitch is maintained. He or she covers a designated route within the pitch period, picking up kanban cards, tooling, and components, and delivering them to their appropriate places. If a heijunka box is used, the runner removes kanbans from it to use as "visual" work orders. In a sense, the heijunka box is like a mailbox for the value stream, and the runner is the mailman. If a heijunka box is not being used,

Runner Qualifications

- Understands value stream production requirements.
- Communicates well.
- Able to recognize and report abnormalities.
- Understands lean concepts.
- Understands the importance of takt time and pitch.
- Works efficiently and precisely.

then the runner picks up and delivers parts from store locations as required to sustain efficient flow through the work areas or cells.

Runners play an important role in proactive problem solving. Because they continuously monitor the functioning of a line or cell as well as pitch (or takt time), runners are closely attuned to how well the value stream is fulfilling customer requirements. Normally, when a problem occurs, an operator immediately notifies a team leader or supervisor and the problem is addressed *after* it occurs. However, runners are in a unique position to help prevent small problems before they become large problems that seriously disrupt process flow.

Remember that leveling occurs *after* you have achieved continuous flow. It is a refinement of your lean design. You may find that specific techniques implemented earlier will be eliminated as you successfully level production.

Identify Non-Lean Conditions

After learning something about lean, you will begin to look at the value stream in a new way. As a first step in applying your knowledge, start observing ways in which the manufacturing process is not lean, or could be improved. Ask yourself questions about what you are observing, such as:

- ❑ Does the floor layout promote waste-free flow of parts through the process?
- ❑ Do you have a push system or a pull system? How do you communicate orders to the upstream process? How do you pass components to the downstream process?
- ❑ Are you producing in large lots, small batches, or one-piece flow?
- ❑ Is customer demand being met? Are you working to takt time? Have you determined the pitch?
- ❑ Is the work area messy and disorganized?
- ❑ Are you tolerating inventory, waiting, and other forms of waste?
- ❑ How long are your changeover times?

Enter your observations on the storyboard in the space labeled for Step 3.

PREMIERE MANUFACTURING CASE STUDY, STEP 3

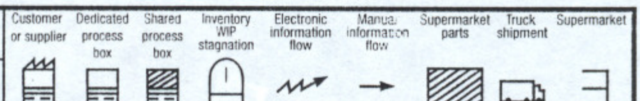
The team creates a training plan and spends the next six weeks learning about lean manufacturing tools and methods.

Two of the members attend a one-day seminar on lean. On June 15, the entire team attends a four-hour overview on lean manufacturing techniques conducted by Premiere's training department. The overview includes a simulation that demonstrates the difference between batch production and continuous flow production. On June 30, five team members go on a benchmarking trip to a local company that has successfully implemented lean methods. By July 30, the team leader completes and gives a report on *Lean Thinking*, by Womack and Jones, and *The Toyota Production System*, by Taiichi Ohno.

Team Member	Training Activity	Completed by
Bob	Attend Overview/Simulation	6/15
	Benchmark Company C	6/30
	Attend Lean Workshop	7/15
Rob	Attend Overview/Simulation	6/15
	Attend Lean Workshop	7/15
Juan	Attend Overview/Simulation	6/15
	Benchmark Company C	7/15
Judy (Team Facilitator)	Attend Overview/Simulation	6/15
	Benchmark Company C	6/30
Rita	Attend Overview/Simulation	6/15
	Attend Lean Workshop	7/15
Tom (Team Leader)	Attend Overview/Simulation	6/15
	Benchmark Company C	6/30
	Read Lean Thinking	7/30
	Read Ohno's Toyota Production System	7/30
Tracy (Scrbe)	Attend Overview/Simulation	6/15
	Benchmark Company C	6/30

Premier Manufacturing Lean Training Plan

After discussing what they have learned and observed, the team members conclude that the target value stream is operating currently with a push system and limited continuous flow. The work areas are generally disorganized and disorderly, neither takt time nor pitch is being used, and there is tremendous variation in the way different operators perform value-adding tasks (in other words, it will be necessary to implement standardized work). The team enters these observations on the storyboard and looks forward to mapping the current state in Step 4.

Date originated 2/2/01	2 Value Stream #4 & #6 hoses			
1 Champion Rob				
1 Team Tom, Judy, Bob, Rita, Tracy, Juan		3 Push production	No takt time	Limited continuous flow
		No pitch	Disorganized workplace	No standardized work

Storyboard excerpt