Powerful Tools for Dramatically **Reducing Waste** and **Maximizing Profits**

LEAN MANUFACTURING THAT WORKS

BILL CARREIRA

Lean Manufacturing That Works

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INTRODUCTION

The Why

This is a book about lean manufacturing. More specifically, this is a book about how to put lean manufacturing to work to improve your particular business. There are many excellent books that address the concepts of lean manufacturing, and I do not bring any revolutionary new concepts to this body of knowledge. What I attempt to bring to the party with this book is a more "everyday" approach to the topics under discussion, with enough detail and illustration of some of the basic tools of lean to give the reader a clear view of how to implement (do) what we are talking about.

That being said, the first questions that should come up are, "What is lean, and why should I consider changing the way I currently do business?" These are good questions.

If you boil lean down to its essence, it is a culture. It's not so much a discrete "thing" as it is a way of thinking, an overall philosophy of running a business. I have observed companies that have an annual operations plan in addition to a set of lean initiatives, treating them as two different categories of activity. When I question management about the distinction, the responses are usually along the lines of: "We have a 5S initiative" or "We have a plan to reduce headcount on line 4." I then make the point that lean should not be separate from your business plan; instead, it should be used to develop and support your business plan. I am often surprised to see a fundamental disconnect in the interpretation and execution of this powerful operating mindset. My wife has suggested that my time would be better spent writing a book entitled *Why Companies Fail to Implement Lean*. This is probably a good suggestion; my wife is often a great deal smarter than I am.

The Fundamental Principles of Lean

In attempting to define lean, we could discuss the guiding principles of the lean mindset. One is the concept of value. In contrast to the conventional business view, in lean, all value is defined from the vantage point of the customer. Does something add value for the customer or not? When this question is asked, it takes you to a focus on product deliverables. You could restate this question as, ''Does this activity directly contribute to my customer's product's becoming more complete, and is the customer paying for this activity to occur?'' If the answer to either of these questions is no, you might ask, ''Why am I doing it?'' This concept and this definition of value take us to two of the key analytical terms of lean, *value-added* and *non-value-added*. The term *value added* refers to activity that transforms the product or deliverable, in the view of the customer, to a more complete state. The product has been physically changed, and its value to the customer has increased. Conversely, the term *non-value-added* refers to activity that consumes time (people expense), material, and/or space (facilities expense), yet does not physically advance the product or increase its value. This is pretty straightforward logic, yet it's profoundly different from the operating definitions used by many conventional companies.

Another foundation principle of lean is that of a systemwide view when evaluating your business: the value stream. This is a critical departure from the focus of a conventional (nonlean) business. A value stream is the total cycle of activity, from initial customer contact through receiving payment for a product that has been delivered. I observe companies struggling to find ways to reduce their costs by 3 or 4 percent annually, yet the adoption of lean techniques has been repeatedly demonstrated to provide double-digit improvements in operational performance. I believe the disconnect here is the focus on maximizing pieces of the business while failing to recognize the noise at the intersections of the pieces. A value-stream approach to analyzing your business provides a very different view of where the opportunities are and what the priorities for leveraging these opportunities should be.

Next come the principles of *flow* and *pull*. Flow, in the ideal state, simply implies a seamless sequence of activity throughout the process, with no stalls, no disruptions, and no disconnects or backtrack loops. The concept of pull means that things are done when they are required to be done, not before. It implies a consumption-driven or customer demand–driven system, as opposed to a forecast-driven system.

Perhaps the essential principle of a lean mindset is the ongoing and continuous elimination of waste. The differing element here is in the definition of what waste is. We want to eliminate wasteful activity and free up time and resources to be devoted to additional value-added activities. ''More with less'' does not mean a way to work people harder or cut their jobs. It means more product produced with the expenditure of less resources, which results in increased customer satisfaction, growth through the taking of market share, greater profitability for your company, and increased opportunity and stability for your employee population.

In order for these principles to be implemented in any organization, they must be driven from the top management level and embraced by all individuals within the company. It's not a piecemeal philosophy; it's a way of being.

What This Book Will Do for You

This book is composed of two sections. The first section is the ''what,'' and the second section is the ''how.'' The ''what'' chapters discuss and illustrate the ideas and logic of what we are trying to accomplish by adopting a lean operating philosophy. The ''how'' chapters illustrate some of the tools of lean and how to put them to good use. There are many possible variations for skinning the lean cat. Slightly different formats can produce the same results. Time frames can be longer or shorter, depending on the sense of urgency and the resources available. This book illustrates some of lean's fundamental tools in a specific, how-to manner, with the hope that you will go to your production floor and make something happen.

In response to the second question, ''Why should I consider changing the way I currently do business?'' I would take you to the fundamental concept of business in general: ''Make money by being the premier satisfier of customer demand.'' We all have competition, and our competition wants our business. If you are not continuously and aggressively improving, you are stagnating. It is simply not possible to stand still in an aggressive global business economy. It will be only a matter of time before your more forward-thinking competitors surpass your performance and you begin to decline. Enough said there; I'm probably preaching to the choir.

And so, back to the why. American industry has crashed and burned over the last few decades. We manufacture very little of what we consume—cars, appliances, clothing, you name it. There are some people who tell us that this is the result of international competition, with cultural differences being at the heart of more effective (competitive) manufacturing techniques.

Over the last few decades, dozens of American auto plants have closed, putting hundreds of thousands of autoworkers out of work. At the same time, foreign automakers have come to America, opened facilities in these same areas, hired the same people that were displaced, and are operating profitably. So much for cultural differences.

When we look at technique, we begin to see fundamental differences. Production technique is pretty much a level playing field. Anyone can purchase identical equipment and facilities, hire and train qualified people, and purchase the raw materials required to make a product. There are certain steps required to make a particular product, and everyone does them the same way. The difference appears to be in the manufacturing technique—how we manage and balance people, materials, and machines.

It would appear that it is not so much the way people are doing their jobs as the way management is directing overall resources that leads to fundamental differences in competitive effectiveness.

And so we come to the essential why. We need to be more competitive in order to survive. It's time to look at the most effective companies and pay attention to what they are doing. It's time to look at our own operating methodologies and ask some silly questions. Let's go.

PART 1

THE WHAT

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CHAPTER 1

Customer Satisfaction

What is the objective of a manufacturing company? I've given this subject a lot of thought, and I have derived a somewhat complicated, yet elegant hypothesis.

A manufacturing company wants to make something that it can sell to someone for more money than it cost the company to make it.

That being said, how do you go about achieving that objective? What do you need in order to start?

1. A product
2. A place to make the product
3. People to do the work
4. Materials to make the product
5. Machines and tools for your people to use

Since we are talking about lean manufacturing, I will accept as a given that there is a product. That leaves us with a place, people, materials, and machines and tools. Seems pretty easy so far.

What have we forgotten? Ah, yes, one very important item: a customer who is willing to buy your product. This very important component is at the heart of the lean manufacturing message.

When I talk to various executives about their primary performance drivers, I am invariably told that customer satisfaction is the number one indicator. Then the conversation usually turns interesting.

Mr. Exec: Yes, Bill, we are truly a customer-driven company. Our clients are king.

Me: What is your on-time delivery rate?

Mr. Exec: Well, it's running about 85 percent right now, but we've been very busy lately.

Me: I see. Is that to your customer's requested date or to your negotiated delivery date?

Mr. Exec: Well, to our date, of course. We can't always react to customer requests because they are simply not realistic.

Me: How so?

Mr. Exec: Well, sometimes the customer will call and request delivery within two or three days. Sometimes even the next day.

Me: Imagine that!

Mr. Exec: Exactly. They don't understand that such a short lead time is simply not possible.

At the center of the lean philosophy is *measuring all activity from the customer's point of view*. I'm sure you have heard the story of the extremely complicated product that was developed by a group of extremely talented engineers. I won't tell you what the product was, just that it was a marvel of complexity. It was just the sort of product that strokes an engineer's ego into hyperdrive. When the product failed to sell, it wasn't the engineers' fault.

Mr. Engineer: Yes, Bill, our triangulation gizmotrometer is truly a marvel of cutting-edge technology.

Me: Very impressive! What's the selling price?

Mr. Engineer: Well, it's quite expensive; the complexity of this design does not come cheaply. Not to mention the research and development expense that we need to cover.

Me: With such a complicated design, what's the cost of maintenance and repair in case of a malfunction?

Mr. Engineer: Again, quite high. Troubleshooting malfunctions is complicated and time-consuming and requires a high-level technician.

Me: I see. So why is this product not selling?

Mr. Engineer: We believe that the average consumer simply lacks the sophistication to appreciate what we are offering. Consumers just don't seem to understand the value of this product.

Me: Lack of demand is the customers' fault because of their lack of sophistication?

Mr. Engineer: Exactly!

I do run into some interesting examples in my travels. I recently spent a few months with a client doing an extensive lean-engineering analysis of two of the company's main assembly areas. As I learned more about the business, I kept hearing comments that lowest cost and best lead time (quality is a given) did not always mean being awarded a project in this industry. The claim was that a lot of politics were involved in awarding a project and that performance was not always the deciding factor. As I became privy to more of the details surrounding these comments, it became clear that the company had lost a major job that it had bid on to a competitor whose price was significantly higher and that did indeed have a longer lead time. In talking to some of the engineering types, I learned that a major characteristic of the product had changed, and that the customer had specified this new feature as a requirement in its product quotation process. My client would have had to do a considerable amount of engineering design work and process redesign to accommodate this new characteristic.

My client chose to take the position that the product as it was currently produced was better, and it submitted a bid that ignored the newly specified characteristic. Its price was lower, its lead time was better, and its quality was excellent. The job was awarded to a competitor with a higher price and longer lead times. Curious indeed? Clearly a political issue! Even though the company had completely ignored the customer's specific description of the desired product, when it failed to get the job, the reason was politics, not the fact that the company had submitted a quotation on a product design that the customer clearly was not interested in. Amazing but true.

The lesson: Give customers exactly what they want—no more, no less.

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CHAPTER 2

Cost and Profit

The next not-so-silly question is: What are you trying to do? The obvious answer is, *make some money*. Since we are talking about lean manufacturing and not lean market research, the next questions are:

- How do you make a profit?
- How do you control your costs?
- What are your costs?
- How do you provide faster lead time to the customer if needed?
- Assuming that you are using the same equipment as your competitors and equally skilled people, how do you take work away from them and grow your company?

Let's talk about profit in a manufacturing firm. You have a great product that everyone wants to buy. All you have to do is buy some material, rent a factory, hire and train some employees, start making your product and selling it to customers, and start accumulating some profit.

In order to make a profit, you need to establish a couple of things:

1. What is your cost?
2. What is your selling price?

Your profit (or loss) will be the difference between your cost and your selling price. That being said, where do you begin—with the horse or with the carriage?

Let's start with the horse—that is, cost.

You would think that as your cost goes, so goes your selling price. However, this is not really the case. Unless you have no competition, your selling price is actually set by the marketplace. If you care to test this hypothesis, identify a competitor who produces the same product as you, with comparable quality and lead times, and raise your price to twice that competitor's. Then track market share. You should have plenty of time to do this, since you will probably be sitting at home, in your boxer shorts, drawing unemployment. You'll have lots of free time.

So the operative relationship here is really, as your cost goes, so goes your profit.

Determining Your Real Cost

Let's start with the obvious stuff: taxes, lights, gas, water, real estate, steel, copper—whatever it is that you need in order to operate and make your product. Can your company buy materials and components more cheaply than other manufacturers competing for the same business? Are there any suppliers that are willing to sell material X to your company at a lower price than they sell it to all of their other customers? If your answer is yes, please contact me with the name of your HR manager so that I can fire off a résumé in the morning (do you have profit sharing and dental?). I digress. If your answer is no, then we can assume that your company buys its raw materials, processed material parts, electricity, water, and so on at the prevailing market value. So far, so good.

Next, let's look at what the average company considers to be the actual (real) cost to produce a product.

When you walk through the typical manufacturing plant, you usually see everything moving very fast. People are working; there are batches of material and parts in front of every station and batches of parts after every station; forklifts are busy taking parts from one area to the next area; expeditors are moving and tracking materials—everything is busy, busy, busy.

This is good, right?

There are two primary rules of (nonlean) production:

1. Everybody needs to be busy.
2. All of that expensive equipment needs to be running *all the time.*

If we are measured primarily on direct labor efficiency and machine utilization, this is what we focus on. We'll discuss standard cost systems and metrics later.

So, how does this relate to cost?

Here's the question: If you add up all of your current costs and obtain a total, is this your true manufacturing cost for a certain product?

In order to make one item of a certain product (let's call it a gizmo), a person must work a certain number of hours and process a certain amount of material. This is close to the true manufacturing cost to produce one gizmo.

The Cost of Overproduction

I've built the five gizmos that are due to ship today, and I still have three hours left on my work shift. What am I to do?

My 300 assembly and machining people have built all the customer orders that I have for this month, and I still have four working days left in the month. What am I to do?

If direct labor efficiency and machine utilization are considered your most important operating goals, you will keep everybody busy and keep the machines running. How exactly do you do this?

First, you need to figure out what to make. So you talk to your sales guys and have them try to guess what your customers will want to buy in the near future. We'll call this your sales forecast.

Now you need to buy some materials, schedule the product from your forecast into production, and get your people to make these items.

Your product is built, and since you built it to forecast—that is, nobody has ordered any of this stuff yet—you need a place to store it until the orders for these particular items come flooding in.

If you leave this product on your manufacturing floor, it will get in the way of future production, so let's add a stockroom to your operation. Now you need a way to get the product to the stockroom and someone to put it away. Let's hire a person to move materials and buy him a forklift. And on and on. If the amount of inventory in your storage space increases, you will need to hire people to count it, track its location, add systems and computers to manage the information, and so on.

The people involved in these newly developed tasks need to be paid, you'll have to buy the machines, and in the end the additional costs for space, people, and equipment will be counted as part of the cost of these products. In addition, the materials used are already paid for. If you paid cash, you are losing the opportunity to invest this money where you would receive a return. If you borrowed the money, there is an interest charge accumulating on this idle product.

What else could happen? You get a leak in your storeroom roof, and some of your product becomes rusty. Your material handler drops a skid, and product is broken. When you pull some product to ship in future, you have three left units, but you can find only two right units to make the pairs. Your customer changes his product style to a newer version, and the stock you have becomes obsolete. You could probably add a few what-ifs to this list. The bottom line? Your accounting department adds all of this waste into the cost of your product.

In reality, when they take inventory, many companies discover that they have inventory and supplies sufficient for one or two months sitting idle in storage. It is not uncommon for a company to have several months' worth of supply of some items.

An enormous amount of additional cost has been created by doing what lean experts would call *overproduction*.

Overproduction is building something before *you can ship it to someone in exchange for cash.* Overproduction and excessive inventory are the two most critical areas of waste in the lean philosophy. More about these two topics later.

CHAPTER 3

METRICS

What we measure dictates what we do. If we don't measure it, it's not important.

This will be a short chapter. I'll spare you a dissertation on accounting and finance theory; however, there are a couple of critical points to be made in this area. Measuring what you do is the foundation of continuous improvement. Are your results what you intended? Is your performance getting better, is it staying the same, or are you going the wrong way?

In many areas, you're not so much concerned with the actual number as with the trend. But the important point is, your metrics control your performance and your business decisions. The second important point is that metrics must be complementary; they must stack up throughout the organization and give everyone the same message. In many organizations, I see people in various areas with conflicting, contradictory, or, worse, no metrics.

I also see almost obsessive measurement of the direct labor category in many operations. Direct labor is those people who are actually building product—value-added people, if you will. Indirect labor is those individuals that most directly support the value-added people: material handlers, inspectors, maintenance, shipping and receiving, and so on. And then there are the overhead people, all the salaried individuals in the organization: sales, engineering, accounting, purchasing, scheduling and materials, and all categories of supervisors and managers.

Companies seem to need to measure the direct portion of the population, which today probably accounts for 6 to 10 percent of cost, on the average, to three decimal places, but the other 90 to 94 percent is treated very loosely. The practice is to measure the overhead and indirect boxes against departmental budgets, not specific activity. This is the conventional mindset, and it is driven by the standard cost system that is in place in the majority of companies today: Measure your direct activity, value your inventory, and absorb your overhead.

A Better Way of Measuring

In a lean organization, measurement of direct labor loses its position as the primary metric. What is looked at is all activity across the entire value stream. Inventory represents waste and large expenditures, even though it shows up as an asset on the financial statements. Financial measures and integrated accounts remain important for external reporting, but it is realized that with regard to day-to-day control and management of an operation, these accounting formats are confusing at best and harmful at worst.

In lean logic, there is a strong focus on reporting measurements in a much more direct fashion, and at the source, if possible. It is common, and preferred, to see whiteboards located at production cells measuring production rates and performance to schedule, customer-service levels such as on-time delivery, quality performance, safety performance, and setup time trends, to name a few. Traditional reporting logic gets you a report about a week after the fact, and in a sufficiently complex format that it requires some fairly complicated analysis to translate the information to the point where anything can be done with it. For the most part, it's old news.

Activity-based costing is an accounting system that attempts to address these discrepancies by assigning costs based on resources consumed. This type of system, and thought process, is becoming more common as companies integrate lean concepts into their operations. Where the logic of the standard cost system is to optimize the pieces and the whole will take care of itself, activity-based theory focuses on actual cost, systemwide.

The Problem with Standard Cost Accounting

This takes us back to the idea of a standard cost system (I think I started on this a couple of pages ago). At the risk of oversimplifying, I will oversimplify. Here's how it works.

The standard cost system is an accounting system that has been in use for many years in manufacturing companies. When a product is developed, a cost is calculated for that product. A list of all the materials in the product is created, and this is called the bill of material (BOM). This materials cost is assigned to the product and usually updated once a year. The number of labor and/or machine hours needed to make this product is also calculated, and these standard labor/machine hours are assigned to the product, again updated once a year. In addition, since all company costs must be paid for by products that are sold, overhead costs are spread over the products that a company sells and paid for in proportion to the standard hours required. This includes all factory costs and the salaries of sales, engineering, accounting, personnel, supervisors, and such. In short, overhead is the cost of all the people and items that are not directly associated with the product.

In a standard cost environment, when product is made and reported to accounting, the producing department earns credit for these "standard hours," and a percentage of the overhead cost is absorbed; hence the term *absorption* (you have absorbed, or paid for, a portion of the overhead). So, if gizmo A has 4 standard hours of labor and gizmo B has 6, and you produced 100 units of gizmo A and 200 units of gizmo B in a day, you would earn 400 (4 × 100) standard hours for gizmo A and 1,200 (6 × 200) standard hours for gizmo B, for a total of 1,600 standard hours for the day. If your employees actually worked 1,600 hours to produce these products, your labor efficiency for the day would be 100 percent. If your employees actually worked 3,200 hours to produce these products, your labor efficiency for the day would be 50 percent. In addition, whatever amount of overhead was allocated to 1,600 hours would be paid for (absorbed).

Since these standard costs are usually locked in for a year, if your actual work hours are greater or less, the difference goes into a labor variance (this can be positive or negative) line on the financials. The same thing is done with materials costs: if you pay more or less than standard cost for a particular batch of materials, the difference goes into a material variance line on the financials. As you may imagine, people managing production and materials areas spend a great deal of time explaining these variances to their bosses if the actuals are more than the standards.

If you have no orders for the product being produced and you send it to the stockroom to be stored, you still earn standard hours for this product. Accounting logs this production activity on the financials as if the product has been sold—regardless of whether it ships to a customer or goes to stock. Any production supervisor worth his salt will quickly learn how to be successful in this game: Keep people busy producing (direct labor efficiency and machine utilization), regardless of where the product is going, and your department will be extremely efficient—on the books. Your boss will love you, you'll get raises and promotions, and you'll become very visible within your company as a real manufacturing go-getter. In theory (and in reality), a department could be the most efficient area in the company and be sending all its production to the stockroom for storage. As you can see, this system will lead managers to perform unnecessary work just to make the numbers look good.

Now here's the kicker: *If you do not send product to a customer, who in return sends you money as payment, you may be headed for a difficult experience.*

So, what should we measure and how should we measure it? That's a complicated question with a number of reasonable answers. For the day-to-day decisions, measure what's important, and keep it real-time and ruthlessly simple.

CHAPTER 4

Cash Flow

Cash flow is a term you will hear frequently in the company president's office—and rarely on the manufacturing floor. If it's important to the president, then why doesn't the production manager consider it equally important, you might ask. This question takes us back to standard costing systems and how and what we measure in various areas of the business. It's curious how everything ties together. Now that we have discussed standard cost, I'm thinking you'll be catching on.

There are two important adjectives used in connection with the term *cash flow*: *positive* and *negative*.

As you might guess, positive is good and negative is not so good.

Here's the way it works: I spend money; I get money. The riddle is in the timing.

The things that a company needs in order to do business—materials, payroll for people, taxes, supplies, heat, lights, and so on—must be paid for within a certain amount of time. When a company ships an order to a customer, that customer must pay within an agreed-upon time frame. The difference in the time frames defines your cash flow position. The question is, how much cash is going out and how much cash is coming in—and, more importantly, when?

When you buy something, you have created what is called a *payable* (you have to pay somebody for something). When you ship product to a customer, along with an invoice for payment, you have created what is called a *receivable* (you're going to receive some money from someone). Companies usually measure their payables and receivables in days. If your receivables are at 57, that means that the average time it takes for your customers to pay their invoices is fifty-seven days. If your payables are at 37, this means that, on average, you are required to pay for your purchases in thirty-seven days. So, what does this mean? Good question. . . . .

Case in Point 1

Let's say that you received an order for 100 gizmos from one of your regular customers on June 15. You have no materials in stock. You order the materials from your various vendors, and you receive them on July 12. The money clock has started ticking. You will have to pay for these materials thirty-seven days from now (usually calendar days, not business days; let's call it August 19). You have to pay the people who are building this product (your employees) every Friday. You schedule and build the product over the next six weeks (a six-week lead time is fairly common in a conventional batch manufacturing company) and ship the product to your customer—let's call it August 23. Your customer receives the product on August 25 and will pay you in fifty-seven days—on October 21.

Here's the math: You paid your people in July and August, you paid for your materials in August, and your normal running expenses are paid monthly. You do not receive any money from your customer until the end of October. You have spent a big chunk of your money (or your bank's money—remember the interest you're paying) a couple of months before you receive your return. That's negative cash flow. If you look at this as a rolling-through-time exercise, you are paying for today's expenses with money you received from past orders shipped.

Case in Point 2

Here's the same example with a standard cost mentality. In addition to building the 100 gizmos that were shipped to your customer, your manufacturing people kept very busy and built 150 whatchamacallits that were sent to stock. Great efficiency; everybody stayed busy—they kept those expensive machines running night and day. Your accounting people are very happy with your efficiencies. You are showing great profitability; you gave your production manager a raise for his performance. However, you paid your people, bought materials and manufacturing supplies, and incurred overhead on product (150 whatchamacallits) that is sitting in your stockroom. *There is no cash on the way for this product.*

If you continue to operate in this manner, your inventories will increase over time, your payables will approach or exceed your receivables, you'll start to pay later or be unable to continue buying materials, your vendors will begin to squeeze you or shut you off, and the cash crunch will begin.

Any thoughts? There's a famous quote out there from a captain of industry—I cannot remember the exact phrasing, but it's to the effect that *"I'd rather have good cash flow than be profitable."*

Case in Point 3

Here's a real-life example of the other end of the spectrum. I was consulting with a small company that manufactured high-end trailers for racecars. These vehicles carried up to four racers and had living quarters, full workshops, you name it. I had been contacted to develop a layout for a new facility that the owner was putting up. I had analyzed his work flow to minimize wasted time and space, and I was questioning the owner about his inventory levels one afternoon. The conversation went something like this:

> **Me:** You've got a good bit of inventory out there, Jake *(not his real name, of course)*. How's your cash flow?
>
> **Jake:** What do you mean by cash flow, Bill?
>
> *[This gentleman's shop was filled with amazing jigs and fixtures capable of rotating fifty-three-foot-long trailers (his designs), his product was a work of art (his designs), I had been working with him for a few weeks and estimated his I.Q. at around 530, but he had apparently missed school the day they were discussing financial terminology.]*
>
> **Me:** Well, you're buying materials and building trailers—what are your receivables to payables? How much is your line of credit, and what kind of interest are you paying?

Jake: What do you mean by line of credit, Bill?

(Uh-oh. He missed more than a day of school—maybe a whole semester.)

Me: How do you buy your materials, Jake? *(Good recovery, don't you think?)*

Jake: Well, I usually just write a check. *(He was now starting to look at me like I had missed a day or two of school myself.)* If someone wants to buy one of my trailers, we get together, and I put up a design for them. If they want to go ahead with a purchase, they give me a check for the full amount, and I fit them into the next available time slot for a build.

Me: Huh? *(I guess it's OK to miss a day or two from school.)*

There it is—very positive cash flow. Which leads to a not-so-famous quote from a non-captain of industry (that would be me): *"I'd rather have great cash flow and be profitable at the same time."*

Needless to say, my friend Jake is not the norm. The important lesson here is: *"Don't build or buy anything until you can sell it."* (This strategy used to be called "just in time" years ago.)

CHAPTER 5

INVENTORY AND CARRYING COST

Inventory is always an interesting topic. I once had a call from a potential client who had gotten my number from a mutual associate. In our initial telephone conversation, I asked him several questions concerning his company's products, annual sales, operating income, number of facilities, number of employees, labor and materials as a percent of sales, blah, blah, blah, yada, yada, yada. I was trying to get a feel for the position his company was in.

We had an interesting talk, and my initial take was that this was a very bright guy who had just been promoted to run the manufacturing side of the business and was burning up the books researching alternative manufacturing strategies. He stated that he had an interest in exploring a lean operating philosophy, and he questioned me on what I felt the key characteristics of this system were. I told him that the crucial elements were (1) waste elimination and (2) flow processes with very high velocity. He liked the idea of velocity and stated that his company had \$20 million and growing in finished goods inventory. He threw me the question, "How do we get our finished goods inventory under control and begin to reduce it?" That's a tough question. My immediate response was, "Stop building product that you don't have hard orders for." There you go, mission accomplished; where do I send the invoice?

This conversation began a long and stimulating relationship. This client always comes to mind when I begin to discuss inventory and associated costs, partly because of the wrestling match I had with the company's finance people to define carrying costs, and partly because the company did such an absolutely bang-up job of addressing this issue and other change-related issues as it implemented lean and flow philosophies and integrated them into its company culture.

And so, let's discuss inventory. Why do companies have so much of it, what are the impacts of carrying inventory, and how do you establish what you need and what is excess?

Measuring Inventory

Let's start with some common methods of measuring inventory. One of the most common metrics is inventory turns. I spend a lot of time working with cross-functional manufacturing teams that are involved with implementing cells and flow processes. I am frequently accused of oversimplifying issues, and I remain guilty as charged.

The scenario is a team training session in lean concepts. Here's one of my favorite exchanges:

Me: OK, let's talk about inventory turns. Anybody here familiar with the term? I'm sure many of you have heard it; what's it mean?

(Lots of looking around, no responses.)

Me: How often do you buy groceries?

(This question is thrown to the team. Everyone is looking at everyone else, waiting for someone to answer first. I'm looking around at the body language, and I find a candidate who looks like he wants to talk but is reluctant to break the silence first. His name is John.)

Me: John, come on; how often do you buy groceries?

(I address my question to John in order to draw him out and get this team rolling.)

John: *(Somewhat reluctantly.)* Once a week.

Me: Why once a week?

John: Well, I get paid once a week, on Thursday, and we go grocery shopping for the week on Thursday evening.

Me: I see. If we look at the way you manage inventory (groceries) in your home business, your inventory turns are 52. Once a week, or fifty-two times a year, you purchase seven days of groceries (inventory). Between Thursday and the following Wednesday, your inventory is consumed, and on the next Thursday you buy another seven days of groceries (inventory). You turn your inventory 52 times a year.

Me: What do you do here, John?

John: I'm a machinist.

Me: Anybody in this group work for materials?
(A young woman raises her hand.)

Me: I'm sorry; what was your name again?

Julie: Julie.

Me: And your position is?

Julie: I'm the purchasing supervisor.

Me: OK, Julie, are turns one of the things you folks measure in your department?

Julie: Yes.

Me: And your turns here are?

Julie: Well, it changes depending on the time of year, but we're averaging around 4 turns.

Me: You might want to consider offering John a purchasing position; he's really good at managing inventory at high turns. *(Everybody's laughing now, things are starting to loosen up.)*

Me: OK, if we turn the measurement inside out, when we say we have 4 turns, we're also saying that we have three months' worth of inventory on hand. If we say the average month has twenty days, that translates to sixty days of inventory on hand. You don't have to buy anything for the next sixty days of production!

Julie: I wish that were true, but the inventory we have on hand is not the right mix for the next sixty days of production. Some of it is, but we also continue to buy every day.

Me: I see. What do you have invested in inventory?

Julie: What do you mean?

Me: Well, break it up into three boxes. What kind of dollars do you have in raw, WIP, and finished goods?

(One of the team members raises his hand.)

Jerry: Bill, what do you mean by WIP?

Me: Your name again?

Jerry: Jerry.

Me: OK, Jerry, WIP is work in process. That means materials that have had something done to them; somebody's touched them, and you've added cost. The three categories are raw, WIP, and finished goods. Raw materials are parts that your company has received but no one has done anything to yet. They were received and put into stock to wait for the first operation. You could, in theory, return them if you wanted to. Once parts are pulled from raw and the first operation has been performed on them, they are considered work-in-process materials. You've added labor dollars to the part, and it is not in its original shape. It's yours now; you've added cost, and you can't send it back to your vendor. Finished goods are products that you have completed and are available to sell to a customer. The product is done and is sitting in your stockroom. Those are the three boxes that inventory typically falls into. Questions?

Jerry: Got it, thanks.

Me: OK, Julie, back to the question; where are the dollars?

Julie: Well, in round numbers, we have around $2 million in raw, a little over $4 million in WIP, and a little under $4 million in finished goods.

Me: So $10 million plus or minus, systemwide.

Julie: Yes. Those numbers are approximates.

Me: With all that inventory available, you must have no problem with stock-outs or parts shorts.

(Quite a few members of the team start laughing; the message is clear.)

Me: What? Are shortages a problem here?

Mal: We have a lot of shortages. *(Another team member jumps in.)*

Me: And your name is?

Mal: Mal Hathaway.

Me: Thanks, Mal; what do you do?

Mal: I'm the lead person in final assembly.

Me: How often do you have parts shortages in assembly?

Mal: Well, some days are better than others, but we seem to be looking for something every day.

Me: Even with all that inventory?

Mal: It's usually only one or two part numbers that we come up short on, but even one short part causes us to not be able to complete an order.

Me: So what do you do?

Mal: Well, we usually just go to the next order on the schedule until all the parts become available.

Me: What do you do with the half-done orders?

Mal: We just set them aside and work around them.

Me: Mal, how's your on-time delivery to your customers?

Mal: I'm not sure. We build to our schedule. Unless we know it's a hot order, we don't know what ships and what goes to stock.

Me: Julie, you guys must track on time; where are you on that?

Julie: We're pretty good with on time, usually in the 85 percent plus range.

Me: I see. So at any given time, only about 15 percent of your customers are unhappy with your delivery performance? How about lead time? What's your standard quoted lead?

Julie: Depends on the order size and product complexity.

Me: Vanilla product and average order size?

Julie: We would quote four weeks for an average order.

Me: What's the average in your industry, and where's your competition?

Julie: I'm not sure about those numbers, you'd have to talk to marketing, but I guess we're doing good; our company is pretty well regarded.

Me: OK, let's go back to cost of inventory. You guys have lots of inventory, but you still have shortages; your on-time delivery leaves a lot to be desired; and your average lead time is measured in weeks. What do you guys think about these observations?

Let's talk about money. When we talk about the cost of inventory, there are four main areas that come up. When your company buys materials, it doesn't just fire up the checkbook and pay for them. Here's the way it usually works. The first thing that happens is, you get an order. Julie, so far so good?

Julie: Well, it's not quite that simple. We do get new orders entered into the system every day, but we also have a forecast that we are working with. We're usually looking about three months out, kind of a rolling three-month window.

Me: I see. So you're working with a mix of hard orders and forecast?

Julie: Exactly.

Me: If I looked at your rolling three-month mix, I would bet that a safe assumption would be that the next two or three weeks of your schedule are hard orders from customers, and beyond that you'll see your forecast kick in. Yes?

Julie: Yes.

Inventory Carrying Costs

Me: OK, we're getting off track a bit and going down the forecasting hole. Let's get back to inventory carrying cost. Again, the first area is *cost of money*. When your company buys, or should I say pays for, materials, it doesn't use its own money. It pays for these materials from a line of credit at the bank. Kind of a big Visa account. Payment comes from the line of credit, and when you get checks from your customers to pay for product received, this cash goes into your line of credit to pay down what you have borrowed. Your company pays interest on this money that is borrowed. So the cost of money is the interest you pay on your line of credit. This interest rate is tied to the prime rate and floats around depending on where the prime rate is. With interest rates as low as they are today, the cost of money is probably in the 6 to 7 percent range, maybe lower. I can remember years ago when the prime rate was in double digits; interest then was really steep.

The second area is a little fuzzier; this is the *opportunity cost* of the money you have tied up in inventory. If you didn't have this cash invested in inventory, you could be putting it to use in areas that would provide you with more return on your investment. Or so you would hope.

The third area is *obsolescence*. Julie, do you know how much obsolete or slow-moving material you have on the books?

Julie: I'm not sure of the exact amount, but I know that we have $300,000 of one part number in finished goods that we made to forecast and the design has changed. Those parts have been there for a couple of years, and I believe the customer will never take them. We also have $100,000 or so of parts in raw that were special parts for this same customer that we cannot use anywhere else and can't return because they are a custom part. Engineering has a list, and it's trying to substitute when it can, but it's a slow process.

Me: How much do you write off every year to obsolete?

Julie: I don't know if it's every year. When we have a good quarter, we usually get a call from finance, and they write off a little when they can.

Me: OK, team, the lesson here is, when you buy to forecast, things have a tendency to change, designs get upgraded, schedules change, and you are left hanging with materials that you can't use. Most companies budget for obsolete materials and write off a pretty good chunk of money every year. This is a cost associated with carrying inventory.

The fourth area of inventory carrying cost is related to *people, space, and equipment* to manage inventory. This is usually a big one. If you could bring material into the building, process it through the manufacturing steps to make a finished product, and ship the product immediately to a customer, there would be very little expense associated with inventory. As soon as you accumulate materials that you are not processing, you start to add costs for storage (the cost of space at so many dollars a square foot plus heat, lights, and facilities costs), inventory management (accounting for what you have and where it's located; people to track it, count it, and move it from place to place), and the associated computers, software systems, and equipment required (forklifts, conveyor systems, hand trucks, and so on). These costs for people, equipment, and facility space add up quickly to a large amount of expense.

When you add all of these categories together under the umbrella of inventory carrying cost, the number we typically use is around 30 percent. This means that if you have $10 million of inventory, the annual cost incurred is in the neighborhood of $3 million—an expensive neighborhood indeed.

Julie: We own our building. If we freed up space, how would we reduce our costs? We'd still own the space.

Me: Good question; here's where we get into the gray areas. The best case would be, you free up five or ten thousand square feet and lease it to a small company that would like to share a facility. The worst case is, you free up a bunch of space, close it off, and reduce your heating, air conditioning, and maintenance costs to maintain that space.

Jim: OK, Bill, I've got a question. *(This gentleman has been listening quietly during the session.)*

Me: Your name, sir?

Jim: My name is Jim Torney.

Me: Hi, Jim; what's your question?

Jim: It doesn't make sense to me that you would borrow money to buy materials. Why doesn't the company just pay cash for it and avoid the interest?

Me: OK, you guys are getting tough now. I think the simple answer is that it doesn't have the cash available. There is always a balancing act going on between when you spend money, and how much you spend, and when you get money to pay for your expenses. When you accept an order, there is a large amount of cash that has to be spent on people, materials, and running expenses and must be carried for several weeks while the order is being produced, with no payment coming in until quite some time after the customer receives the product. Most companies simply don't have that kind of cash lying around. We'll be talking about cash flow, specifically lean flow, later on today. I can probably make my point better during that discussion.

But let me take you back to one of my earlier questions. When we first started talking about inventory turns, I asked you how often you buy groceries. Here's another question along those same lines. I'll address it to Julie, since she does some buying. Julie, suppose you go to the market on your way home and you find that chicken has gone on sale for fifty cents a pound less than you have seen it in years. Do you fire up your Visa and buy $10,000 worth of chicken because it is such a great deal?

Julie: Nope, that would be a definite no! *(Lots of laughter from the team.)*

Me: But when I talked to some of your other materials people earlier this week, they said that large lots, usually way beyond what is needed short term, gave them the best price. That's part of their pricing and buying strategy: large-lot buying, lowest price.

Julie: Maybe that makes sense for the company, but for my personal budget, if I spent that kind of money on this one purchase, I'd be short for my other monthly expenses—mortgage, car payment, and so on. I wouldn't be able to make all my bills.

Me: Not to mention that if you had $10,000 worth of chicken, you'd have to build an addition on your garage, the same as a stockroom, and buy several freezers to store this stock in—that's a large capital expense to maintain the inventory, yes? *(The team is cracking up now. There's lots of kibitzing going on.)*

So, Julie, you're willing to pay more per pound and buy just what you need for the week. Short-term demand is the driver, offset by cash coming in every week.

Julie: Yes; I'm a very good budgeter.

Me: I would agree completely. Here's my last question on this topic. If it makes sense for you to manage your home budget—your personal business, if you will—under the guidelines of buying what you need and no more, with a tight eye on cash flow, why wouldn't you run your professional business, your company's money and resources, the same way? Doesn't good business sense transcend the size of the budget? Your home, your company, what's the difference?

Julie: I guess I've never thought of it in those terms before. I don't have a good answer.

Me: It's been an interesting session. Thanks, everybody. Let's take ten and we'll expand on these thoughts and add some stuff to look at lead times, velocity, and throughput.

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CHAPTER 6

Velocity, Throughput, and Lead Time

Me: OK, group, we're all back; let's go. In this session, we'll discuss lead time, velocity, and throughput time, and, more importantly, how they relate to one another, what factors affect them, and how they affect cash and customer service.

Let's start with some definitions, or maybe interpretations would be a better term. Mine may differ slightly from what you have heard or read about, but that's OK; we're going to end up in the same place.

Velocity is the speed at which an order moves through your facility. The idea here is, ''The faster the better.'' The longer it takes for an order to move through your plant and your processes, the more time it has to accumulate cost.

You usually see the term *throughput* used as a measure of how much product you can get through a given process—a measure of your bottleneck, if you will. I've also seen this term used as a measure of how much finished goods can be available to ship to a customer within a given time frame.

And last but not least, *lead time* is the length of time it takes to process an order through your system. You can break this one up into pieces, but from the customer's point of view, it is the time from your receipt of the customer's order to the time when the customer receives the product. This lead time is an important measure to your customer.

Velocity vs. Lead Time

Me: OK, any questions out of the gate?

Jim: Yes, I've got one. What's the difference between velocity and lead time? They sound the same.

Me: Good question, Jim. Velocity is a measure of how long it takes to process an order through your manufacturing processes, whereas lead time is a measure of the time it takes to respond to your customer with delivery of an order. I've heard slightly different definitions of these terms used by various lean practitioners, and I'm probably putting a slightly different spin on them myself. I can't remember when I started using the term *velocity*, but it's an important item to measure from my vantage point. Here's why. Everyone is chasing lead-time reduction. You get a big advantage when you can respond to your customers more quickly. Everyone gets a cost-reduction opportunity. If you reduce your lead time by one day, there is a corresponding reduction in finished goods of a day's worth of product. Here's an example: Let's say you have a customer that orders the same product over and over. Every week he orders one unit and requests that you deliver it in five days. If it takes you ten days to produce that particular product through your process, how many units of finished goods will you have to carry?

Jim: Um, one?

Me: Exactly. You can't produce within the requested delivery window, so you have to carry finished goods, one unit in this example. When you get the order, and it's a repetitive demand product, you ship out of finished goods in five days, and on the tenth day a new unit shows up in the stockroom from your production floor, in time to cover next week's five-day requested delivery. There's always one unit on the shelf and one in the pipeline. Now, if you could produce this product in three days and your customer requested delivery in five days, how many units would you have to stock?

Jim: None; you could build inside of the requested delivery timeline.

There it is. *Faster lead time reduces your need for finished goods.* Now, this example is greatly oversimplified, and if you were producing thousands of orders, you would be considering scheduling and capacity and all those types of issues. But the math stays the same.

Now consider your customer's situation with regard to forecasting and inventory. If your lead time is twelve weeks, your customer has to place his orders twelve weeks in advance, not knowing exactly what his demand will be twelve weeks into the future. So he has to forecast, which is another word for guess. Let's say your customer is selling an item that is holiday-sensitive. It's close to Father's Day, and one model of his product is selling like crazy, but it's not the model that he anticipated would sell heavily. He runs out of this particular item in his distribution chain, and he calls you for a rush order of more of the hot item. It's two weeks before Father's Day, and your lead time is still twelve weeks.

What's going to happen? He's going to lose a bunch of sales because you can't respond quickly enough, and he's going to have a bunch of excess inventory of the units that he thought would sell but didn't. His solution next time might be to increase his inventory levels on several models, just in case. If your lead time was just a few days, he would not have to forecast, and he wouldn't have to carry a large amount of inventory in his distribution chain. Lead-time reduction is very important!

Now let's talk about velocity. You decide to put kanbans in place inside of your processes to reduce your lead time to your customer. We haven't discussed kanban theory yet, so for the time being let's just say that a kanban is a queue of work in process. This is a queue of product that you sell repetitively, week in, week out. You have determined the quantity to stock from a combination of historical sales and time to replenish through your process.

Your company's important metric, what you measure, is lead time. Let's use a foundry–machine shop company example. You're selling a machined part to your customers; let's say it's a gear. The lead time through your foundry is five days, and the lead time through your machine shop is five days. So you've got a ten-day lead time. The situation is shown in Figure 6-1.

You decide to implement kanbans to reduce your lead time. Now the situation looks like that in Figure 6-2.

You are selling a highly repetitive product, so you do the kanban calculation of usage times replenishment, and you put these particular castings into kanbans (inventory queues) in your machine shop.

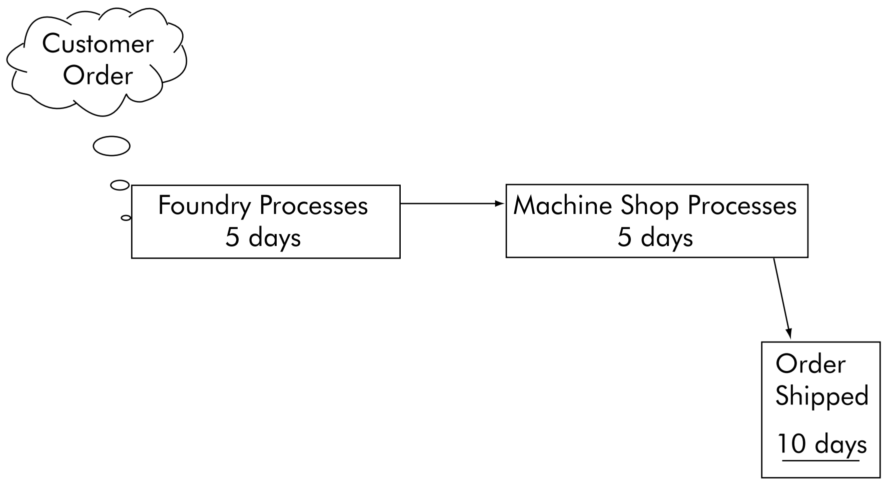

Figure 6-1

When the customer orders, you pull units from the casting kanban and trigger replenishment by your foundry. Your customer sees your lead time drop to five days. That's a great job of improving customer response! If your only metric was lead time, you would be very happy; you've cut it in half.

However, *your velocity did not change*. It still takes ten shop days to move this product through your process. You artificially reduced your lead time by creating the additional waste of more work-in-process inventory. You now have to increase your velocity to reduce the waste

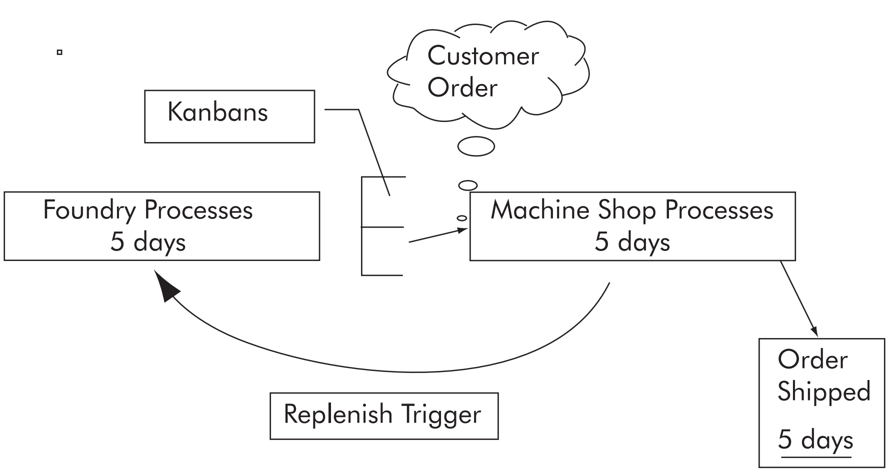

Figure 6-2

of inventory (kanbans), while maintaining your reduced lead time to the customer.

Me: Any questions so far on lead time or velocity?

Throughput and Bottlenecks

David: I've got one on throughput. You mentioned throughput as a measure of your bottleneck. Don't you have lots of bottlenecks?

Me: Your name is?

David: David.

Me: Where do you work, David?

David: Shipping.

Me: Lots of bottlenecks. What are you thinking?

David: Well, I don't know; it just seems that there'd be more than one.

Me: There may be people who would disagree with me, but my answer is that you can have only one bottleneck in a system. But here's the interesting thing: As you change things at your bottleneck to improve the speed through that area, your bottleneck will move to another area. As you improve different spots in your process, the bottleneck keeps jumping around. You'll always have a bottleneck somewhere in your total process; it just changes location as you continue to improve your business processes.

Let's take the question of bottlenecks down one more level. What does a bottleneck really mean, and why is it important to know where it is? Anybody care to take a stab?

(An older man in the back row raises his hand.)

Bill: I've done some reading on this topic. I believe it is your constraint.

Me: Exactly, but can you expand on what a constraint really means? How does a constraint affect your business? By the way, what department do you work in?

Bill: My name is Bill Higgins. I'm in cost accounting.

Me: OK, Bill, lead us down the path.

Bill: Well, a constraint is a limiting factor in your production process, or any process really. It determines how much you can get through the pipe.

Me: Ah, yes, the old pipe comparison. For those of you who have not heard the pipe comparison for a production process, the idea is, if you visualize water flowing through a pipe with sections of different diameters, the smallest diameter determines how much water can go through. It's a good visual for the idea of a constraint. OK, Bill, give me an example of when a bottleneck or constraint is not a constraint?

Bill: How about when your customer demand is well below your bottleneck limitation?

Me: Exactly. It sounds like semantics, but the terms *bottleneck* and *constraint* do imply that you are prevented from achieving something. If you are meeting your objectives, it would seem that you have no constraints.

Bill: Since we're talking bottlenecks, how does the term *throughput* come into play? You say that throughput has to do with product available to ship within a given time frame, and that it is somehow a measure of bottleneck. I hear the definition, but how do you actually do something with this theory in real life?

Me: OK, let me think. All right, let's build an example. Here's how it goes.

Let's say I run a motor company, and we build fractional-horsepower electric motors. I have two different motor assemblies that are similar and very popular with my customer base. Oversimplified, each of these two motors consists of three assemblies: a field (stator), an armature (rotor), and a motor assembly, which consists of the marriage of the field and the armature with bearings, housings, brushes, and so on. For the sake of a simple illustration, let's also say that the material costs for the stator and the motor assembly are the same for motor 1 and motor 2. The difference is in the armature. The armature for motor 1 has a 12-bar commutator, while the armature for motor 2 has a 24-bar commutator. This means that the armatures have different magnet wire windings and vary in the time needed to fuse the commutator tangs, since one has 12 tangs and one has 24. Since we pay for copper by weight, let's say that the materials price is the same for both units; although one has twice as many turns of wire, that wire is roughly half the diameter of the wire used for the other. There are nine steps in the manufacturing process. Let's look at a sample routing for each of these motors (Figures 6-3 and 6-4).

Motors Inc. Routing					Armature #1		
	Cell Target per Shift=						
	960						
		Std. Data	Per Hour	Per Shift	Ops	Totals per Shift	Std Cost
	Sequence of Activity	Cycle					
Element #		Minutes					
10	Stack	0.5	120	960	1	960	$0.175
20	Insulate	0.4	150	1,200	1	1,200	$0.140
30	Wind	0.43	140	1,116	1	1,116	$0.151
40	Wedge	0.45	133	1,067	1	1,067	$0.158
50	Fuse	0.5	120	960	1	960	$0.175
60	Varnish	0.35	171	1,371	1	1,371	$0.123
70	Balance	0.41	146	1,171	1	1,171	$0.144
80	Test	0.3	200	1,600	1	1,600	$0.105
90	Inspect/pack	0.35	171	1,371	1	1,371	$0.123
						Unit Cost	$1.294

Figure 6-3

Motors Inc. Routing							
	Cell Target per Shift=			Armature #2			
	495						
		Std. Data	Per Hour	Per Shift	Ops	Totals per Shift	Std Cost
	Sequence of Activity	Cycle					
Element #	Minutes						
10	Stack	0.25	240	1,920	1	1,920	$0.088
20	Insulate	0.28	214	1,714	1	1,714	$0.098
30	Wind	0.43	140	1,116	1	1,116	$0.151
40	Wedge	0.45	133	1,067	1	1,067	$0.158
50	Fuse	0.97	62	495	1	495	$0.340
60	Varnish	0.35	171	1,371	1	1,371	$0.123
70	Balance	0.29	207	1,655	1	1,655	$0.102
80	Test	0.3	200	1,600	1	1,600	$0.105
90	Inspect/pack	0.35	171	1,371	1	1,371	$0.123

Unit Cost	$1.288

Figure 6-4

Let's summarize the costs for these two products.

Motor 1	Stator labor	$1.458
	Armature labor	$1.294
	Motor labor	$1.313
	Materials	$12.368
	Total direct costs	$16.433
Selling price:		$21.50
Motor 2	Stator labor	$1.458
	Armature labor	$1.288
	Motor labor	$1.313
	Materials	$12.368
	Total direct costs	$16.427
Selling price:		$21.50

Me: OK, Bill, in looking at these two models, what are your observations?

Bill: Well, my first thought is that model 2 is marginally more profitable to produce.

Me: How so?

Bill: As a cost accountant, I look at contribution margin when we evaluate product volumes and mix. Motor 2 has a slightly higher contribution.

Me: Can you explain briefly for the group what that means and how it applies to the example we're using?

Bill: Sure. A product's contribution is simply the direct costs to make it subtracted from the selling price. Direct costs are the materials used and the direct labor to manufacture the product in question. In your example, both motors sell for $21.50, but the direct cost for motor 1 is $16.433 and the direct cost for motor 2 is $16.427. If you do the math, the contribution for motor 1 is $5.067, while motor 2 gives you $5.073. You make a bit more money by producing motor 2.

Me: OK, so how would you use these numbers in making a decision for your business?

Bill: Well, when we look at mix and capacity, if you can fit only so many products into today's build, you run the products with the highest contributions. In this example, we would run motor 2 instead of motor 1 because the numbers are bigger.

Me: Does your contribution theory consider the flow of the product through the plant?

Bill: No. It's the job of the production guys to run the product; in accounting, we're interested in the profitability.

Me: I understand. Let's analyze these routings a little more closely and introduce the real-life issue of throughput and bottlenecks. This example addressed your question of how you would use throughput theory in real life. In this example, I'm going to make element 50, fusing, my bottleneck. Fusing is the hot staking of an armature commutator tang over the copper wire to connect the unit electrically and burn the insulation off of the magnet wire. It requires a very specialized machine. You will notice that fusing on motor 1 takes 0.5 minute, while fusing on motor 2 takes 0.97 minute; the fusing time for motor 2 is almost double because motor 2 has twice as many tangs on its commutator. Using all available fusers allows us to produce 960 units of motor 1 or 495 units of motor 2 per eight-hour shift. The best we could do would be to run three shifts on a given day. Here's the math.

Motor 1: 960/shift × 3 shifts = 2,880 per day × \$5.067 contribution = \$14,592.96

Motor 2: 495/shift × 3 shifts = 1,485 per day × \$5.073 contribution = \$7,533.41

Me: So, Bill, what do you think about these numbers?

Bill: I guess I'd have to say that conventional contribution theory, without consideration of the process bottleneck, would have caused us to make a bad decision on what product to run. You've answered my question on how to use throughput theory in real life. Before seeing this illustration, I would have said that running a lower-contribution product was contrary to good business logic.

Me: It is a bit counterintuitive. Cost and profitability of products are important considerations, but they must also be balanced against product flow through your plant to get the total picture of cash impact. OK, any questions on these three terms or their impact on your company and your customer? We'll get into more examples later on in the session, but I think we've covered the initial topic enough for now.

CHAPTER 7

Batch and Queue vs. Lean Flow

Let's look at a typical batch operation—a hypothetical factory with five operators (departmentalized) working in a 45,000-square-foot facility, with the triangles representing inventory queues (see Figure 7-1).

To be more precise, this would be called a batch-and-queue model. In this production method, large orders of product are produced through a series of operations, with the entire product order or batch being sent from one operation to a queue (holding area) before the next operation is started. This mass-production approach is the opposite of single-piece flow in a fully integrated lean environment. With this technique, an order of product is kitted out of stock and sent to the queue holding area for Department 1. Department 1 performs its work on the order, and when the work is complete, the order is moved to the queue for Department 2.

These various queues usually hold several orders for various customers with different due dates. These large orders work their way through the facility in this fashion until they finally arrive at the finished goods stockroom or the shipping dock to be prepared for shipment to the customer. Since each department is already working on previous orders or batches, there is storage before and after each department. It is common for this type of operation to consolidate or-

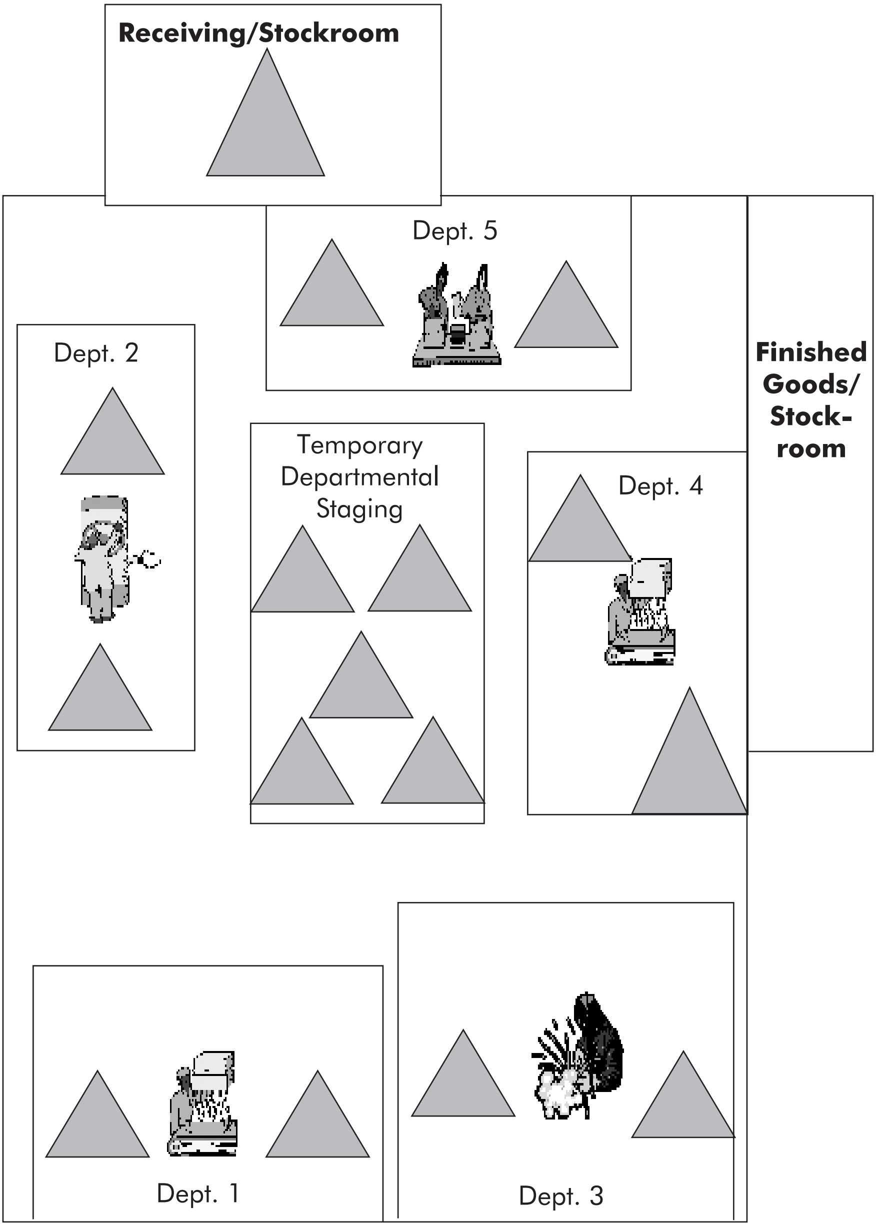
Receiving/Stockroom
Dept. 5
Dept. 2
Finished Goods/ Stock- room
Temporary Departmental Staging
Dept. 4
Dept. 1
Dept. 3

Figure 7-1

ders of like product to minimize changeover time and maximize machine uptime (utilization).

Now let's have a look at a theoretical lean flow operating model (see Figure 7-2).

Here are the stats for this model: Five operators are working in a 15,000-square-foot facility with small work-in-process queues. (Notice that there are no triangles, since there is no inventory buildup.)

In this production method, the total process workload has been analyzed, and an equal amount of time is required at each operation to move a unit (one piece) to the next operation—in other words, the operations are perfectly balanced. (Right about now, the manufacturing guys reading this are falling off their chairs as they compare this illustration to real life. Hey, guys [and gals], this is the goal; I'll make it anything I want.) So far, so good. The material comes from receiving to the first operation, and when the first operation is complete, the first piece is immediately passed (that's right; all processes are physically linked together) to the next operation. This facility is much smaller, with 15,000 square feet, since everything is coupled and I have very little inventory in queue.

OK, let's put some money into play as we consider these two manufacturing techniques.

Let's go back to the batch model (Figure 7-3).

Let's run this factory for a day. At 6:00 A.M., we receive \$2,000 worth of raw material on our receiving dock. We have a stockroom, and we always have about \$3,000 of raw material there, even though we continue to receive more every day. There are five operations in

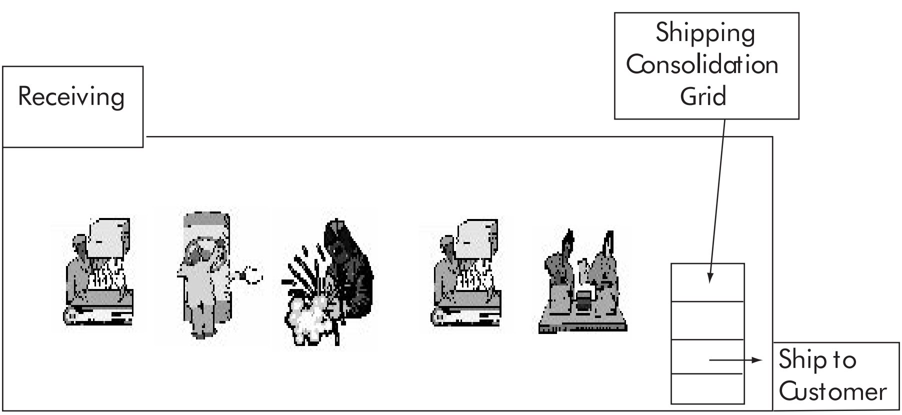

Figure 7-2

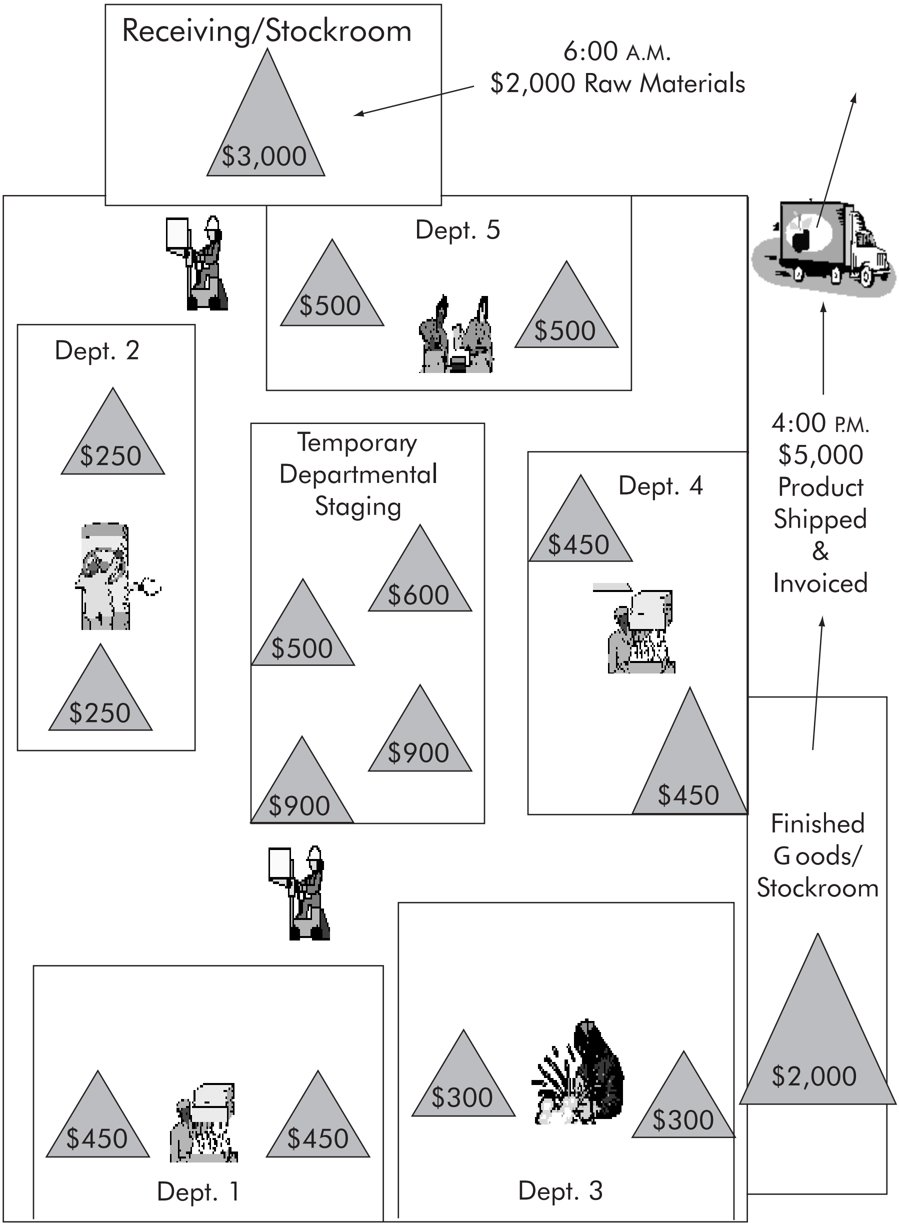
Receiving/Stockroom
$3,000
6:00 A.M.
$2,000 Raw Materials
Dept. 5
$500
$500
Dept. 2
$250
$250
Temporary
Departmental
Staging
$600
$500
$900
$900
Dept. 4
$450
$450
4:00 P.M.
$5,000
Product
Shipped
&
Invoiced
Finished
Goods/
Stockroom
$2,000
$450
$450
Dept. 1
$300
$300
Dept. 3

Figure 7-3

our process. The workload has been analyzed at the department level, but no attempt has been made to balance the departments or to combine any part of any operation with the following processes. (Right about now, the manufacturing guys reading this are thinking, "That looks like my shop.") So far, so good. The first operation will finish the entire lot before any product is sent to the next operation. My facility is 45,000 square feet—mostly occupied by materials—with aisles to let all those forklifts move around the plant. Over the course of the day, I consume $2,000 of raw material, and $5,000 of product is shipped to customers (*with invoices*—the money clock is ticking). Everybody goes home; the building is full of work in process. Tomorrow we'll do it all over again.

Here's the batch math. We pay our people $10/hour or $80/day (× 5). We received $2,000 of materials. Today, we have $3,000 in raw materials inventory, $6,800 in work-in-process inventory (queues), and $2,000 in finished goods inventory. Our overhead is $600/day for factory costs, payroll, and so on. We shipped and invoiced $5,000 of product.

The tally for the day is:

People	$400
Materials	$13,800
Overhead	$600
	$14,800

We tied up (invested) $14,800 for the day, with a return (shipped and invoiced) of $5,000.

Let's have a look at a lean flow operating model (see Figure 7-4).

It's the same day; let's go. At 6:00 A.M., we receive $2,000 worth of raw materials on our receiving dock. This material flows to station 1 over the course of the day. With the balanced flow, as a piece is fabricated in station 1, it moves immediately to the next operator at station 2, and so on, until it reaches the shipping consolidation grid. Over the course of the day, all the raw material is consumed, and at the end of the day, $5,000 of product is shipped to customers (*with invoices*—the money clock is ticking). Everybody goes home; the building contains no people or inventory. Tomorrow we'll do it all over again. Oh, I almost forgot—my throughput time is one day.

Here's the lean math. We still pay our people $10/hour or $80/day (× 5). We also received $2,000 of materials for the day. Our

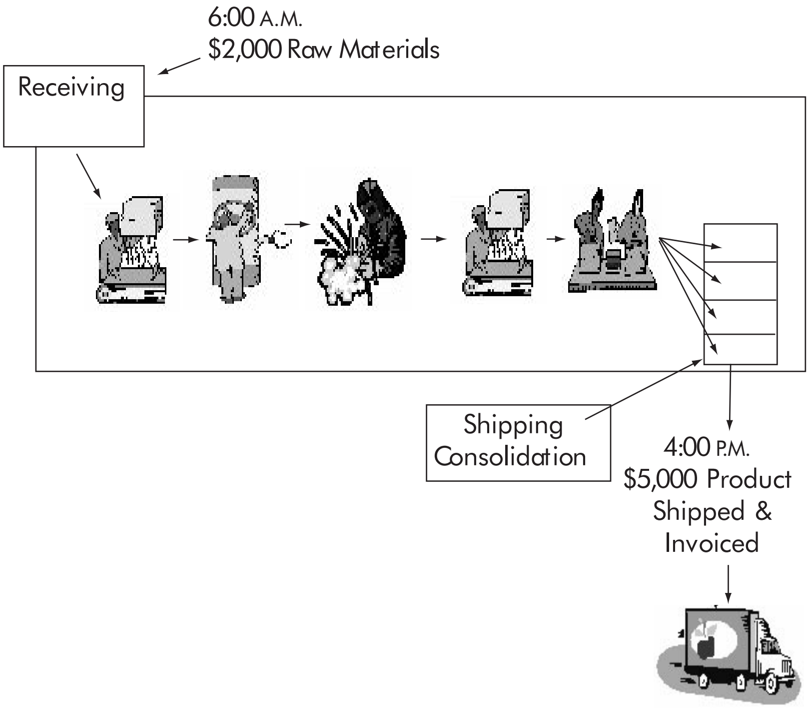

Figure 7-4

overhead remains at $600/day for factory costs, payroll, and so on. We shipped and invoiced $5,000 of product.

The tally for the day is:

People	$400
Materials	$2,000
Overhead	$600
	$3,000

We tied up (invested) $3,000 for the day, with a return (shipped and invoiced) of $5,000.

I won't get into the calculations for return on assets employed or return on investment (you can crunch the numbers if you care to). We'll look at the proportions and keep it real simple.

Now I ask this simple question: If you were concerned with return, which operation would you invest your money in?

CHAPTER 8

WASTE

One of the cornerstones of the lean philosophy is waste elimination. When I walk through many facilities, I see large motivational signs hanging here and there with slogans like "Eliminate Waste!" Instinctively, you have to agree that this sounds like a good thing to do. It makes sense; let's all get out there and eliminate some waste!

It's not uncommon to see these posters hanging over several thousand dollars of work-in-process materials, or hanging over aisles where forklift operators are busily transporting large batches of materials from one department to the next. I once saw a similar poster hanging over an inspection bench.

This raises a question: If waste elimination is a priority, than why is it so common to see so much waste when you do a walk-around in the typical plant? Apparently people are being directed to eliminate waste, but are not being collectively trained in exactly what waste is.

I think the slogan should be changed to "Identify Waste!" Most employees would respond to this directive with, "I'd be happy to identify waste—what's it look like?" With that thought in mind, let's talk about what constitutes waste and what it looks like.

It would seem that the answer to the question "What is waste?" should require only a little common sense to put together. After all, everyone understands waste, right? The assumption that people understand the meaning and impact of commonly used words is one of the basic challenges to changing and improving a business. More about communication later.

As you walk through any company, be it manufacturing or otherwise, everything you observe can be translated as having one of two impacts:

1. Generates revenue
2. Adds cost

Let's noodle this around.

Example 1

You observe a person carrying parts from one department to the next. This activity takes her 6 minutes. Her rate of pay is $15.45 per hour, with fringe benefits worth $4.50 per hour (fringes at 29 percent, which is not uncommon). This makes this person's total cost to her company $19.95 per hour, or $0.33 per minute. The activity in this example cost $1.99 (6 minutes times $0.33) to perform and did not result in a product's becoming more complete in terms of the customer's specification. This person will receive $1.99 in her next paycheck for this time spent. The company will receive no money from a customer related to this 6-minute activity; it is not an activity that can be invoiced. This person accumulated cost and generated no revenue.

Example 2

You observe an operator assembling fractional-horsepower motors in his work area. The last component of his assembly cycle, the motor housing, is staged on a cart eight feet from the point of assembly, requiring the operator to walk to and from the cart during each work cycle. This walk-about averages around 11 seconds per cycle (11 seconds is nothing, right? we've got bigger things to worry about). This station produces 100 units a shift and runs three shifts a day. The effect of this layout and the cost of this specific activity is 100 units per shift times 3 shifts times 11 seconds per unit, which equals 3,300 seconds, or 55 minutes per day (across 3 shifts) of walking to and from the cart. Let's use the same labor rate as in Example 1. Now, 55 minutes per day times 260 days per year equals 14,300 minutes per year. At $0.33 per minute, 14,300 minutes adds up to an annual cost of $4,719 for this particular station. These 11 seconds of walking in the middle of one specific assembly cycle add almost $5,000 of annual cost to the company and generate zero dollars of revenue.

The typical reaction of most production management folks to this type of observation is, "Hell, it's only 11 seconds. I can't be worried about that level of detail; I've got larger issues to deal with." Let's expand on this observation. Activity is being mistaken for work, and a few seconds here and there are considered too trivial to be concerned with. If we see everyone moving at a breakneck pace all day, we happily assume that everyone is working very hard. OK, now suppose that I have 400 assemblers in my plant, across three shifts, and my layouts have not been closely looked at. The observation in Example 2 applies to my entire operation. During the course of most assembly cycles, my operators are spending several (unnecessary) seconds gathering parts because of excessive distance in my workstations' layouts. Using the number from the earlier example, 11 seconds per cycle, times 100 units per operator per shift, times 400 operators, times 260 days per year, times $0.33 per minute equals an annual cost of $629,199. My father would have called this amount of cash "walking-around money," meaning a lot of it. In this example it literally is walking-around money. This type of activity adds cost and generates zero revenue.

"But it's only 11 seconds!"

Example 3

You observe a quality inspector busily performing a final inspection on a completed refrigerator prior to the unit's being shipped to the customer. This inspector is following a checklist and looking for dents, blemishes, correct placement of UL and serial stickers, correct number of shelves and bins, cleanliness, silicone and tape removal, sharp edges on the metal surfaces, correct assembly and placement of screws and fasteners in the unit, door seal integrity and alignment, and so on. This individual is working diligently; she believes that she is performing important work and assuring the customer of a quality product. Upstream operators have performed all operations contributing to the completion of this product. It is a finished product. Looking at (inspecting) the unit cannot change its physical characteristics. The inspector finds the unit to be satisfactory, fills out several quality logs, and allows the unit to proceed to shipping. Inspectors in this company are paid at a rate of $15.45 per hour and have a fringe benefit package worth $4.50. Total cost per hour for this activity is $19.95, or $0.33 per minute.

The time required to inspect a unit averages fifteen minutes or so. Let's add this one up. We have 15 minutes per unit, times $0.33 per minute, times 30 units a shift, times 2 shifts per day, times 260 days per year, and on and on. The annual cost added by this specific activity at this specific workstation is $77,220. The annual revenue generated from this activity is $0.

Having fun? Let's do some more.

Example 4

A supervisor in an electric motor plant has four people who run Artos lead-cutting machines. They have completed cutting and stripping the leads required for the week's production requirements. This supervisor is being measured in a standard cost environment, meaning that if he produces product, he earns standard hours, regardless of whether the product is shipped to a customer or goes on a shelf in the stockroom. He wants his efficiency to look good, and he needs to keep his people busy. He pulls some raw lead wire coils, part 001, from stock and runs a four-inch lead, part 123, that is commonly used in the plant through these four machines for the last two days of the week. He produces 400,000 leads, uses up all the raw lead wire, part 001, in the plant, turns in the production counts, earns 72 standard hours, and sends the product to the stockroom. His four Artos operators worked 64 actual hours to produce these leads, providing an efficiency report showing 113 percent efficiency for these two days. This supervisor's boss gives him a "well done" on his effective use of his staff. When these products are received in the stockroom, the stock people carry out several inventory transactions and place the units in the correct location.

It sounds like this guy is doing a great job of running his department. But what's the effect? He worked four people for sixty-four hours producing product that will go on a shelf—there's no invoice in the mail for this activity.

The raw lead wire, on the coil, can be used to produce a wide variety of leads, whatever the length required may be. The materials people are ordering raw material based on orders in the system.

When this material is consumed to build stock, the ability to produce a variety of different part numbers to satisfy customer orders is lost. When next week's schedule comes out, it is discovered that there is a shortage of raw lead wire, part 001, to produce the eight-inch leads required by the particular models in demand. There are lots of four-inch leads in stock, but there is no material to produce the eight-inch leads that we need.

Imagine that.

Why do these darn materials people keep letting us run out of parts?

The materials people fire up their telephones, jump through hoops, and expedite getting more lead wire, paying a FedEx rush premium for shipping. They save the day by getting the additional material in time to complete the orders on hand. (Does this example sound familiar to any of you manufacturing folks out there?)

There are some manufacturing executives who would say that this is an example of a very effective supervisor getting the job done—maintaining high labor efficiency and machine utilization. And let's not forget the materials people. These are "can do" people who will put forth the effort and make it happen. They really know how to turn up the heat and get materials into the plant! (We love adrenaline!)

There are others who would say that this supervisor created an enormous amount of additional cost in several areas of the facility by producing product that nobody ordered. The activity described in this example, in production, in the stock room, and in the purchasing group, generated zero revenue.

I could go on with examples in many industries, and we might do that later, but for now let's get back to waste.

Seven Categories of Waste

There are several categories of waste that are addressed by lean theory, the most general being:

1. Overproduction
2. Unnecessary inventory
3. Transport
4. Process
5. Activity resulting from rejected product
6. Waiting
7. Unnecessary motion

These activities add cost and do not cause a product to be transformed into a more complete product, from the customer's vantage point. They are non-value-added activities, as they add no value from the customer's point of view.

I have had people comment that an additional category of waste is unused people potential. While I agree in concept, this area is difficult to observe or measure, so I will defer this topic to a later chapter.

When I discuss these seven areas of waste with groups who are evaluating their operations, I like to add an eighth category called work. (Obviously, this is a separate category, not part of waste.)

8. Work

Work is the activity that generates revenue by causing the product to change form to a more complete state. Product is actually being built. This type of activity adds value to the product in the customer's eyes.

As you observe all activity that goes on in your facility, everything that you see should fall into one of these eight areas. Let's discuss these areas in detail.

Overproduction

Overproduction, as the name implies, means producing more than you need to produce. You might ask, why would anyone produce more than he needs to? That doesn't sound like good business. A better question might be, how do you determine what you need to produce, what is your true demand? This is a bit tougher and is subject to manipulation in the definition and timing. Let's play with this question for a bit.

Let's say I own a restaurant that specializes in fried oyster sandwiches. I have a thriving business, and over time I have determined that I will sell somewhere in the neighborhood of 1,200 oyster sandwiches on the average day. I'm open Monday through Saturday, closed on Sundays. I open up on Monday morning, and my first three customers walk in and order an oyster sandwich each. Pretty easy so far; my demand is three sandwiches. I fry them up, deliver them to my customers, and present them with their bill (invoice), and they give me the amount of money due. Great cash flow, by the way!

My inventory is perishable (oysters and bread), so I have my bread delivered fresh every morning and carry enough oyster inventory to cover a touch over my forecasted typical day, enough to put together about 1,400 sandwiches. I can cover a little spike in demand, but if that doesn't happen, I'm good to go into the next morning with no worry about inventory shrinkage due to spoilage. Here you could say that I am planning my materials to forecast; I have no hard orders.

My product is a sandwich, and I build sandwiches (turn raw materials into a finished product) in response to hard orders. I fully expect to build around 1,200 sandwiches a day. However, when no demand exists (there are no customers in the shop), my cook and three waitresses do not continue to build product. They don't come in and start the day by making 1,200 sandwiches. Instead, they engage in non-value-added activities—cleaning, organizing condiments, discussing ways to improve our menu selection and customer satisfaction issues, and so on. There's no overproduction here. Right about now I can hear the objections mounting: "No fair! A restaurant is not the same as a manufacturing operation." Right you are; let's take a minute and examine the differences.

Here's how a restaurant works:

1. You define and design your intended product (oyster sandwiches).
2. You purchase or lease a building.
3. You buy or lease tools and equipment (refrigerators, freezers, stoves, tables, etc.).
4. You hire and train people.
5. You purchase raw materials (oysters, bread, etc.).
6. You make your product and sell it to customers.
7. You invoice your customers for product delivered.
8. You cash the checks.
9. You pay your bills (people, materials, facility costs, etc.).

And, here's how a manufacturing operation works.

1. You define and design your intended product (fractional-horsepower motors).
2. You purchase or lease a building.
3. You buy or lease tools and equipment (winders, fusers, stackers, hand tools, work benches, etc.).
4. You hire and train people.
5. You purchase raw materials (steel laminations, copper wire, housings, bearings, etc.).
6. You make your product and sell it to customers.
7. You invoice your customers for product delivered.
8. You cash the checks.
9. You pay your bills (people, materials, facility costs, etc.).

See the difference? Enough said. Let's go to a manufacturing example.

Case in Point. I'm now the owner of a small company that produces steel gears and pulley systems. I have a good customer base, and I supply a wide variety of systems for a broad spectrum of applications. My process is (1) foundry, (2) machining, (3) assembly, and (4) paint. My primary measurement in my foundry operation, driven by my standard cost accounting system, is weight of metal poured per day. I tell my employees, ''We're making money only when we're pouring steel.'' I like to say that; it makes me feel really savvy.

My foundry guys are a sharp bunch, and they know that the first question at the daily production meeting will always be, ''OK, guys, what was your weight yesterday?''

The process of making steel castings to machine into finished steel parts, greatly oversimplified, consists of making a hole in a box filled with sand and pouring liquid steel into the hole in the sand. This box has a top and a bottom, called the cope and the drag, that when put together form a three-dimensional hole in the sand that steel can be poured into. In addition, a pathway has to be created to allow the liquid steel to enter this hole. The item that is used to make the imprint in the sand is called a pattern, with the path to enter created by a riser. After the liquid steel cools and returns to a solid, the casting is knocked out of the sand, the risers are cut off, and the casting is ground to allow machining to take place.

My molding box is capable of holding four patterns to make imprints for castings, as shown in Figure 8-1.

So far, so good? OK, now comes the interesting part.

I have orders today for 50 of casting 135 and 100 of casting 346. These are my total orders for the day. I have one pattern for casting

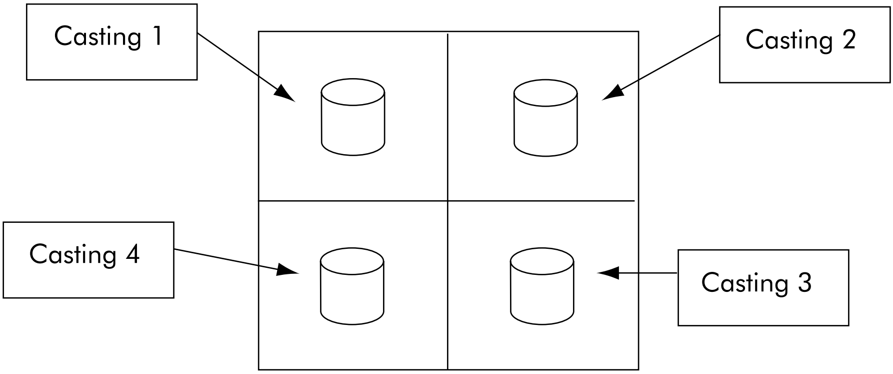

Figure 8-1

135 and two patterns for casting 346. Since I can fill only three of the four segments with my available patterns, I will fill the fourth cavity with the largest casting that I can come up with, as in Figure 8-2. After all, I'm being measured by weight poured, with no metric to connect my production to sales dollars shipped or inventory quantities.

Like so! Overproduction at it's finest.

Here's where you can rationalize demand over different time frames. I do not have an immediate demand (a hard order) for this large casting, but I know that someone will order some of these someday. We'll just hold it in inventory until an order comes in, and then we'll already have a jump on it. Management may ask why inventory keeps increasing, but the higher priority is my daily performance, more specifically, "OK, guys, what was your weight yesterday?"

What you measure will drive behavior, and conventional metrics will often cause good managers to make bad decisions.

Unnecessary Inventory

Unnecessary inventory, again as the name implies, is inventory that is not needed. Now, how can you tell when inventory is not needed, you might ask. Well here's a thought: If inventory is sitting idle somewhere (anywhere) in your facility, with nobody working on it, is it needed? There are pretty much only two ways to accumulate inventory that is not needed: buy it or make it.

The first question is, why would you make product that is not needed? We discussed this in the overproduction section. Gotta keep our people busy, gotta keep those expensive machines running.

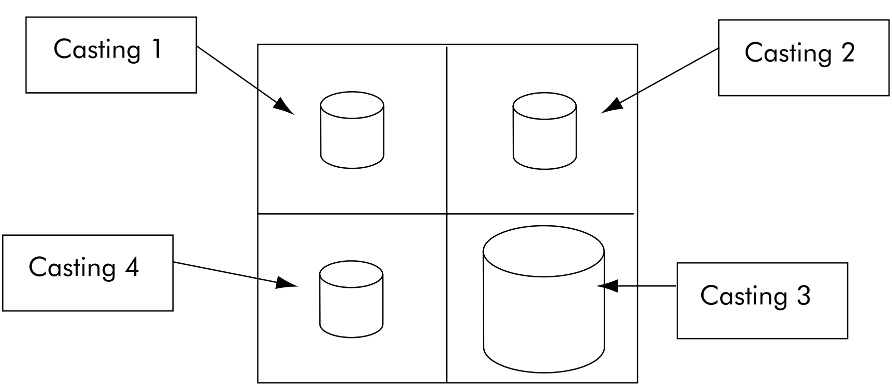

Figure 8-2

And so the next question would be, why would you buy materials that you don't need? There are lots of reasons, and the problem is that they all sound like they make sense, at least on the surface. Let's try some out.

Me: So tell me, Karl, why do you have 120 days of housings on hand?

Karl: Let me explain, Bill. Our vendor has a minimum order quantity.

Me: I see. So you can't buy smaller quantities?

Karl: No. If I were to buy smaller quantities, my cost per part would go up, not to mention my shipping cost because of more shipments of smaller quantities.

Me: So you could order just what you need, but you feel that the cost offset doesn't make sense?

Karl: Exactly.

Me: What are you currently measured on?

Karl: My primary measurement is PPV, with a secondary for shipping cost.

Me: PPV?

Karl: Yes, purchase price variance. At the beginning of our year, I develop a budget that defines price per part for the coming year. I also develop a shipping cost based on the order quantity for each part and the number of shipments it will take to get the parts delivered. Over the course of the year, I am measured on whether I am over or under costs in these two areas, the variances.

Me: What about other costs associated with the material you purchase? Isn't that a factor in part cost?

Karl: Such as?

Me: Well, let me think of an example from your operation. OK, here's one. You buy magnet wire to wind your motor armatures from two vendors. Both vendors have identical specifications on their wire and insulation chemistry; however, vendor A causes about 5 percent more rejects for internal electrical shorts than vendor B. Your manufacturing guys use as much of vendor B's wire as you have in house and switch to vendor A's wire only when forced to. They claim the insulation on vendor A's wire is more brittle, hence the insulation breakdown and resulting electrical shorts. You have a huge cost associated with cutting the magnet wire out of rejected armatures and scrapping the parts. The only components you can save are the shafts. Are these costs for scrap and rework labor factored into your part price from vendor A?

Karl: Wait just a minute, Bill; I'll tell you the real story! I've had this vendor in, and we've discussed rejects and quality issues. We've analyzed the insulation, and it is the same as that of our other wire vendor. This is a manufacturing quality problem. Our analysis can't find any difference in wire.

Me: I see. So, same machines, same people, same product, but you switch wire from one vendor to another and get an immediate jump in rejects. Your analysis can't come up with a difference in insulation characteristics. Why don't you forget the analysis and simply switch to the wire that performs better in your application?

Karl: The guys on the floor need to figure out what is wrong with their tooling. If I switched to vendor B for all our requirements, the purchase price variance would look bad. I'm not going to look bad because they can't solve their tooling and equipment problems.

Me: Hmm, manufacturing problems, yes, I understand. Looks like we kind of veered away from unnecessary inventory and slid into the rejects category. It's interesting how these categories are all interconnected. Let's go back to PPV. So, Karl, how do you get the lowest possible price for any particular part?

Karl: That's easy: Buy the largest possible quantity, and get delivery in full truckloads.

Me: It will sit in the warehouse for months.

Karl: I'm not measured on days of inventory on hand, Bill, I'm measured on purchase price variance.

Me: Got it!

Transport

Transport is moving stuff from place to place. This happens a lot in the typical manufacturing company with a batch-and-queue philosophy. We move materials into our building and take them to receiving. We move our materials from receiving to a staging area for incoming inspection. We move them from inspection to the staging area for the stockroom. We get the materials and move them to a stock location.

Sound familiar so far? Let's move the materials some more. We get materials from stock and move them to the first production operation. We perform the first operation and move the parts to a staging queue. We get these parts and move them to the next production operation, and on and on throughout the production process. When this batch of parts is complete, we move them to final inspection, do the inspection, and move them to the stockroom again. We then pull units from stock and kit orders for a move to shipping. We then move the order from shipping to the truck loading area, and, last but not least, we put them on a truck. These are gross moves around the facility; let's look at a smaller subset.

We have floor conveyor systems to move units from one workstation to the next, usually with several units in between operators. We have overhead conveyors to move product through various processes. We have sophisticated automated systems to move and retrieve product and kit orders from storage upon demand.

And let's not forget the "double move." I have rarely seen a material handler go to a staging area to pull a particular order of parts without having to move a couple of orders out of the way to get the needed order, then move the orders that were in the way back to their position in the queue. It's like a *Seinfeld* episode. I can see Jerry saying to George, "I'm telling you, they double moved."

Any transport of product falls entirely into the waste bucket. When product is being moved, it is not being transformed into a more finished stage; it is merely being moved from one place to another. People seem to have a tough time with this one. I was working with a team in one facility, and there was a fellow who would not give up on this category. Materials in this plant were brought in and moved about 800 feet to a position on receiving racks. From these racks, they were moved once again to the first step in their manufacturing process. This gentleman argued that the materials had to be brought into the facility from the trucks they arrived on, a common-sense approach. I conceded that they did need to be brought into the building, but I posed the question, "Do they need to be transported 800 feet to the initial staging area?" Surprisingly the response was, "Yes; that's where the racks for receiving are."

Huh?

Getting out of the box is difficult sometimes.

Companies tie up a great deal of cash in support of the activity of moving materials around. I have been through many facilities where I've been shown elaborate conveyor systems that transported product all over the plant. I have seen elaborate automated stockroom systems to put and retrieve. It is common to see several forklifts zipping around the average facility. This type of equipment is expensive to buy and maintain. On the people side, maintenance and material-handling jobs are commonly at the top of the pay scale in most operations. Remember, these areas generate no revenue; they merely add a great deal of cost.

Process

Process waste can have a number of different causes. One example that comes to mind: An assembler is using a jig or fixture that sticks when it is closed and requires a hand adjustment or jiggle to compensate during each cycle. In addition to wasting time, this type of process problem is very irritating to the person working at this station. Here's another one that I see frequently when fasteners require a certain torque. An operator puts a bolt and drives it into position with an air or power impact wrench. He then sets the impact wrench aside and goes to a cabinet where a calibrated torque wrench is kept safely in its container. The operator gets the torque wrench, returns to his work area, and torques the assembled bolts to the required torque specification. In this sequence of activities, the entire secondary torque operation is wasted activity. There are torque drivers on the market that will both drive and torque in the initial sequence. When I see this type of activity and question management about purchasing the correct tools for the job, I usually get the same answer.

"But Bill, those guns are quite expensive! It only takes a minute or two to use the torque wrench."

If you calculate the go gets, secondary torque, and put-aways involved in this type of two-part operation and turn this time into cash, the correct tooling usually pays for itself in very short order.

I was recently performing a lean-engineering analysis of a process for manufacturing refrigerators and freezers. In analyzing the tasks involved in the assembly process, I found that the high station in the process was the station where the completed unit was cleaned prior to packing and shipping. As I documented the activity, the operator sprayed cleaner and wiped down the units with a cloth over and over, often cleaning the same areas two or three times. She wanted to make very sure that the units were very clean when the customer received them. I gave her high marks for her concern for quality and her diligence in paying attention to detail; however, she was adding unnecessary cost by doing much more than was actually required to provide an acceptable product. This is commonly called overprocessing. This type of process waste is usually performed in the name of quality.

Here's an example that I see frequently when parts are pressed together. An operator places parts into a press and activates the press, and the press slowly moves down to complete the coupling operation. The ram is set so that there are several unnecessary inches of space above the parts. During the first fifteen seconds of the operation, the machinery is pressing air prior to contact with the parts. The next ten seconds complete the coupling task. During the next twenty seconds, the ram retracts to the up and stop position. If the ram were set with just sufficient space to comfortably place and remove the parts, with the ram distance lowered accordingly, this cycle time could be cut in half.

I like to categorize setup and changeover cost as process waste. These activities are non-value-added (waste) and are highly process-sensitive. The extent to which quick-changeover tooling and techniques are used falls under the definition of process. More about setup reduction later.

Rejects

Reject/rework-related waste is a big one for many companies. Cost that is directly related to rejects and the associated rework is pretty straightforward. A product is worked on until the point in the process where someone determines that something is wrong—a characteristic is out of specification; something doesn't look quite right; something doesn't meet the aesthetic expectations. For whatever reason, in the name of quality, a member of our production team has stopped this unit from proceeding to the next step in the process. Up to this point, we have accumulated cost for materials and cost for labor for the operations performed. Once this unit is rejected from the production stream, we begin to accumulate a huge amount of cost, all of it falling into the category of waste, non-value-added from the customer's view. And so it goes.

Enter Mike, an assembly-line tester. Mike has found a suspect stator on his line and sees his supervisor, John, coming down the center aisle toward him.

Mike: Hey, John, I don't like the looks of this stator.

John: Did it fail on test?

(The negative money clock has just started ticking for these people. They are now adding cost rather than generating revenue.)

Mike: It passed the electrical, but it was in the high range on resistance. There's a ding on the mag wire. You know KB Electric; their incoming inspectors might reject this for damage if they see it. What do you think?

John: I don't know; let's call engineering and let them make the call. How many of these have you seen?

Mike: I do a visual spot check only every hour or so. We'll have to go through the last hour of production to visual them. That's around 200 parts.

John: Damn; we'll have to pull all those parts and inspect them. Where are they?

Mike: Staging for motor assembly.

John: All right, we'll deal with them later. Let me get engineering out here to take a look.

(John now goes to the nearest phone and dials the extension of Jim Haslow, the applications engineer for this product line.)

John: Hey, Jim, we need you to come to the K field line to look at a questionable stator. It passed electrical, but one of the coils has a dent that we're concerned will get it kicked out at incoming visual inspection.

Let's cut to the chase on this example. The typical sequence of activity that would follow could be something like this:

1. Engineering reviews the condition and determines that the parts are usable within a certain range of coil disfiguration. It establishes an inspection criterion that is subjective and difficult for line operators to follow, such as, "This size dent is acceptable, but more than that is cause for rejection and scrap out."

2. Quality Assurance personnel get involved and document the discrepancy and the procedure for sorting and repairing.
3. Materials people pull the suspect lot and bring it to a sorting/rework area.
4. Line repair operators visually sort for damage. Accepted parts are repacked and forwarded to motor assembly. Rejected parts are sent to the salvage area, where the coils are cut out and the lamination stacks are returned to the stator line. The copper that has been cut out is sold to a scrap dealer, and associated scrap and processing paperwork is generated.
5. These reworked stacks are reinsulated, rewound, have new leads and brushes connected to the coils, are assembled with leads oriented and tied to the coils, and finally are retested. This entire sequence has already been performed once; this work is all the second pass through the system. As these parts pass through the system the second time, they are consuming time in which new product cannot be run—kind of a double negative impact.

And so on. I'm probably leaving out a few steps; however, the point has been made. If you assign cost to all of the activities across the various departments involved, you will find that an enormous amount of time and money have been spent in response to this rejected parts example. You will have to process many, many new parts to pay for the additional cost created here. If you wish to turn this example around, you could say that many, many new parts will be produced at zero margin to cover the expense of these rejected parts.

Waiting

There are many reasons that people wait during the course of the day. To name a few:

1. Waiting for materials to be delivered to your work area.
2. Waiting for inspection to perform a required task.
3. Waiting for information from a number of sources—engineering, supervision, scheduling.
4. Waiting on equipment cycle time. This one is common in facilities that have Computer Numerical Control (CNC) machine centers. Operators load parts, begin the machine cycle, and wait for the machine to run through the cycle activity. I have seen operators wait through cycle times as long as seventy or eighty minutes. The management teams in most of these operations will argue that the people are working because parts are being produced. Not so; waiting is waiting. We'll cover this area in more detail when we discuss work sampling.

Unnecessary Motion

Motion is a waste category that refers to people. This has to do with areas where work is being performed. If you observe the layout of a typical work area with an eye to what many people call the ''strike zone'' (baseball term), it is common to see excessive distance traveled or reached to by people during the course of their operation. Excessive twists or turns, lots of walking, uncomfortable reaches or pick-ups, lots of turnarounds when required parts are stored 180 degrees behind people, and on and on, contribute to wasted motion. The compounded costs associated with this category include worker injury, compensation costs, and costs associated with ergonomics issues.

These categories of waste all have one important characteristic in common: They add cost and reduce the profitability of your operation, which kind of leads us into a discussion of value as it relates to activity. Let's go.

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CHAPTER 9

VALUE-ADDED, NON-VALUE-ADDED, REQUIRED NON-VALUE-ADDED

In this chapter, we're going to discuss the activities that people engage in and the value of different types of activities as they relate to the customer. Here are the words:

- Value-added
- Non-value-added
- Required non-value-added

And there you have it. Any questions so far? Only kidding. All right, let's get into this topic.

The first term, *value-added*, in simplest terms, refers to activity that makes a product a more complete product. It's as easy as that.

How so, you might ask. Well, we form liquid iron into castings, we machine components, we weld components, we assemble parts, we drill, we polish, and we paint, to name a few things we do. As we perform these activities, the product changes shape and becomes a more complete product until we reach the point where we have a completed product or system that is ready to ship to our customer. These activities are required if we are to create whatever it is we're making. Our customers value these activities and are willing to pay to have them performed. The bottom line is, when we do these things, we get money for doing them. Two important notes:

1. The definition of value is always in the eyes of the customer.
2. The end result of this cycle of activity is the receipt of cash for our actions.

The second term, *non-value-added,* is also pretty straightforward. This is activity that does not advance the product to a more complete or finished state, that adds no value in the customer's eyes, and that the customer is unwilling to pay for. The seven categories of waste we discussed in the previous chapter all fall into this box. In case you skipped the previous chapter, here they are again:

- ❒ Overproduction
- ❒ Unnecessary inventory
- ❒ Transport
- ❒ Process
- ❒ Activity resulting from rejected product
- ❒ Waiting
- ❒ Unnecessary motion

The third category, *required non-value-added,* gets a little fuzzy at times.

Example 1

Here's an example that's fairly black and white. You're supplying a product to a government agency, and that agency requires certain tests to be performed and documented. The task of testing does not change the product into a more complete product. The product is complete, done, it's over; all you're doing is testing for performance and compiling the associated documentation package. By our strict definition (the product changes shape), this activity is non-value-added; however, the customer requires you to do it, and you are being paid for doing it. And there it is, required non-value-added. In this example, the definition of non-value-added holds, since the product does not change form to a more complete product. But the customer is paying for this activity, and it is required.

Example 2

Here's another example of an activity that has nothing to do with the customer and does not further the product. It's Wednesday, and your accounting department is running payroll for the employees of your company. You have seven accounting clerks with adding machines busily compiling the mechanical time clock cards that your employees punch when they arrive in the morning and when they leave at shift end. This task typically takes your seven accounting clerks the entire day on Wednesday. Thursday morning they will have the totals owed your workforce for the week and will hand-write 475 checks—let's say this takes four hours—and present them to you to sign. You have probably guessed by now that you are about to sign 475 checks manually, with a ballpoint pen. (Pretty good system so far, eh? You never did trust those darned computers.) OK, you've spent Thursday afternoon signing checks. They are hand-folded and put into envelopes, passed to your supervisors on Friday morning, and passed out to your workforce on Friday afternoon. Your workforce has now been paid for another week's worth of good work.

This activity is required non-value-added. It does not contribute to your product's becoming a more complete product, and it adds no value to the product in the eyes of your customer. And so, you might ask, why is this activity considered required? We can rationalize a bit and say that your customer requires you to remain in business to provide product to her. If you do not pay your workers, they will probably stop coming to work. To expand on this logic, the act of paying your workforce is required if you are to remain a viable company. But (and here's the but), while the act of paying your people is required, the process you use to accomplish this is totally up to you.

Example 2A

Same company, different process. It's Wednesday, and your accounting department is running payroll for the employees of your company. You have one accounting clerk who is responsible for analyzing the database printout created by your payroll software for glaring errors prior to approval to proceed to check printing. Your employees scan a card upon entering and leaving work each day, and these data are processed automatically and electronically. The task of completing this double check typically takes your accounting person thirty minutes once a week. After this check, approval to print is keyed into the system, and 475 payroll checks are printed and auto-signed—again, this is an electronic process, with no time required. Once the checks are run, your accounting person places these checks in envelopes and places them in the company safe. Placing these checks into envelopes and putting them in the safe typically takes about four hours. The checks are given to your supervisors on Friday morning and passed out to the workforce on Friday afternoon.

Let's do another one.

Example 2B

It's Wednesday, and your accounting department is running payroll for the employees of your company. You have decided that all employees of your company will be paid on a salary basis. The historical reason for having some people (hourly workers) punch a clock while others (salaried) do not was the need to make sure that you don't pay someone for that additional few minutes if they arrive late or leave early. Your old accounting manager used to argue that you needed this record to make sure people were actually at work. In real life, you know when people are absent, and since your old accounting manager has retired, you have decided to trust all employees equally. Payroll is now run by your software package and electronically transferred into the bank account of choice for each of your employees. The funds are available for withdrawal by your employees on Friday morning of each week. The task of monitoring the payroll process and making whatever adjustments or corrections are necessary typically take your accounting clerk about thirty minutes per week.

Let's do the math.

Example 2:

1. Tally—7 clerks times 8 hours = 56 hours
2. Hand-write the checks—7 clerks times 4 hours = 28 hours
3. Hand-sign the checks—1 president times 2 hours = 2 hours
4. Stuff into envelopes—7 clerks times 4 hours = 28 hours
5. Pass out checks—6 supervisors times 1 hour = 6 hours

Total process activity/cost = 120 hours at whatever dollar rates you care to apply.

Example 2A:

1. Tally and check—1 clerk times 30 minutes = 30 minutes
2. Write checks—electronic, no time

3. Sign checks—electronic, no time
4. Stuff into envelopes—1 clerk times 4 hours = 4 hours
5. Pass out checks—6 supervisors times 1 hour = 6 hours

Total process activity/cost = 10.5 hours at whatever dollar rates you care to apply.

Example 2B:

1. Tally/monitor—1 clerk times 30 minutes
2. Write checks—no activity
3. Sign checks—no activity
4. Stuff into envelopes—no activity
5. Pass out checks—no activity

Total process activity/cost = 30 minutes at whatever dollar rates you care to apply.

OK, we beat that one to death. The important message here is that a process to accomplish something can be very expensive or very inexpensive. All three of these processes accomplished the same end task; however, the cost to perform the task was dramatically different.

When you are looking at value-added activity, the work is the work. There is not a lot of opportunity to change the content, short of automating.

When you are considering non-value-added activity, you have the opportunity to make this activity go away by redesigning your processes and procedures.

With required non-value-added activity, you have the opportunity to greatly reduce the cost through process redesign. You still need to get the activity done, but how you do it is under your control.

We'll discuss the "how to" of performing a lean-engineering process analysis to identify and quantify the value content of the tasks that make up a given sequence of activity later.

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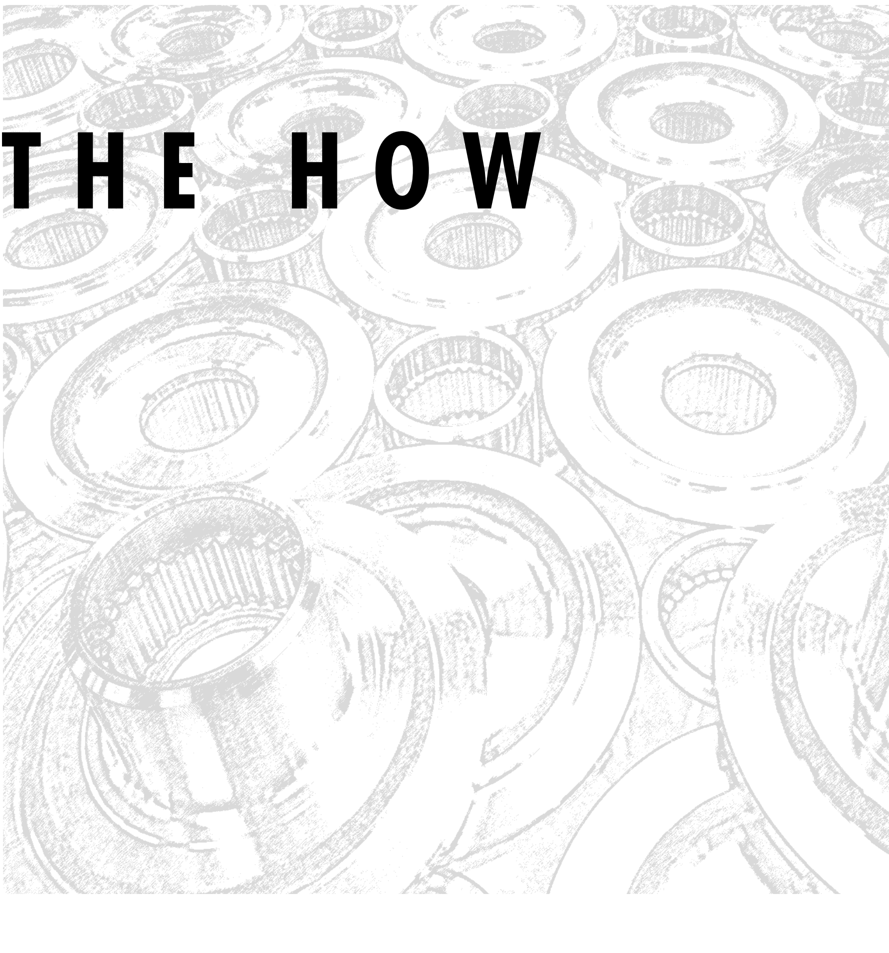
PART 2

THE HOW



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CHAPTER 10

Doing a Baseline

As a lean-manufacturing consultant, I spend my time working with manufacturing companies that have decided they are going to change from a conventional batch operation to a lean-flow operation. At a typical company that contacts us, management has read a lot of books and talked to a lot of people. Sometimes the managers have visited other companies that are already in transition; quite often they have had one or two of the large consulting firms in to conduct training in various areas of lean theory. The one common factor I see in all these firms is this: When they leave the conference room and go to the shop floor, they still don't know exactly how or where to start doing the work.

So the big question is, where do we start?

I am reminded of a client of some time ago. (This may even be an imaginary client, who knows?) The president of this particular company was a man of many singular ideas, as opposed to a man with a broad vision. Every day he would show up at work with a hundred ideas that had come to him the night before, and he would do a walk-around. During the course of his walk-around, he would notice things that offended his sense of order and priority. Possibly there would be a number of units stored in an out-of-the-way location with no clear identification and no discernible explanation. He would go back to his office, call in his vice president of manufacturing, and create a great deal of havoc about this particular issue, terminating the conversation with the statement that he expected some answers, and damn quick! The vice president would leave this meeting, contact his reports, raise some hell, and pass along the demand for explanations, reasons, and corrective action, and make it damn quick! The manufacturing floor team would leap into action, attempt to find out why these units were there, find out what the problem was that put them there, mobilize people to get them out of there and do something with them, write some reports and develop plausible reasons and excuses, and get back to the vice president toward the end of the day with the data and results. The vice president would return to his boss's office with the results and go over the data in detail. Man, everybody was really working on a burning issue today. The boss wants answers, and he wants them fast! The next day seven different minor, yet obvious, issues would be brought to the forefront, and the floor team would run over there to deal with these particular hot topics of the day. Every day was a different series of minor firefights concerning whatever was noticeable at that particular time. I like to call this "flock management": The flock runs over here today, the flock runs over there tomorrow, everyone to the left on Tuesday, oh, wait, stop, to the right on Wednesday, "gobble, gobble, gobble."

The critical observation here is that this company had no collective vision of where it was going from an improvement standpoint. There was no overall vision of the transition to a more effective company. The model was simply to react to the biggest fire that happened to be in your face at any given point in time. Over and over, day after day, month after month.

I see this behavior in small companies and large. At times the veneer is more sophisticated, but the underlying activity model is the same.

Where to Start

The tool we use to begin the lean journey is a *baseline*. Some people may call it a value-stream mapping event. Call it what you will; the intent is to define your current state of operations, analyze it for waste, and create a desired future state and a highly detailed plan of execution to get there. This is typically done at the site level for best results. I have seen this tool applied to a multiple-business-unit system with a deploy-down strategy, with vague and unmanageable results. The site level is much more practical in that a facility typically has discrete products that are being delivered to customers, usually all functions are represented, and a clean value-stream model that is under the control of the functions present in the facility can be constructed. This tool is an event-based process, meaning that a cross-functional team gets locked up for typically five days to deliver the goods. No interruptions, no escape. The common reaction to this requirement is: ''Good heavens, my key people are far too busy to be sidelined for an entire week. It simply cannot be done.''

I've done countless baselines, and I have yet to see a company go under because several of its key people were sequestered for a few days. Curious indeed? I've seen companies attempt this process with the conventional ''We'll meet for two hours a day'' approach, and the results have been sadly disappointing. This process is driven by the objective of eliminating waste, with all activity being categorized from the customers' viewpoint. This having been said, there are a couple of assumptions, namely:

1. Your company has a basically sound business strategy. (For example, developing a windows-based software package in your basement office with the intent of taking market share from Microsoft might be an illustration of a less-than-sound strategy.)
2. The top managers in your organization recognize that a change in operating philosophy is needed if the company is to improve and see different results from those you have been experiencing.
3. The top managers are prepared to support the change and provide the resources needed to make it happen.

If you don't have these pieces in place, save yourself some time, money, and aggravation and just keep doing what you're doing. To expand on the purpose of the baseline event, the deliverables are:

- A clear picture of your current state
- An equally clear picture of your future state
- A specific definition of the waste in your target process
- A highly defined illustration of the disconnects across your system processes
- A prioritized plan of activities to implement the change
- Quantification of the expected results and the cost to implement (payback)
- An energized group with one collective mind

Everyone has the same objective and the same priorities, and is using the same numbers. No blur, no noise.

If this sounds like an obviously common-sense approach, than why is it so hard to do? That's a good question. I wish I had a pat answer.

A Testimonial to Going Lean

This is a good place to plug in an article written by a long-time client and friend, Will Macfarland. Will is an unusual executive, with extremely high energy, a big brain, and an eclectic style that absorbs, assimilates, recombines, and applies everything that goes by him. The environment he creates is highly creative and supportive, and it's always a stimulating, warp-speed ride. I was putting together a newsletter on manufacturing practices focusing on lean implementation, and I asked Will to put together an article on his experiences as he took (and continues to take) his company down the lean path—a sort of "how did you get going, and what were your lessons learned" dissertation. It's very interesting stuff.

> *What Do We Do Next?*
>
> We read all the standard books and had seen a number of impressive magazine articles. We talked to and visited some successful, lean companies. We even had some scattered internal success with techniques like cellular manufacturing and point-of-use storage. Meaningful improvement opportunities were becoming harder and harder to identify. We were convinced lean was our future. But, the big question loomed. What do we do next?
>
> The search for an approach began with phone calls to a number of well-known consultants. Perhaps lean boot camp was the solution—send our best and brightest off for a week to be whipped into lean shape. Or maybe a black-belt program—take a few people, teach them "everything" there is to know about lean, certify them as dangerous, and turn them loose on an unsuspecting organization. We had three concerns with both of these solutions. First, they were long on immediate expense and short on near-term results. Second, the organizational issues would be less than ideal—sending in storm troopers is typically not a great way to engender local ownership. And third, it was not clear to us that endless classroom training and simulations would translate to real results on the shop floor.
>
> Finally, we decided to (as the saying goes) Just Do It. By good fortune we found a consultant—really more of a facilitator—who is as comfortable on the shop floor as in the classroom. We chose several projects and scheduled "baseline" events. These events, typically a week in duration, use value-stream mapping as an organizing concept, supplemented by a variety of well known analytical techniques, such as work sampling, spaghetti diagrams, and root cause analysis (fish boning). At the end of each event we had a clear view of some major improvement opportunities,

a list of projects and preliminary action plans, cost-benefit analyses, and a highly motivated team.

We are now approximately sixteen months into our lean journey. We have completed baseline analyses on a half-dozen parts of our business, are pursuing many improvement projects, and have encountered broad and enthusiastic support from virtually everyone involved. For one important segment of our business we have: reduced lead-times from twenty days to ten, and are headed for four; reduced total process setup times from an average of $3^1/_2$ hours to 55 minutes, and are targeting 20 minutes; reduced total inventory (including finished goods) by more than 50%, on our way to 80%; and have significantly improved on-time performance.

In another important segment, we have improved on-time performance from the chronically poor level of 65% to 92% and climbing. We have also applied this thinking to an under-performing paperwork process in which we quote and process orders for custom products. Order processing times (including drafting, bills-of-material, routings, etc.) have been reduced from an average of 50 hours to 29 hours, and are still declining. Quotation times have dropped from 15 hours to $4^1/_2$ hours, and are still declining. Our goal is to quote 80% of these jobs in real time.

These are a few of the more spectacular successes we have enjoyed through this process. There are other successes, and there have also been a few false starts. Here are some of the more important lessons we have learned along the way.

Exploit the Value-Stream Perspective

Most of the popular improvement methodologies (quality circles, TQM, reengineering, etc.) focus on improving a function rather than a process. For example, in a traditional improvement setting we might ask ''how can we get a certain machine to run faster?'' or ''how can we process drafting requests on time?'' Using a value-stream approach, we might define a process as: from the time we initially recognize customer demand to the time the product is shipped. We might then ask ''how can we significantly accelerate this process and eliminate the non-value-adding activities?'' Instead of looking at an individual function vertically across the entire company, we are looking at a complete process laterally—some people would say cash-to-cash.

For us this is an important distinction. After many years of function-by-function improvement efforts, low-hanging fruit was getting harder to find. We now find such fruit in abundance, located mainly at the boundaries between ''optimized'' independent functions. Furthermore, we often find activities that, in abstract, seem important, but that are not adding value in the process. These types of discoveries are obvious in a well-reasoned value-stream analysis, but are nearly invisible in more traditional improvement methodologies. Choose your value stream broadly. Narrow definition of a project will obscure many of the best improvement opportunities.

Lead from the Top

Radical transformation of a process is seen by most as risky. The perceived risks are personal (how will my role change?) as well as organizational (what happens if we fail?). In our experience, with a highly motivated group, the risks are few—a good team will nearly always redouble their effort and make the necessary adjustments, rather than allowing a project they believe in to fail. The real risk is the manager who fears change (or failure) more than he craves breakthrough. Continuous and active leadership from the top can encourage bold and comprehensive change. It can immediately clarify what avenues are, and are not, reasonable, thus minimizing wasted time, frustration, and disappointment. And, it can mitigate perceived risk.

Formulate and Communicate Clear Objectives Early and Often (but Be Flexible)

The lean concept does not impose a specific set of objectives. It is really more of a philosophy. One could argue that the absolute elimination of waste is an objective, but waste takes many forms. We began our journey with broad appreciation for the benefits of lean, but without specific objectives. After three baseline events it became clear that our biggest opportunities were improving on-time performance while significantly reducing inventory. This realization has led to very strong, clearly stated, regularly communicated objectives on lead times and setup reduction. Prior to establishing these objectives, the baseline events and projects might wander off course.

We also recognize, though, that circumstances vary from plant to plant, and from process to process. Thus, we will modify our objectives on a particular project, but we never lose sight of the primary objectives. In a larger, more complex operation, we find that a degree of flexibility on objectives is essential. However, we will not let a group drift, or find their own way. For us this is a gentle balance between encouraging a team to be creative and to set ambitious goals, and keeping them focused on the most important needs of the business.

Consider Your Metrics and Measurements

In our foundry the rule has been that you only make money when you empty the furnaces (at least this is what our standard cost system tells us!). Thus the temptation, in the name of earnings, is to pour castings not really needed right now. Measurements of machine utilization can encourage us to avoid building process-oriented cells, thereby inflating the number of workers, increasing work-in-process inventory, extending lead times, adding material handling costs, etc. Narrowly defined overhead rates can lead us to work overtime on more ''cost-effective'' centers, while more ''expensive'' centers, and their operators, are underutilized. All of these are real examples of conventional measurements leading us astray. It often takes the perspective of a (brave) senior manager, or of an executive, to recognize and be willing to challenge some of these measurements. If you make (and sell) more product while spending less money, it would seem you are more effective, regardless of what the variances say.

Use ''Events'' for Better Results

We have experience with two different approaches to improvement initiatives. Our ''traditional'' approach has been to charter a team to tackle a particular project, and then have them meet periodically to work together on the project. In theory, team members worked individually on the project between meetings. Such projects tend to lose focus and drag on over long periods of time. Over time, team members (and managers) become distracted and/or show up for meetings unprepared. The outcomes typically add activities, rather than changing or eliminating wasteful practices.

The alternate approach is to do the ''heavy lifting'' in an event format. Gather an appropriately broad (but not too large) team with a good facilitator. Set some clear objectives. Sequester them for a few days to a week. Sit in often, stay abreast of where things are headed, and provide feedback and encouragement regularly. Properly done, the event ends with a well-defined list of projects and action plans. We will often do the resulting projects as a series of smaller events, with preparation and independent work by team members prior to these follow-on events.

We find this event-oriented approach yields more creative and substantial outcomes. On several occasions since beginning our lean journey, individual groups have attempted to use the more traditional approach of meeting for a few hours each week—results have been disappointing to nil. One key point: in an event-oriented approach, the quality of the event is highly correlated with the quality of the facilitator.

It Is Not About the Tools

When talking with potential consultants, we noticed a general preoccupation with teaching the tools of lean—things such as Kanban, setup reduction (Single-Minute Exchange of Dies, or SMED), Point of Use Storage (POUS), Total Productive Maintenance (TPM), etc. There are many such tools, and no doubt all are useful in the right circumstances. However, rather than pushing tools, we have chosen to focus on desired outcomes. This approach naturally leads to choosing the appropriate tool for a particular need, and then pulling through the training on that tool. We find this far more efficient. We only train when we have a need for a particular tool. The training is then reinforced by implementation. Of course, this approach does require a general knowledge of the tools available. Much of this can be gained through reading and observing, and by choosing the right facilitator or consultant. Remember, when the only tool you have is a hammer, everything looks like a nail!

W. C. Macfarland
Vice President, General Manager
Mechanical Division
TB Wood's Incorporated
Chambersburg, PA

Interesting article, isn't it? Where was I? Oh, yes, baseline stuff. Back to the process.

Baseline Basics

A typical baseline is a five-day event preceded by some preparatory data collection, organizational discussions to define a good cross-functional team, and, depending on the client, a little training for the management team and/or key players.

And so, these are the key steps in the implementation path.

Step 1: Top management has decided that it is going to embrace a new operating philosophy. The organization will be ''lean'' driven, and management is ready to pull the trigger. Deployment of any strategy or policy must come from the top of the organization and be driven down, since all changes must be cross-functional to be truly effective, and the CEO, president, or owner's office is where all these functions intersect and receive direction.

Step 2: Choose a pilot area to analyze. This is usually a difficult choice the first time. It gets easier as you go along because you come to know what to expect and how the process works. The important point here is, do it! Get going! My suggestion is to pick a product line or family of products that represents a respectable percentage of your sales mix, is relatively straightforward, and can be expected to provide a good financial gain to your bottom line if optimized. More specifically, don't pick your easiest area and don't pick your hardest. The first baseline is not only an analysis of a portion of your business, but also the initial model to change your company culture. That's easier said than done.

Step 3: Pick a good cross-functional team to engage in the event. I find this step to be the most treacherous. The first impulse of many top managers is to staff the team with their high-potential managers. The thought is, get my best and brightest together and we'll have a sure win. In most cases, this is not true. At the risk of being presumptuous, managers have an in-depth understanding of the standard data, the information that is in the system, but they rarely understand the details of the actual process. I spend a great deal of time performing lean-engineering analysis of various processes to provide companies with the foundation data to recombine and balance their floor activity.

The real-life processes as performed on the floor are never the same as the standard data portray them to be. The people who understand the details of what the work really is are the folks who do the job every day. Curious, but true. That being said, your team should be composed of a mix of managers, technical support, and actual assembly and machine shop floor people. And here's where the first ego speed bump comes into play. Managers are paid to know what's going on, to be on top of things. It's difficult, if not impossible, to get them to admit that they really are not in touch with their processes at the task level. The message here is, ''Get over it, leave your ego at the door.'' We need real facts, not ''data,'' if we are to successfully analyze our process for waste.

Mapping the Value Stream

OK, management is ready to go, we've identified our pilot process, and we've picked a good cross-functional team. What's the agenda?

As a preliminary activity, we want to collect some data for use during the baseline. If this is your first baseline, you will have picked a segment, process, or family of parts to map, plus you will want to map the flow before and after, which includes all activity from initial customer contact through release of the manufacturing package to the floor, the manufacturing flow through shipment to the customer, and all activity following shipment through receipt of payment for the product. This is what is referred to as the value stream—what my friend Will Macfarland has called "cash to cash." As you do additional baselines on additional families or segments, the information piece of the flow is universal; only the manufacturing process maps will change. Figure 10-1 shows what the typical value-stream diagram looks like.

The concept of the value stream is critical, and it supports one of the key concepts of a baseline analysis: *You will not see the desired financial improvements unless you analyze the complete activity cycle, from customer order to payment for product received by the customer.*

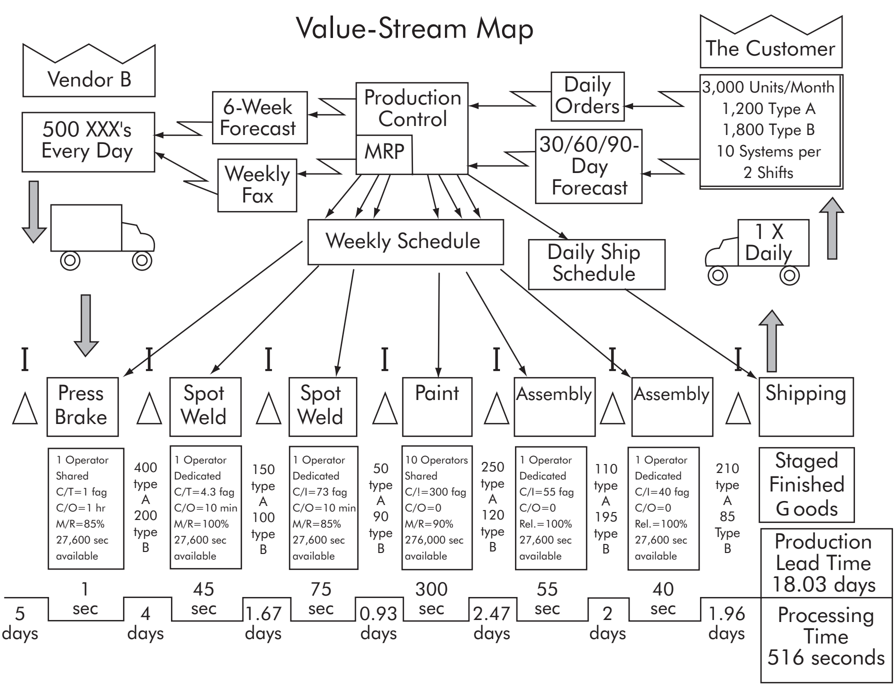

Figure 10-1

Case in Point

I once worked with a client whose basic process was:

1. Foundry—make castings
2. Machine shop—machine and paint castings
3. Assemble and kit system
4. Ship to the customer

The foundry supplied several machining facilities across the United States and Mexico. The machining facilities were essentially stand-alone businesses, with the foundry acting as a vendor. The machining facility I'm going to use in this example was, by conventional measures, a pretty nice operation. It had lots of CNC machining centers, a very talented workforce (both on the floor and in the technical support functions), and a good people-oriented environment.

The facility had everything going for it, right? Well, it certainly had some good tools to start with.

By lean measures, its performance with regard to lead time, work in process, labor and space utilization, and the associated costs presented a huge opportunity. In our initial meetings, as we discussed flow and cells and doing a baseline, the manufacturing engineering folks listened patiently, then informed me that they had been working on optimizing their cells for years, and that there was very little, if anything, that could be done to improve the operation. The engineering staff in this operation were all degreed industrial engineers, with MBAs topping off their academic credentials. A pretty high-powered group. OK, away we go.

We defined the value stream as initial customer contact to delivery of finished product to the distribution center. This was a slight compromise, but it was a good enough segment to analyze with measurable effect. As we worked through the current-state definition, we found that the lead time through the machining facility was about twenty-four days, the company produced product in batches determined by EOQ calculations, the facility was choked with work in process, the distance traveled within the facility was measured in miles, and the direct machining people spent about 65 percent of their time either waiting or going to get something. These initial observations may sound bad to you, but rest assured, this was a very well-run operation in a batch-and-queue model. And on we go.

The physical flow is shown in Figure 10-2.

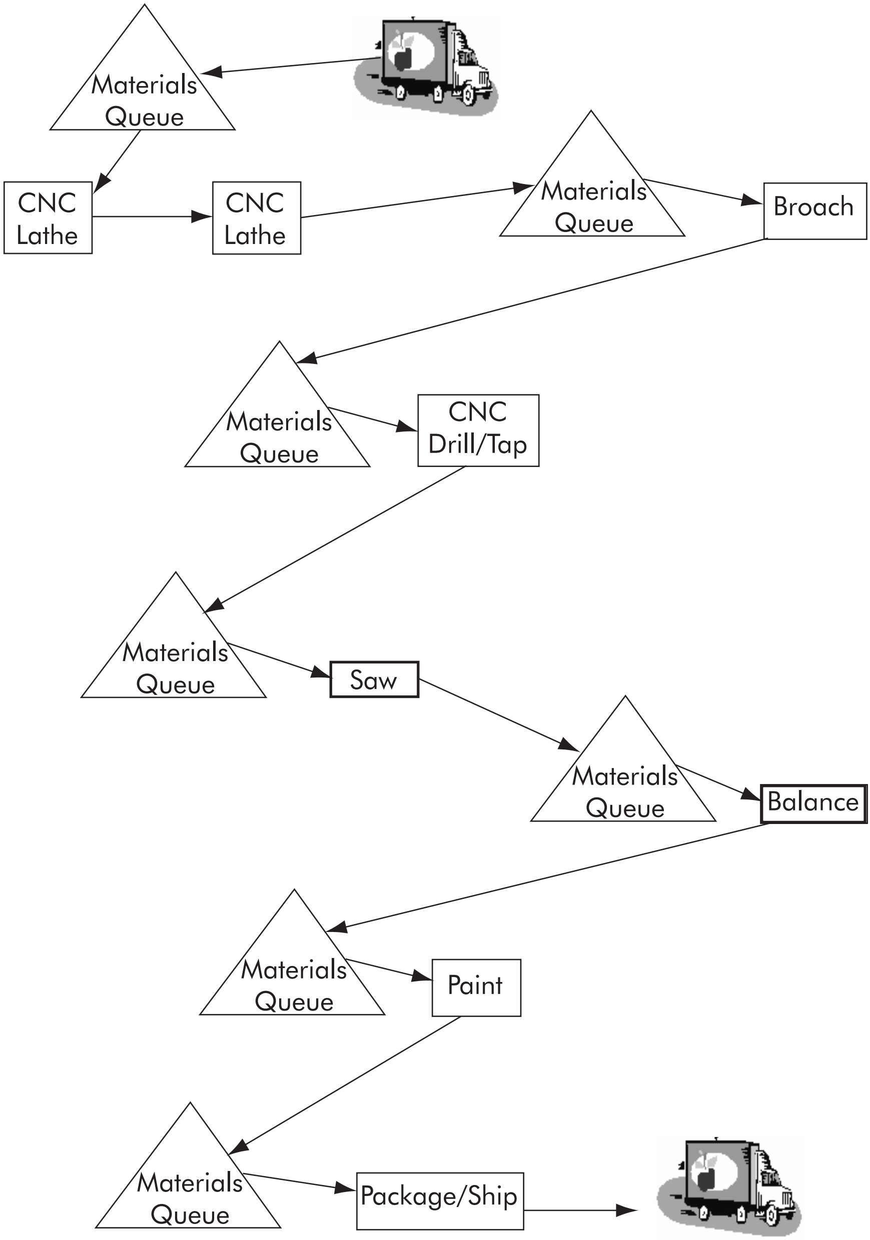
Materials Queue
CNC Lathe
CNC Lathe
Materials Queue
Broach
Materials Queue
CNC Drill/Tap
Materials Queue
Saw
Materials Queue
Balance
Materials Queue
Paint
Materials Queue
Package/Ship

Figure 10-2

The first serious disconnect was in the definition of a cell. The company's definition of a cell was two or three machining centers (in Figure 10-2, the first two lathes), grouped together so that one person could tend both machines. My definition of a cell is a group of machines or processes that are linked together to produce a product from start to finish.

The second disconnect was in the primary key performance measurement. The company's key metric was machine utilization, with a further focus on CNC centers. There were dozens of very expensive machining centers, and the mission was to keep these expensive pieces of equipment running all the time. The additional steps in the process—balancing, gear cutting, painting, and so on—were treated almost as afterthoughts: ''Yeah, we have to do them, but that's not really what we are about—we are machine guys.''

We may expand on this example later, but I'll cut to the chase on this point. As these engineers spent massive amounts of time, energy, and money reducing the machining cycle times by 7 seconds here and 15 seconds there (new tooling, new million-dollar machining centers), they saw no bottom-line changes in their operating income. Their justifications showed reduced machining times, but no additional product seemed to go out the door. A mystery indeed! Since the capacity constraints in the system were downstream in the balancing and painting operations, the only thing the engineers were really accomplishing by optimizing the machining cycle time was to increase work in process and create additional idle time for the operators standing in front of the CNC centers. Only by analyzing the entire value stream can you hope to put together a plan to optimize overall throughput—product out the door. As Mr. Ripley would say, ''Amazing, but true, believe it or not.''

Pre-Event Data Collection

And so, back to the baseline. Let's collect some prebaseline data. Have your team gather all available information on the following:

1. Area layout. You'll need several CAD drawings, to scale, of all areas covered by the analysis.
2. Process maps, flowcharts, and any descriptive detail on the following processes:
   a. Customer contact activity
   b. Engineering activity

   c. Sales activity
   d. Purchasing and scheduling
   e. Work order and work package development and release
   f. Manufacturing process detail, to include setup and changeover data
   g. Examples and copies of all paperwork used in these processes
3. Current schedule
4. Current forecast
5. Financial and systems data on:
   a. Direct labor
   b. Indirect labor
   c. Overtime
   d. Inventory dollar amounts: raw, work in process, and finished goods
   e. Rework
   f. Scrap
   g. Lead time through the various areas and in total
6. Organizational data—a current organization chart showing all employees, salaried and hourly. This is different from the conventional chart, which shows only salaried employees. We want to know where everybody on the payroll is and what they do.
7. Materials. Details on the components used in the target process—parts purchased, vendor lead times, and annual dollars spent.
8. A PPQ (product, process, quantity) matrix of all product in the target area. This is a listing of all the work centers, machines, and process points in the system and the product that flows through each area, with monthly quantities produced, across a sample year.

We'll gather and construct more information during the course of the event, but this is a good start. The agenda for the event is flexible depending on the process being evaluated, but it follows this general sequence.

Day 1. Kickoff and introductions, overview and objectives of the week, training and discussion on the categories of waste and the concepts of value-added and non-value-added activity, a walk-about to observe areas of waste as discussed, a discussion of process mapping, and the beginning of process mapping, with the group split into subject area teams. At day's end we review the maps, discuss the flow of the week's story, and discuss the placement of data on the wall.

Day 2. Continue mapping, expand the detail, and finalize maps with all activity and materials queues; begin the construction of space utilization, people utilization, and spaghetti diagrams and distance traveled analysis. The tasks included in the process maps are assigned times and categorized as value-added, non-value-added, or required non-value-added. All categories are added to create a visual of the percentage of the process that is value-added, non-value-added, and required non-value-added, with the definition of the total lead time through the process.

At the end of the day, we brief the executive team on our results, findings, and observations.

Day 3. We evaluate the process, as it has been defined, for undesirable effects (UDEs). We list the UDEs and collectively prioritize them with regard to their impact on the business. We then take the top four or five UDEs and perform root cause analysis. The root causes are discussed and applied to the current-state process, and preliminary solutions are developed. A rough plan of activity to implement these preliminary solutions is discussed. Discussion of the future state is begun if time permits. At the end of the day, again brief the executives.

Day 4. With solutions applied to the current state, the team constructs an improved future state. The future state is evaluated for its impact on people, space, materials, flow, lead time, and costs, and a preliminary plan of implementation is developed. Projects required to implement the future state are defined, and cost to implement, resources required, timelines to complete, and cost reduction/payback are projected. At the end of the day, again brief the executives.

Day 5. The implementation plan with project details is expanded and justifications are finalized. A summary briefing is presented to the management team, with approvals to proceed finalized.

The following chapters will take us through the week at a greater level of detail.

CHAPTER 11

Doing a Baseline, Day 1

The company is Carreira Sim, Inc., and it makes a product that is machined from a purchased casting, painted, assembled into a system, and shipped to customers across the United States.

Day 1, Monday

"Good morning, I'm Bill Carreira. Does everyone know why we're here and what we're up to this week?"

I'm always surprised by the number of people who look at each other, shrug, and shake their heads in response to this initial question. They have been told that they need to attend, but they're not quite sure why they're here or what it is they're about to be involved in. Communication is such a tricky thing.

"OK, this week we are going to conduct a baseline analysis of your synchronous gizmo department. We will map the current state of the process, in excruciating detail, from start to finish; evaluate the opportunity to improve the process based on the data that we construct; and develop a future, improved state and a fairly detailed plan of attack to get there. For the first couple of days, we're going to map the "what is"—the current state. On the third day, we'll get into effects and root causes, with some ideas for improving the process. On the fourth day, we'll construct an improved future state and develop some projects to take us there. On Friday we'll wrap it all up into a nice, clean, linear story and brief your executive management team on the plan. You've all been introduced, I hope, to the basics of what we call lean-manufacturing theory. We'll talk a little bit about the rules of engagement and the definitions we'll be using to evaluate what we do this week. Questions?

"Before we start, I'd like to ask all of you to introduce yourselves—who you are, what you do, how long you have been with the company, and maybe a few words on why are you delighted to be included in this week's marathon." (OK, that got a couple of laughs.)

I point to the gentleman to my left. "Start us off," I say. And away we go . . .

Jimmy: Well, my name is Jimmy Pointer, and I'm the supervisor of the machine shop. I've been with the company twenty-three years; I started out as a machinist on the second shift and have worked pretty much everywhere in the machining areas. I'll let you know how I feel about being here at the end of the week.

Me: Fair enough. Next.

John: John Bots, scheduling, twelve years. I guess if this week is about improving the company, I'll give it my best input.

Me: Are you the master scheduler, John, or just responsible for this product area?

John: I'm responsible for this area. I work for Cathy Newell; I guess you'd call her the master scheduler. She coordinates the overall shop scheduling activity.

Me: OK.

Mike: Hi, I'm Mike Bender; I'm the lead in assembly. I've been with the company eighteen years.

Me: Mike's an interesting name for a girl; is that short for something?

Mike: Michelle, but my dad called me Mike from the time I was a kid. I guess it kind of stuck.

Me: OK. Who's next?

Frank: I'm Frank Simms. I work in order entry, and I've been here at Carreira Sim for fourteen years.

Bill: Bill McDougal, shipping, twenty-eight years.

Don: I'm Don Booker, and I'm the senior lead in machining on the second shift. I've been with the company seventeen years.

Me: Are you a journeyman machinist, Don?

Don: Yes. I did my apprenticeship and got my papers at DMS across town.

Me: I see. Does Carreira Sim Inc. have an apprenticeship program?

Don: No, we don't, but most of our senior guys have papers that they got before they signed on here.

Me: Interesting. OK, who's next?

Jeff: I'm Jeff Styles. I'm the supervisor in assembly.

Me: How long have you been here, Jeff?

Jeff: Oh, sorry. I've been here twenty-one years. I started in shipping, worked in machining for a few years, and moved into a salaried spot in assembly about six years ago.

Nate: I'm Nate Carbone, sales engineer; been here thirteen years.

Sid: I'm Sid Krupen, and I work in design engineering. I've been with the company eight years.

Julie: Julie Ventner. I'm a senior manufacturing engineer and programmer. I've been here twenty-three years.

Fred: I'm Fred Morgia, and I'm the manager of manufacturing. I've been with the company seventeen years. I came in as a supervisor, moved into production management, and moved into this position about four years ago.

Fran: I'm Fran Jenkins, and I'm the controller. I've been here six years.

Tony: Tony Aiello, MIS, eighteen years.

Me: Excellent. It seems we have expertise in all areas of the business represented here. It should be an interesting session. All right, let's move on. I'd like to start with some words. Some of you have been exposed to lean manufacturing, some of you probably haven't, but I'm going to cover some of the fundamentals anyway, so that as we move forward this week, we are all using the same definitions. Words are funny, in that different people associate different meanings and interpretations with the same words. The process we're going to work through this week is really an exercise in identifying waste in your process. That being the case, the first area I want to discuss is the definition of waste and where it exists.

Talking About Waste

Me: When we talk about waste, there are seven types we'll be considering. The first is *overproduction*. This means exactly what it says. You are producing something before it is needed.

Fred: Excuse me, Bill, we don't produce just for the fun of it. Everything we make is needed.

Me: Fred, you're the manager of manufacturing, right?

Fred: Correct.

Me: OK, let's talk about what you're producing today, a real-time example. Give me an order that's running through your shop as we speak.

(Fred turns to John Bots, scheduler.)

Fred: John, what's a good order that we're running today?

John: We're running a large order of 341s today.

Me: OK. John, do you cut work orders here?

John: Yes.

Me: What's the order quantity running through your shop for your 341s, and when is the order due to be complete?

John: We're doing 400 units. They should be into shipping and ready to go by around 9:00 tomorrow morning.

Me: How many 341s are scheduled to ship tomorrow?

John: 180 units.

Me: Where do the other 220 units go?

John: Well, they'll go into finished goods.

Me: When will you ship those to a customer?

John: We'll ship them when we get the next order for them.

Me: You don't have hard orders for the entire 400 units?

John: Well, um, no.

Me: So why are you tying up shop time and capacity to build units that you have no demand for?

John: We have demand for them; we ship around 600 units every month, at different times.

Me: OK, let's narrow this down a bit. You will have 220 units of 341s, above and beyond the 180 units that will ship tomorrow, complete and available to ship. Are you going to put them on a truck to a customer, or are you going to send them to your stockroom and put them on a shelf?

John: They're going to the stockroom.

Me: So the next question is, why did you produce units that you did not need?

Fred jumps back in: Our run quantities are calculated using the EOQ formula. That's the most efficient way to operate our business.

Me: Is everyone here familiar with what EOQ is?

(Lots of look-arounds; unless people are in the scheduling discipline, they generally are not familiar with EOQ.)

Me: Let's talk about it for a minute so we're all on the same page. EOQ stands for economic order quantity. Here's how it works. *(I write this formula on a flip chart.)*

$$\sqrt{\frac{2AR}{IC}}$$

A = setup cost = setup hours $\times$ hourly factory cost
R = annual quantity
I = inventory carrying cost, %
C = standard cost of item

Let's work an example. Let's use these numbers:

Part number	XYZ
Setup hours	2
Annual quantity	1,000
Standard cost	\$5.00
Factory cost per hour	\$35.00
Inventory carrying cost	25%

Remember, carrying costs are made up of obsolescence, cost of money, lost investment income from the money tied up, warehouse space and associated cost, material handlers, material-handling equipment, and taxes and utilities related to all these categories. If we plug these numbers into the equation, we get:

$$\sqrt{\frac{2 \times (2 \times \$35) \times 1{,}000}{0.25 \times \$5.00}} = \underline{\text{EOQ} = 335 \text{ units}}$$

The logic here is, ''If it takes me a long time to set up for a product, I want to run a lot of them; otherwise the cost of the setup is prohibitive.'' This is not bad logic; however, it leads you in the wrong direction if you just listen to the words. I would challenge Fred's statement that ''that's the most efficient way to operate our business.'' My opinion is that aggressively reducing your setup times, and thereby reducing the EOQ lot sizes, would lead you toward the most efficient way to run your business, the ability to build to actual customer demand, not EOQ calculations.

OK, the point here is that one reason you are overproducing is that you have long setup times. A couple of other common reasons are, your operations are not linked and balanced, so that work in process builds up between operators; or you're building to forecast instead of hard orders; or you don't have enough hard orders this month, so you've decided to pull in some work from next month. There are always reasons for overproducing; however, it is still pure waste from a lean theoretical viewpoint. I think the worst effect of overproduction is that with everyone active all the time, you can't see the idle time that would allow you to act on reducing this waste. OK, we've beaten that horse senseless; let's move on.

The second category of waste is *unnecessary inventory.* At the risk of oversimplifying, if you have inventory anywhere in your facility that is not being worked with to create product, it is unnecessary at this point in time. You can argue about the timing, ''Well, we will need this tomorrow,'' but if it is sitting idle, it is not needed today. This applies to all three categories of inventory: raw materials (purchased components), work in process, and finished goods.

Transport is the third category of waste. Moving things around is just that, moving things around. Excessive transport is a function of layout. If operations are disjointed, product must be moved from area to area as it progresses to a more finished state. That's pure waste.

Bill McDougal jumps in: You have to move things around the plant. This is a large building.

Me: Agreed, but the distances don't have to be as great as they are. Your process is departmentalized, not coupled. Your layout and balance determine how far the distances are. Your customer could care less. If you choose to place your milling operations 300 yards away from the next upstream operation, you are adding all kinds of handling and WIP costs that have nothing to do with the product's reaching a more complete state, and your customer is not paying for that added cost. One important point about our definitions in lean theory: They are just that, theory. We categorize waste. In a few minutes we'll talk about value-added activity, we'll talk about one-piece flow. The approach to the theory has to be black and white and ruthlessly simple. When we take this theory into real life and start to apply corrections to your operation, we'll run into lots of shades of gray; there will be compromise, and we'll modify as we go. Will you ever completely eliminate waste in your process? No way. Should you establish and approach your goals with an aggressive, ruthless mindset? Absolutely. What do you think?

Bill: OK, I'm on board.

Me: OK, the fourth category of waste is *process*. A jig doesn't work quite right and requires extra unnecessary corrective motions as you do the assembly work. You have multiple handoffs and approvals in your process that are redundant and wasteful. You are required to fill out paperwork that nobody does anything with. These are just a few possibilities; there are lots of examples of process waste.

The fifth category is *rejects*, all activity resulting from not getting a good product through on the first pass. This is usually a giant octopus of cost in most companies, with much of it hidden and difficult to quantify. People just do what is necessary to get the product back into the flow, and much of this type of activity goes unrecorded.

Waiting is the sixth category of waste—waiting for materials, waiting for an inspector, waiting for information from supervision or engineering, waiting for your CNC machine to finish its cycle, and on and on. There are lots of examples and many different reasons.

The final category of waste is *unnecessary motion*. This is the area that refers to people. If you observe a work area, watch the go-gets, the reaches and twists, the reach-ups and reach-downs to uncomfortable locations, the turnarounds to get parts and tools. This category covers all the undesirable effects of a bad work area layout, including ergonomics issues. Many people will say, ''Hey, it's only a few seconds here and there.'' However, these issues accumulate over time and are very important areas to address from your workforce's point of view.

(As I have been discussing these topics, I have been writing the seven categories of waste on a flip chart. We're going to begin a very visual week.)

Me: Questions? OK, let's add one more category, *work*. This is the non-waste activity. Product is being worked on and is reaching a more complete state.

If you look at these eight categories, I would challenge you to walk around your facility and find any activity that is being performed that does not fall into one of these eight boxes. OK, any questions, comments, observations? Good to go? OK, let's talk about value-added activity.

Value-Added Activity

Me: When we look at what people do during the course of the day, there are three additional categories that we place activity into. They are:

1. Value-added
2. Non-value-added
3. Required non-value-added

One important consideration is that all value is defined from the customer's point of view. How you choose to operate your business is not a consideration. The people who pay the bills get to make the rules, and they are *customers*. With that being said, here's the definition of the words.

Value-added activity is anything that causes the product to become a more complete product. We assemble parts, we machine parts, we paint parts, and so on. The product is being transformed to a more finished state. It's a pretty simple definition.

Non-value-added activities are those that do not cause the product to reach a more complete state. We move a skid of parts from one department to another; we visually inspect a part; we rework a defect; we write a report to explain why our variances are where they are. Again, this is pretty straightforward.

Required non-value-added gets a little fuzzier. We plow the parking lot in the wintertime; we test a product to provide customer-required documentation of its performance; we do payroll. These are activities that we have to perform, but that do not physically change the state of the product. The point here is that although we have to get these tasks done in order to operate our business, how we do them is not being defined by the customer; we can change and improve the method of performing these activities.

And there they are, the basic words. The seven forms of waste, composed of non-value-added and required non-value-added activities, add cost. The category of work, composed of value-added activity, generates revenue. Everything we do during the course of a business day falls into one of these categories.

Touring the Facility

Me: The foundation philosophy of lean manufacturing is to evaluate your systems and processes, categorize your activity, and create a future state for the process in which you do less of the non-value-added stuff, which frees up time to do more of the value-added. Nobody works harder; they simply work on different things.

OK, let's take a walk. As we tour your facility, pay close attention to what you see. Take the categories of waste we've discussed and make some notes on what activity you see. As you observe people and materials, jot down what's going on. Let's go.

We tour the facility, and the team members explain what happens in the various areas we go through. The team is observing people and materials and making notes on their observations. Following a quick twenty-minute tour, we reconvene in the conference room.

"OK, everybody," I say, "let's talk about what we saw and do a quick compile. Everybody grab a packet of Post-its and write one observation per Post-it."

I write the categories of waste on a flip chart page. We discuss the various examples that people have noted during the tour and stick them to the chart in the appropriate slot (see Figure 11-1). There is some discussion of what category certain items fall into, and a few tangential points are made as to the why and where of things we observed.

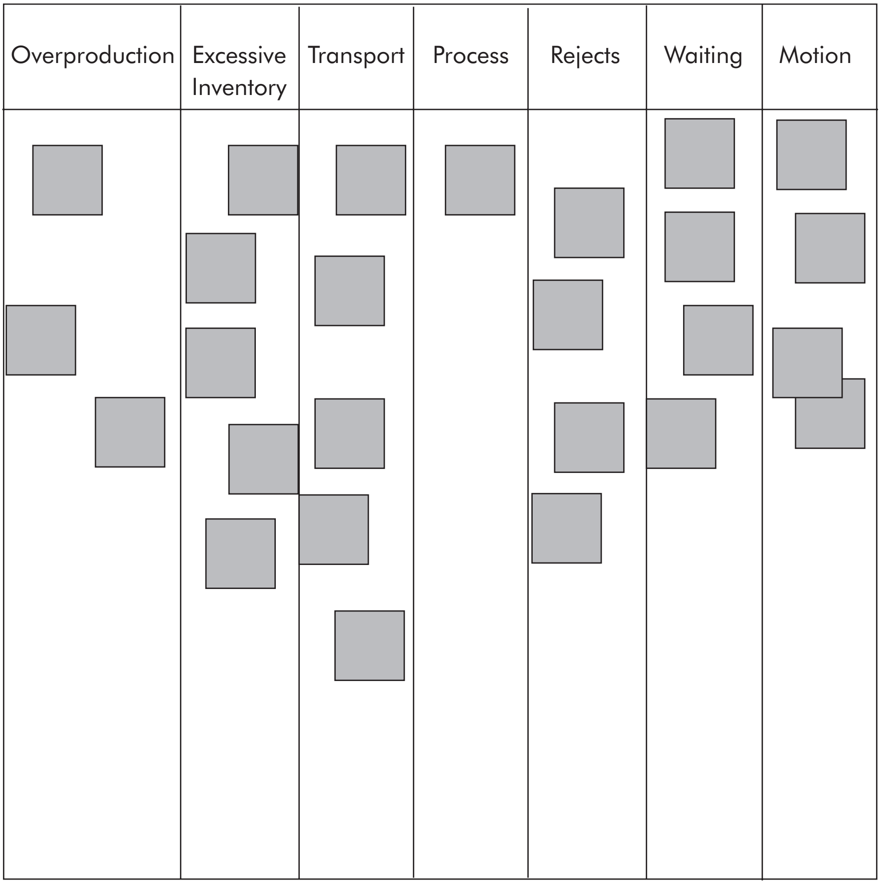

Figure 11-1

"OK," I say, "here are the results of our tour. The only point I want to make here is that waste, in all the forms we discussed, does exist in your facility. That's it.

"Oh, yes, one additional point: When you walked through your plant yesterday and saw Joe driving a forklift with a skid of parts to the next department, you wouldn't have given it a second thought. He's just doing his job; he's working. When you saw several people walking to various areas to get things or return items, you wouldn't have given it a thought. They were doing their jobs; they were working. You would walk by skids of inventory all over the facility, again without a thought; it was just part of getting the job done. After our discussion this morning, not one of you had a problem finding waste; most of you had fifteen or sixteen examples. The point is, your perception has changed; what you were looking at, you were seeing in a completely different way. This is a subtle yet critical observation: Being able to see what it is that you are looking at is at the heart of being able to change and improve your operation.

"OK, enough blah, blah, blah; let's start with our process maps."

Doing Process Maps

Good mapping is surprisingly similar to seeing; it's very hard initially, and incredibly easy once you understand what the map needs to tell you. When I ask the typical manager for a process map of a given process, I am usually given something that resembles Figure 11-2.

This is at a very high level. It's usually the view from management. If I were to ask this same manager to assign times to these various activities, the response would typically be, "Not a problem, Bill; we have excellent history and detail on this activity." He would then turn to his computer and pull out volumes of data—standard times (what the engineers say it should take), actual data (times as clocked by the employees), variance reports (the difference between standard and actual), and on and on. When the manager is pressed to break this process down to the task level, it always becomes fuzzy: "Well, Bill, there are multiple simultaneous activities going on at the same time."

My approach to baseline mapping is different from any I have seen performed by anyone else, anywhere. I have seen maps done by management teams, with times assigned, that resemble Figure 11-2, and my question usually is: "What can you do with these data?"

And the answer is, "No idea."

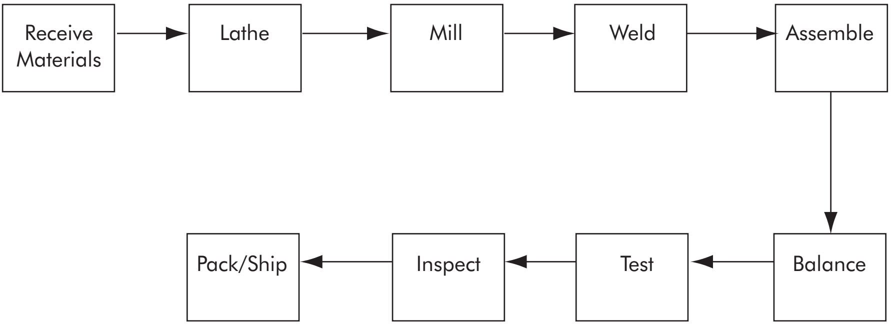

Figure 11-2

So let's talk about what we want to accomplish with our maps and how we need to construct them. The construction is easy: We want the map to illustrate precisely how the current-state process is being performed. We do not want it to illustrate how our management team would like to think it is performed, or even how it should be performed. And so the first point to make here is, there is no good or bad; there is simply what is. Having facilitated countless baselines, I am always surprised by how difficult it is for people to tell me what they do, day in and day out. In a full-scale production facility, there are simultaneous tasks being performed everywhere—lots of things are happening; there's lots of blur.

Categorizing Tasks

So here's what we want to do. We want to map our target process at the task level, define material queues in between the tasks where they exist, assign times to each task, assign consumption time to each queue, categorize each task as value-added or non-value-added, and add up the numbers to see what our lead time is through the system and what our percentage of value-added activity is. This is our "what is" of today, our current state. In order to categorize our tasks, we have to define discrete tasks that can be assigned to one of the eight boxes of activity that we have been discussing. For example, "I inspect the part and take it to the stockroom" is not a task. "I inspect the part" could be assigned to the reject category or the process category of waste, depending on individual choice. "I take it to the stockroom" would be assigned to the transport category of waste. These are two different types of waste, but only on the first pass. If you look more deeply at the content of "I inspect the part," you would probably end up with subactivities like this:

Me: What are you inspecting for?

Mr. Inspector: Well, I need to inspect the I.D. of the bore and the O.D. of the flange, check the micro of the bore, and verify concentricity.

Me: I see. How do you know when an inspection is needed?

Mr. Inspector: When I'm finished with the order I'm working on, I go to our department scheduling board and get the folder for the next job due.

Me: Are the jobs always listed in the required sequence?

Mr. Inspector: Usually they are, but sometimes a hot one will get moved up. I generally get the next order up and then check with Johnny to make sure I'm OK.

Me: Who's Johnny?

Mr. Inspector: He's the scheduling expeditor for the department.

Me: I see. Where's he located?

Mr. Inspector: He's usually running around on the floor, but his desk is over near shipping.

Me: OK,, so you get the next up from the board and check with Johnny. So far, so good?

Mr. Inspector: Yes.

Me: Let's back up a bit. When you're done with the current order, where does it go?

Mr. Inspector: Oh, I just call a materials handler and he takes it to staging for the next operation.

Me: How do you call materials?

Mr. Inspector: I usually page them.

Me: Where's the phone?

Mr. Inspector: Right over there. *(He points to a centralized phone about fifty feet away.)*

Me: OK, I'm with you so far. You've got the next order up; where do you get the parts?

Mr. Inspector: All orders are queued in the inspection staging area. C'mon, I'll show you.

(We walk around the corner to an area about forty feet by eighty feet. It's located about seventy-five feet away from this person's inspection table. Large parts are stored on the floor on twenty or so skids in five rows; two banks of racks run along the side of this area and contain bins of smaller parts on several shelves. There are travelers on top of the floor skids and in the bins of the smaller parts.)

Me: OK, where's the order you're looking for?

Mr. Inspector: I just have to check the travelers to find the one I need.

(Mr. Inspector now walks through the rows of parts looking for a match to the order in hand and finds the order he's looking for.)

Mr. Inspector: Here it is.

Me: OK, what's next?

Mr. Inspector: Well, I'll grab a hand cart and we'll take this order to my station. Hang on, I'll just be a minute.

(He now looks around the immediate area and, not seeing a cart, heads to the adjacent department to find one. He's back in about four minutes with a hand-walkie. He goes to the row that the next order is in and removes the first two skids, which are blocking the needed order. After getting the needed order, he returns the skids that were in the way to the row.)

Mr. Inspector: OK, let's go to my area.

(We bring the order to his station and are ready to proceed.)

Me: OK, what's next?

Mr. Inspector: First I check the bore and the flange for dimension.

Me: Are your micrometers here or stored centrally?

Mr. Inspector: Mics are in the tool crib; they store them and control calibration and such.

Me: I see. How about prints—where do you get the prints or spec sheets you need for each part?

Mr. Inspector: I've got the prints here; they put them in the travelers and they follow the parts through the shop. All right, let's go check out our mics and we'll get to work.

I'll stop this example now, but here's the important point: When you look at a single activity on the map, it can usually be broken down into dozens of separate tasks. This is the level you need to be at in order to do something with the detail. The lesson is: *You can eliminate, add, or change tasks, but you cannot change a broad-brush process.*

Creating a Visual Story

"That being said, let's split the team into groups and start mapping your individual areas," I say.

We cover the walls with large pieces of paper and begin to write tasks on Post-its, one task per Post-it, and arrange them in sequence on the wall. We want to present a "visual story" of the process going from left to right, starting with initial customer contact. The result will look something like Figure 11-3.

OK, the team members are mapping their areas, and we're well into day 1 of our baseline. At the beginning of the day, following our discussion on waste, we assigned two of our team members, Fran Jenkins, accounting, and Julie Ventner, manufacturing engineer, a work-sampling detail. Here's the assignment: They are to walk quickly through the shop, each taking a defined area, once an hour and compile some work-sampling data. We want to record what people are doing at random intervals and record enough data points to achieve statistical significance. The checksheet would look something like Figure 11-4.

Over the course of the next couple of days, we want hourly samples of activity. The categories can change depending on the specifics of the operation, but these are general categories of activity. To expand on these areas a bit, if people are talking to someone, we don't care what they are talking about—work, fishing, whatever—they are determined to be communicating, period. If people are walking, we don't care where they are going; they are simply walking. Transporting means that they have materials or tooling and are going somewhere with it. And so on. I've had a few black belt types question the reliability of this type of sampling, and I have invited them to perform an alternative study using the weapon of their choice. The results have always been gratifying. If you gather a few hundred or more data

Figure 11-3

	12:20 P.M.	1:00 P.M.	2:00 P.M.	4:00 P.M.	8:00 A.M.	10:00 A.M.	1:00 P.M.	2:00 P.M.	8:00 A.M.
Samples	1	2	3	4	5	6	7	8	9
Transport	0	0	2	0	1	0	1	1	0
Walking	1	1	3	0	2	2	1	1	2
Communicating	2	2	4	2	0	2	1	0	2
Inspection	2	1	0	0	1	0	0	1	1
Wait—machine running	2	3	3	3	1	4	2	4	5
Wait—machine not running	4	3	1	1	0	0	2	0	0
Work	3	4	3	2	5	6	6	7	7
Rework									
	14	14	16	8	10	14	13	14	17

Figure 11-4

points, you can safely say that at any given time *x* percentage of the population is doing such and such. It's a nice, simple tool. Enough said; the work sampling has begun, and the mapping is underway.

Wrapping Up Day 1

And so, at day's end, we come back together as a team and begin to discuss the first day's activity. Here's the agenda:

1. Discuss the presentation of the story.
2. Do a run-through as a group to gather questions and observations and reach a consensus.
3. Begin to arrange the wall data in a logical sequence.

The first day of a baseline is a tiring session. The team is beginning to develop a depth of detail that they have never encountered in any company activity. People are generally not accustomed to the concentration and sustained focus required to begin a process flow, evaluate it, add what has been overlooked, evaluate it, add more overlooked activity, and so on. When a group works on this type of session together, it is always an illuminating experience for two reasons: First, people never realize just how many activities they perform over the course of a day, they just do them, and second, people rarely get the opportunity to see what all of their coworkers across the entire business process do. And so:

Me: All right, people, here's where we want to go this week to prepare for our daily briefings and our executive summary at week's end. As we develop our current-state map, accumulate our data, and go to our future state, we want to compile a very visual story. That's why all the work we are doing is on the wall, not in a computer presentation format. We want to begin our map with the initial activity in the value stream, what causes the entire process to start, on the left-hand side of our long wall and proceed in a linear fashion from left to right. And so, what's the first event in our process?

Nate: A customer calls in with an order.

Me: Exactly. We want to go from initial customer contact through order entry, sales, accounting, engineering if required, MRP (Material Requirement Planning), purchasing, scheduling and preparation of the package for manufacturing, the production build, testing, inspection if necessary, packing, and shipping, and finish with the accounting piece that finalizes the billing and collection activity. When you have been paid for the activity of producing and delivering an order, you go back to the first piece, which is, get another order. I don't know if I captured the whole stream here, but you guys get the message.

OK, let's run through the process that you have so far. Each subteam needs to pick a talker and walk us through your activities. The assignment for the rest of the team is, as you listen to the presentation, question anything that is unclear and point out any step that you think was overlooked. We'll expand as we go.

The team walks through their respective areas, questions are asked, clarifications are made, and on and on. As we "walk the wall" with our practice briefing, when we reach the scheduling piece, John, who is talking, starts to fumble and pause as he tries to figure out the sequence of his Post-its. The piece of the map that he's talking about looks like Figure 11-5.

Remember, we're in day 1. The scheduling subteam has gotten quite a good bit of its process on the wall, but it will, no doubt, be expanding the detail as we question each Post-it for task-level detail and activity that was overlooked on the first pass. John is trying to follow the flow of his Post-its, but he is losing the logic as he tries to follow the task sequence. Here's the next lesson of mapping and process activity.

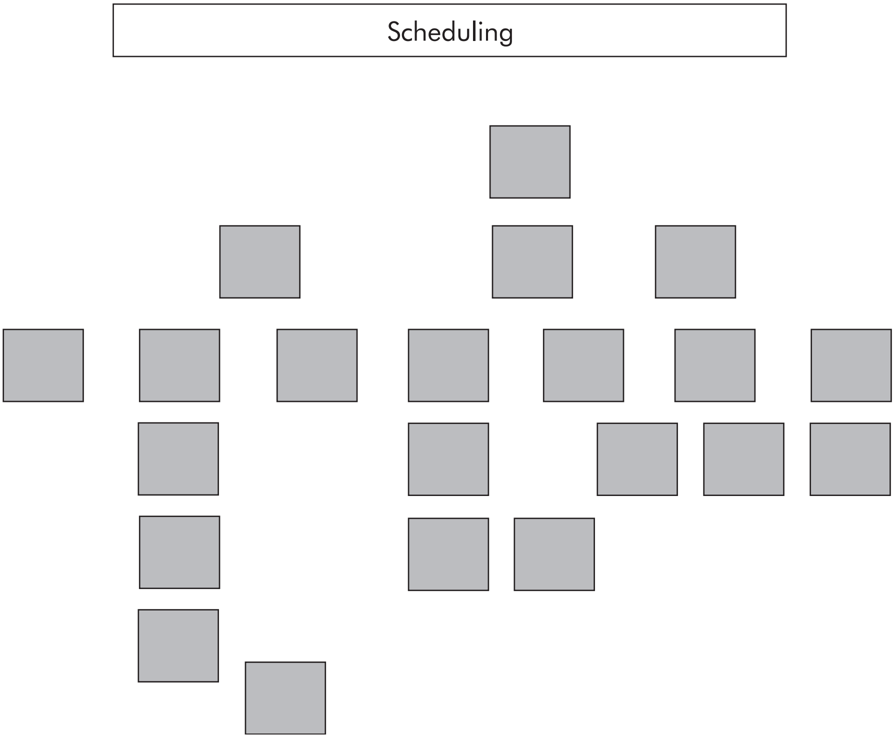

Figure 11-5

Me: John, you're starting to get blurry on your path of activity. You need to clean up that process and make it linear.

John: It's not that easy, Bill. There are many concurrent activities happening. It's complicated.

Me: John, in a process map, there's no such thing as concurrent activity. What's your reaction to that statement?

John: I think you need to take a nap; you're overheating. *(John's getting more laughs from the team than I am; I'm not sure how I feel about this.)*

Me: OK, John, it's time for another Carreira analogy—as usual, dramatically oversimplified. I'm going to fry an egg. That's my process. Here are the steps:

1. I go to the cupboard.
2. I get a frying pan.
3. I take the pan to the stove.

4. I place it on a burner.
5. I go to the fridge.
6. I gather my materials: one egg and some butter.
7. I transport my materials to the stove.
8. I turn on the burner under my pan.
9. I get a knife from the drawer next to the stove.
10. I slice some butter into the pan.
11. I wait for the butter to reach the proper temperature.
12. I get the egg.
13. I crack the shell and drop the egg into the pan.
14. I wait for the egg to cook (cure time).
15. I get a spatula from the drawer.
16. I get a plate from the cupboard.
17. I scoop the cooked egg onto the plate.
18. I take the plate, with the egg, to the table.
19. I put it in the right location.
20. I get a fork from the drawer.
21. I take it to the table.
22. I place it next to the plate.
23. The product is complete and has been delivered.

This process is completely linear. Since it is being performed by one person, one thing happens after the next. You could change the sequence if you wanted to, your go-gets and such, but the process would still be made up of twenty-two steps, one after the other.

Now let's have three people complete this process. The go-gets are now being performed simultaneously; there is concurrent activity, if you will, before and during the time that the egg is cooking. When the egg is cooked, one person puts it at the proper location, the table. As you view the process with three people working, it becomes more difficult to see what's going on. However, the same twenty-two steps are performed, in a given sequence, and the time to complete each task remains the same.

Now let's have 150 people, working on forty-seven stoves, cook forty-seven different eggs simultaneously. There's a blur of simultaneous activity. All kinds of things are happening at the same time. It appears very complicated. However, to prepare one cooked egg, twenty-two steps were performed, in a given sequence, and the time to complete each task remains the same.

Clarity is the mission, and to achieve perfect clarity, when you are defining a process, in your mind's eye, you must have only one person performing all the required steps. The result will be a perfectly linear sequence of steps. When you add multiple people, you don't eliminate steps or speed up the tasks; you merely decrease the overall lead time and make the process more difficult to see.

So my question to you is: If you allowed only one person to perform the tasks as you have defined them in your Post-it process, what's the process look like? Rearrange the Post-its.

John goes to the wall and lines out the process steps with a one-person view. Figure 11-6 shows the result.

"Oh yeah!" I say. "Now I can see the flow of activity. If your map is clean and well defined, the acid test is that anyone could walk through the tasks and understand the flow of activity with no previous knowledge of your particular process." The team finishes walking the wall. It's a good sample run-through; there are lots of comments, corrections, additions, and so on.

Me: OK, folks, we're there for today. The last thing I ask before we break for the day is for you all to quickly regroup your wall data in the proper sequence from left to right.

There is some discussion of which wall to start the process on, and the team rearranges the pieces of the map. Since I asked them to

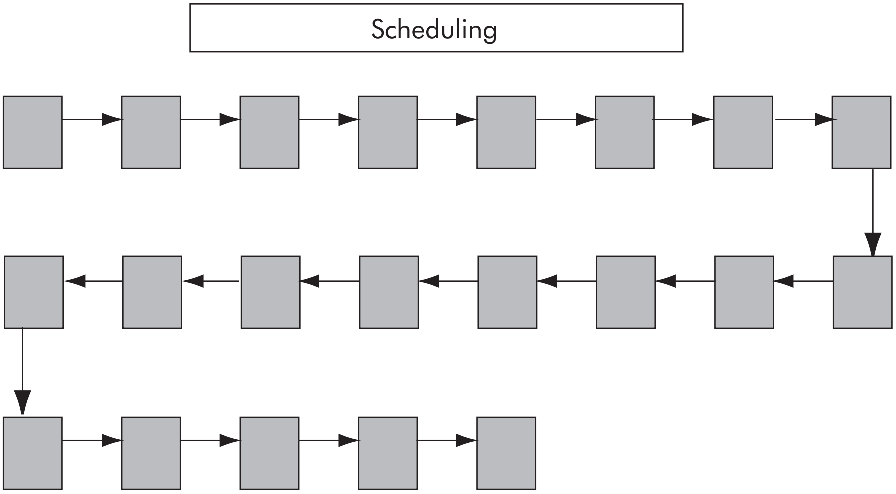

Figure 11-6

start by hanging large sheets of paper on the wall and putting the Post-its for each function on these large sheets, the functions are easily moved in large pieces and rearranged in relation to one another.

Day 1, which has been very busy and very interesting, is done. Day 2 is coming up.

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CHAPTER 12

Doing a Baseline, Day 2

Day 2, Tuesday

> **Me:** Good morning, all. Are you ready for another exciting day? OK, let's rock and roll. Here's the agenda for the day: We need to finish the maps; assign times and definitions to all data; do some different and additional analyses on space, people, and distance; and, in general terms, lock down a quantified picture of our current state. This morning we will begin by finishing the map tasks and material queues, then we'll bring in a few key people who actually do the work in these areas to perform a reality check and bless the process as we have defined it.

And off we go. Most of the team members left yesterday's session and went to their areas to check on the day's activity. They were met with a ton of questions from their work associates about the session that was underway. Whenever you lock up a team of people in a war room for a few days, it seems that the rumor mill throughout the rest of the facility goes absolutely nuts. And so, as the team members explained to their associates what was going on, they received lots of input concerning the real process, the current state. With this newly acquired input, most of the team members have come into the second day with additional data to include on the maps that are being developed. Away we go.

Working around the room, the subteams are adding to, refining, and completing their maps, and so goes the first three or four hours of day 2. Around 11:00 we are slowing down and finalizing the maps to the point where it's time to go to the next level, quantification.

Quantifying the Work

Me: OK, guys, let's stop for a minute and regroup. Your maps are fairly well defined, and now we want to go to the next step. I'd like you all to work through your Post-it tasks and add a time to each task. I realize that these times are your best estimates, but if you really don't know how much time a task takes, go get someone who does. We need to get through this piece quickly, so don't burn up a lot of time going to three decimal places, just get a reasonably accurate time on each Post-it and move on. In addition, every spot where there is a queue of material needs to be identified and the amount of material quantified. The symbol for material is a triangle, so take a Post-it, put a triangle on it, and place it on the map at a point where there is material in your facility today. The method for quantifying the work-in-process queues is by defining time to consume.

Jeff Styles: You lost me. What do you mean by time to consume?

Me: Say you have 200 units of product in front of workstation 4. If I stopped all production going to that station, how long would it take the operator at workstation 4 to consume or process those 200 units and be out of work? Two hours? Twenty-five hours? So, on your triangle Post-its, put the quantity of parts at the location in the triangle, and the time to consume underneath.

Don Booker: What does that tell you?

Me: Among other things, we're looking for time through the pipe, your process. If I introduce an order into your system, under normal circumstances, it will take so much time to process it at each station, so much time to perform the setups at each station, and so much time to process everything in front of that order, namely, all the queues or current orders in the system. If I put that order in today, it will pop out the other end of your process twenty days from now, or whatever your current lead time is. We want to know where the time is.

Jeff: We can put an order through the plant in one day if we have to. We do it all the time.

Me: I'm sure you do. What is your current stated lead time to customers for a new order of your average everyday product?

John Bots jumps in: Our current lead time is twenty-four days, but we tend to promise three to four weeks.

Me: That must cause you a bunch of expediting headaches.

John: You said it. It's a daily nightmare.

Me: OK, so Jeff, that's why I said under normal circumstances, not a super-hot accelerated order. When you blast an order through in one day, what do you do with all the orders that are in the way?

John: Well, we move them out of the way.

Me: So they all go an additional day late?

Jeff: OK, I'm with you. Enough said.

Me: We're measuring the current-state normal system, not your ability to expedite.

Jeff: OK, OK, OK.

(The subteams all work their way through the map tasks and jot down times on each Post-it—one minute here, five minutes there, thirty seconds on this one, three minutes on that one.)

Jimmy: Bill, what do we do if the time is different every time we do something?

Me: Give me a for instance, Jimmy.

Jimmy: I'm looking at the balance piece. If we get a good-tolerance stack-up of components, sometimes we can balance a system in three or four minutes. But if the dimensions go to the wrong side of the tolerance, it can take us fifteen or twenty minutes to bring it into our balance spec.

Me: A range is OK if that's what it really is; we'll sort it out later. If it's four to fifteen minutes, put that down; just try to get the range as accurate as you can. If it's four minutes 85 percent of the time and fifteen minutes 5 percent of the time, give it your best estimate of what the range really should be.

Jimmy: OK, good to go.

The teams are pushing through their tasks, assigning times, still discussing process sequence and details as they come up, and placing work-in-process queues where they exist in today's snapshot. At quarter to twelve, someone brings up lunch, and I suggest that we have it brought in and continue to work through; we have a lot to get done today, and we will most likely end up working late as it is. All agree except Frank Simms, who needs to run out and pick up his son and run an errand. At about 12:30 I interrupt the team for additional assignments.

Doing a Space Analysis Visual

Me: OK, guys, stop what you're working on, please, and gather round. We have to divert some of you to put together some additional detail. I'll explain the assignments, then you guys can figure out who's best suited to divert and who continues on the times. We need a couple of people to take one of our CAD drawings of the facility and compile a space analysis visual. The categories of space we can start with are:

1. Work in process
2. Raw materials
3. Finished goods
4. Tooling
5. Aisles
6. Offices
7. Empty space
8. Value-added activity

And I noticed a big chunk of real estate that Sid said was storage for engineering files that were transferred here when you brought in that new product line from your Louisiana sister division last fall. Let's add an oddball category for engineering files.

9. Engineering files

Can anybody think of additional categories we should add? *(Everyone is trying to picture the floor in their mind; there's no immediate response.)* OK, if you see anything that you want to add, just put it in. Who's up for the space analysis?

(Jimmy Pointer and Sid Krupen raise their hands.)

Me: OK, guys, grab one of those CAD drawings and spread it out on the table here. Here's the game: Grab several different colors of markers and block in the areas in the nine categories we've identified and any other that you see that you care to add. Make a color key on the drawing to show what color stands for what. The detail we want is how many square feet we are using for each of the categories and what percentage of your total facility that area represents. Are these drawings to scale as we requested?

Sid: Yes, they are. My department controls the CAD drawings; these are $^{1}/_{8}$ inch = 1 foot.

Me: Perfect. So after you block in the areas, do a quick measurement of the drawing and get your rough square footage from there. Again, don't get crazy on a couple of feet this way or that, just get the big boxes to a reasonable degree of accuracy. Questions?

Jimmy: Yeah, value added. How do we identify those areas?

Me: For the purposes of this analysis, let's just block in where work is being done. If you've got a machine, take the footprint of the machine itself and add a three- or four-foot working space where a person needs to be to operate it. If it's an assembly bench or floor assembly area, do the same: Where's the work being done, and how much working space do you need around it? If you've got a really big unit and you need swing space to get the unit into the touch area, don't forget to add that space in as required working space. Good to go?

(Jimmy and Sid both nod their heads, grab their markers and drawing, and go off.)

Tracking the Flow of Material

Me: OK, next, we need some spaghetti diagrams of the processes you've got on the wall. We need to take another of the CAD drawings and trace the flow of material as a sample order is run through the shop.

Tony: Where do we even start with this? There are things happening all over the facility.

Me: We're looking for two things from the spaghettis: distance traveled and number of stops. We want to map the path of materials from the time they are delivered by your vendors to the time they leave the building as a finished product.

Jeff: What about people travel?

Me: People spaghettis tend to get a little messy. If you look at material paths, people will be involved in the gross moves from one area to another, so that's usually a one-to-one. However, every time the materials stop, there's usually a blizzard of people moves around them. If it's a stock or stage location, you'll generally see material transactions, go-tos for paper or computer access, the need to move something out of the way so you can get that in, and so on. If the material stops at a work center, there's all the activity of getting tools, getting prints, getting information, doing the work, putting this away here, and on and on. The lines would be a blur, too noisy to do much with. We'll construct the people potential using time from the maps. Again, we want distance and stops for materials. OK, who wants to trace the flow? Who's very familiar with the work center locations and the paths as defined by our wall map?

(John Botts, Jeff Styles, and Fred Morgia step forward.)

Me: Any last questions?

Fred: Yes. You say distance and stops? *(A half question from Fred.)*

Me: Yes. You can measure distance from the CAD scale after you get all your lines in. For the stops, every time the materials stop moving, for any reason, put a triangle on the drawing. So you have a line from here to there, then a triangle, another move to the next location, another triangle. Can you see it?

Jeff: It's still going to be messy—lines over lines, hard to measure. I'm not quite clear on where to start.

Me: OK, here's the lesson on mapping and flow definition. We talked a bit about it when John and his group were rearranging their flow yesterday. Here's your plant on CAD. If you *(I'm pointing to Jeff)* were the only person in the building, and you knew every job in the process, you would come into the facility at 7:00 and build me an order of product. At the end of the day, you would put the completed product on a truck and go home. That's the *Carreira rule—there's only one guy in the plant*. When you map the path for your spaghetti diagram, if you are the only person in the plant, doing every step of production, you will have a completely linear path of activity. Even though activity is done simultaneously in real life, the real flow is truly linear. Simultaneous activity is kind of an illusion that makes the actual path very difficult to see. Can you understand that? Yes, I think we're ready; we'll start and see if we have any questions. OK. And, last but not least, Julie and Fran, you've been gathering work-sampling data for two days now. How many observations do you have so far?

Fran: We've got about 432 observations across three shifts—quite a bit of data, actually.

Me: Great; let's start to put that together. Grab all your sheets and I'll work with you on that for a few minutes. And you folks that are still working on times and queues on the map, stay with it; we'll be looking at tasks for content and the process totals as soon as you get the times completed. Any questions, anyone? Comments, observations? No? OK, we're going.

Work Sampling

The subteams are completing the map times and material queue data, we have a subteam on space analysis and another on spaghetti diagrams for distance, and we are beginning to compile our work-sampling observations. Things are moving along. We need to get as close to a lock on the current state today as we can, to leave us enough time the rest of the week to get to a good future-state definition with a reasonably detailed plan of attack for getting there. And so I'm getting together with Julie and Fran to review the work sampling.

Julie and Fran, a manufacturing engineer/programmer and the controller, are both very comfortable with computers. As I sit down to review their sampling data, Julie pulls up a graph on her laptop.

Julie: In addition to our gathering data, I asked some of the people in engineering to collect data also—as I mentioned, we have 432 points, a good database. I threw the data into this graph to compile the percentages; What do you think?

(Figure 12-1 shows what she has.)

Me: Very nice. Are you surprised by the results?

Fran: I'm not. Remember, I count the beans. I was never sure where the waste in the system was, but looking at the financials, I knew it was out there. I find this study absolutely fascinating.

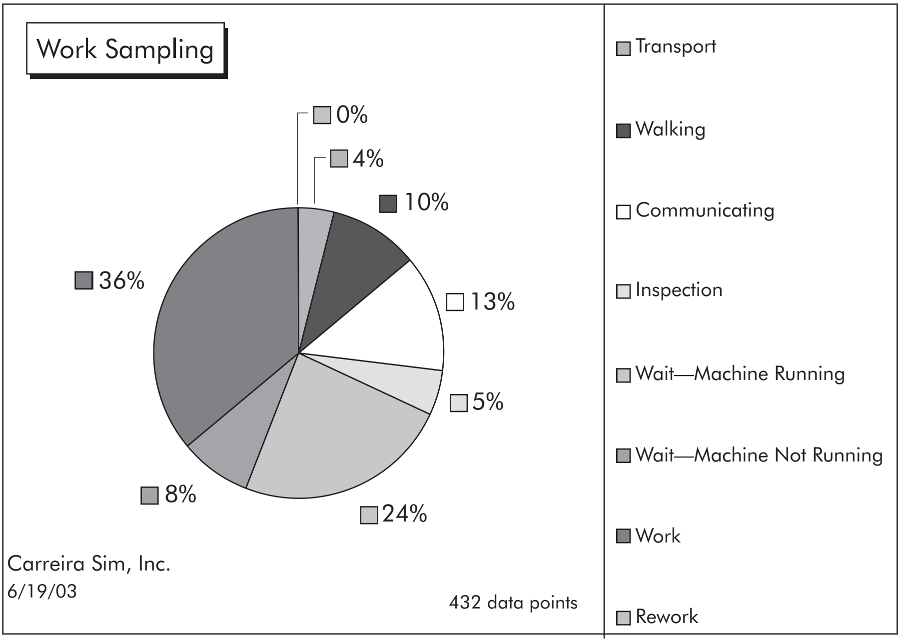


Figure 12-1

Me: It is pretty interesting when you look at things from this viewpoint, isn't it?

Julie: When you work with the floor every day, it kind of becomes invisible. I'm not making excuses, just an observation. I'm just as guilty as everyone else out there of being caught up in the day-to-day activity and never getting a chance to stand back and take a clear look at what's going on. And we've never approached an analysis with the definitions and formats that you bring in. It's pretty cool.

Me: Glad you're having fun. OK, guys, I love your graph, but this is a visual week, and we're walking the wall to tell the story. We'll be briefing management, and most likely you'll be telling this story to your workforce. We want these data on the wall, up in the air. Grab a sheet off the flip chart and build me a graph that looks kinda like this.

I sketch a quick picture that looks like Figure 12-2.

I pull up a couple of files on my laptop. "Here's what we're looking for," I say. "Here's a real-life example." (See Figure 12-3.)

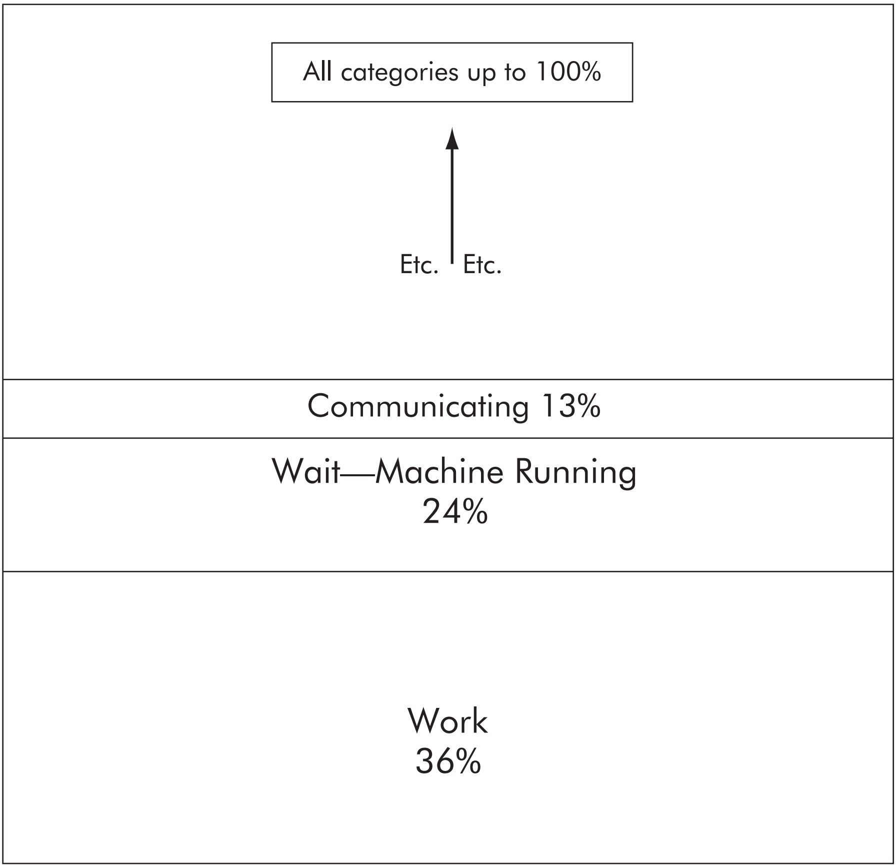


Figure 12-2

"Got it?"

Julie and Fran both nod yes, and away they go to construct their visual.

Defining Each Task

It's 1:30, the wall times subteam is wrapping and the other teams are crunching their visuals, and I interrupt the group again. "OK, guys, let's group up and do the wall for task definition together. This always requires some discussion and talk-arounds to reach consensus, and we need consensus on this piece before we can go to the next step. You have assigned a time, as best you can, to each task; now we're going to walk through the process and assign a value to each

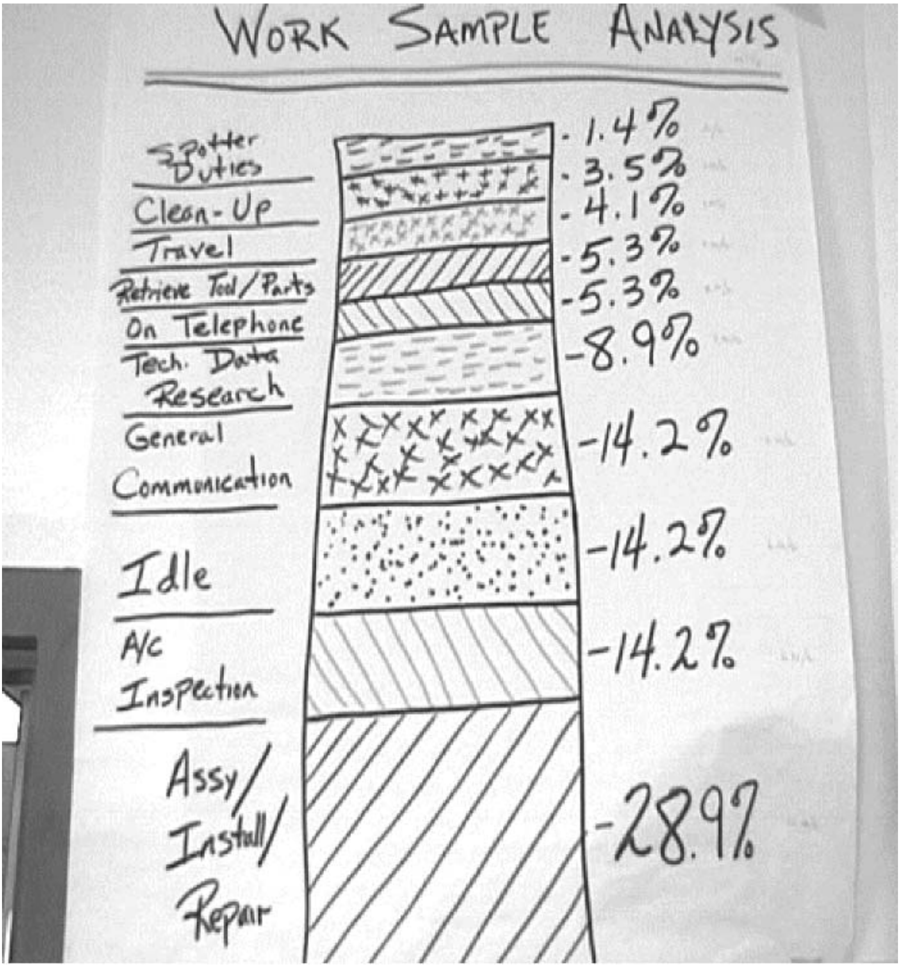


Figure 12-3

task: value-added, non-value-added, or required non-value-added. Grab three markers, red, black, and green, and let's put a circle on each Post-it. Here's the color code." I write this on the wall:

Value-added = ● (Green)
Non-value-added = ● (Red)
Required non-value-added = ● (Black)

"Let's go," I say. We start at the beginning of the process map, which is the initial order coming in from the customer. "OK, initial customer contact. I see you have several paths: fax, phone call, e-mail, and so on. Let's start with the first Post-it task: You get an e-mail, an order request with a pricing inquiry. Does the product change shape?"

Everyone looks around and responds with a no.

"OK, does this activity have to happen? Is it required?"

I get a resounding yes.

Me: Why does this have to happen?

Frank from order entry jumps in: You have to get the order from the customer.

Me: This isn't an order, it's an order pending a pricing definition. Why do your customers have to spend time getting a price on an existing product?

Nate from sales: We have a lot of options and variations. We need to see exactly what our customers are looking for and give them the pricing on those options.

Me: Do these options and variations currently exist, or do you have to engineer a completely new option that you have never manufactured or costed?

Nate: Well, they exist, but they're specials. For example, you want one of our Topeka stainless refrigerators, but you want the doors hinged right instead of the standard left, and you want two additional shelves instead of the standard three. We have to calculate the cost of these specials and get them to our customers before they place their order.

Me: I understand. Do you have labor and materials costed for these variations in your system database?

Nate: Of course.

Me: So, if you chose to, you could develop a catalog or Web site cafeteria-pricing matrix and your customers could simply look down the add-ons and calculate the price for whatever it is they want. Yes, no?

Nate: Well, yes, I guess we could.

Me: Give me a reason why you couldn't.

Nate: There's no reason why it couldn't be done; we just have never done it.

Me: OK, so we're defining tasks with a completely ruthless definition of value-added from the customer's point of view. The part does not become a more complete part because of this specific activity's being performed. All the activity surrounding this task—your salespeople compiling the cost, which, as you've explained, currently exists in your database; time; paper; responses by whatever means (phone, e-mail, etc.); plus all the activity being performed by your customers to contact you and wait for a response—is a total waste of time. Textbook non-value-added. Agree, disagree?

I get a couple of seconds of silence from the group, then Nate takes the red marker and starts putting red circles on the Post-it tasks through this sequence of activity. And away we go. We work through the process map, discussing each task and getting agreement from the group as to the definition of the task. There are occasional stalls and digressions as the group wrestles out a collective decision. Each process is a little different depending on the product and processes that exist in your facility, but the results are universal. Here are a couple of examples.

Example 1

We're at a point where we're pulling a pattern to make an impression in a mold before we cast a part by pouring liquid metal into the mold impression. I have a metallurgical engineer who has joined the group temporarily, and she is absolutely not buying the decision that making the impression in the sand is non-value-added. Let's enter the discussion when it's already underway.

Me: When you put the impression in the sand, this does not make the part a more complete part.

Svenda: You have to make the impression in order to make the part. It has to be considered value-added.

Me: Why?

Svenda: Bill, you seem to be a fairly smart guy; what is it that you don't understand here?

(Svenda is heating up; she is getting impatient with my apparent stupidity and my inability to grasp an obvious and simple concept.)

Me: Svenda, I'm taking you back to our definition. Everything is from the customer's point of view. Let's say the customer ordered a gear made from your metal.

Svenda: OK.

Me: Customers care about the composition of the metal. They care about the dimensions, tolerances, and hardness characteristics of the finished product. But they are ordering a finished product. They do not care how you make it. From their point of view, you could machine it from a slug of solid metal, or you could chisel it using a clovis point arrowhead and a big rock, whatever. You wouldn't even need a pattern, let alone need to make an impression in your sand mold. All of the activity to make and maintain the patterns, make the impression, and finish-grind the casting goes away. You use a pattern-and-mold process because you choose to, not because it is required by your customer to produce the finished product.

Svenda: Bill, that's crazy. To machine from a slug would be outrageously inefficient from a cost standpoint.

Me: Maybe, maybe not. It depends on the part, and you'd have to show me total cost through the entire process to sell me on which way is the most economic. Your current mindset and metric driver is to minimize machining time. The way you accomplish this is by producing several hundred different castings with near-net dimensions. The upside is very good machine utilization. The cost offset is a huge amount of time and money to produce and maintain several hundred different and unique patterns, with a changeover attached to each casting part number; a blizzard of scheduling activity to route this huge quantity of different casting numbers; and the excess inventory required to produce several hundred finished castings from several hundred unique near-net raw castings. Not only does this affect your cost, but it extends your lead time. Remember, a day of additional lead time requires that you attempt to hold an additional day of product in finished goods to provide quick delivery to your customers. So there's a potential cost added in the form of finished goods, space, and additional people to handle the inventory. However, this is not a costing exercise, this is a value-added definition exercise. From the customer's point of view, and with our inflexible definition of value-added, this task is non-value-added. Team, make the call; we need to move on.

(There is a bit more heated discussion, and the group consensus is that this task should be required non-value-added.)

Me: Fine, we'll call it required non-value-added. I'm OK with that, as long we get the point across that it is not value-added. Let's move along.

(This was a tense exchange.)

Me: I just want to make one point before we move on, and I'll address this remark to Svenda. This process of discussion and group consensus is to allow individual participation and empowerment. So, Svenda, as we go forward with the rest of the process, I want you to just shut up and do what I say.

(OK, the group is laughing again, including Svenda. Let's proceed.)

Example 2

A discussion is underway.

Karl (an inspector): You have to perform final inspection to assure that a good part gets to the customer. It definitely adds value!

Me: Does the part become more complete as a result of your inspection?

Karl: Yes. We make sure it is good, it's complete, and it's ready to ship.

Me: Can you change the dimensions of the part by looking at it, can you make the bore larger or smaller, can you change the color by measuring it?

Karl: No.

Me: Looking at or measuring something does not change the part. It's done, and it is what it is. If you produce the product to the print specifications, it will be a good part, whether you look at it or not. This is non-value-added activity. Group, make the call.

The consensus is non-value-added.

And on we go. We finish working through the process map and have all the tasks defined with time and characteristic.

Wrapping Up Day 2

"OK," I say, "the map is done; you subteams can continue to finish your analysis of space, people, and distance. The map team now needs to add all the times to get VA, NVA, and RNVA subtotals and the overall time. What we want to know is what is the total process time; what is the value-added time, the non-value-added time, and the required non-value-added time; and what percentage of the total time is in each category. Grab a couple of calculators and let's go."

The wall team finishes the current-state tallies and percentages. They look something like Figure 12-4.

The other subteams are completing their analysis of space, people, and distance. The resulting visuals look something like Figure 12-5.

And so the team has completed its current-state analysis. It has defined the process and the system lead time, evaluated the process tasks for value-added content, defined the space utilization (how the facility is being used), performed labor sampling to show how the system is utilizing people, mapped materials flow through the plant, and measured distance traveled. Tomorrow we will analyze the system, discuss cause and effect, and begin to construct an improved future state.

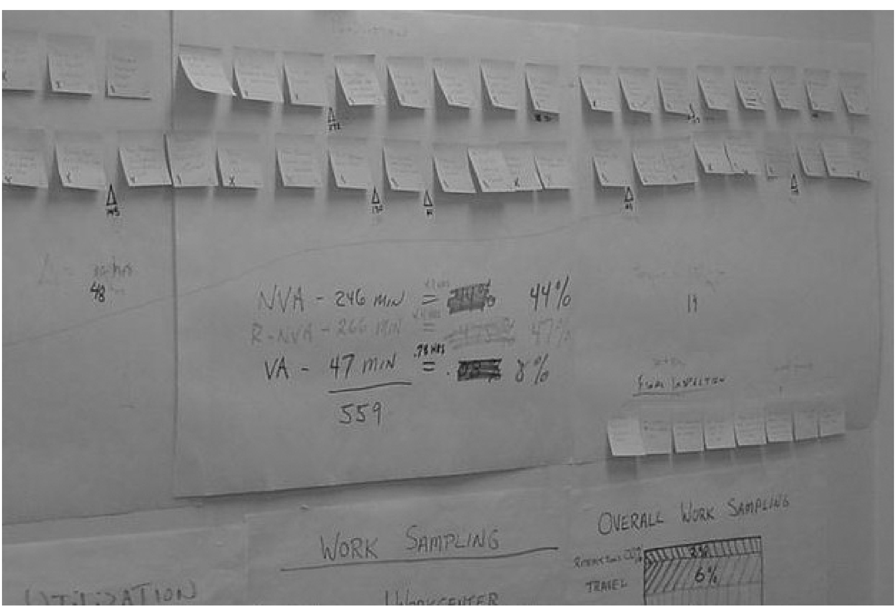


Figure 12-4

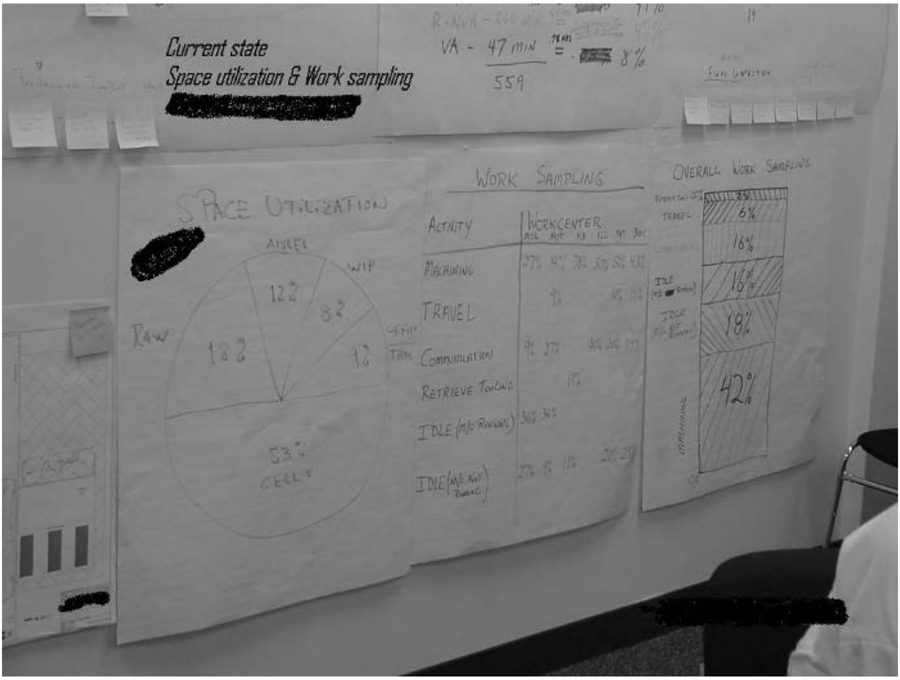


Figure 12-5

By late afternoon on the second day, the team will do a dry run of a briefing, with all individuals taking a small piece of the presentation and handing it off to their associates as they walk the wall. Some coaching is usually required here. Those individuals on the team who are unaccustomed to presenting will tend to want to read each Post-it and get into such a level of detail that it would require several hours to get through the briefing. There are also some management types who really enjoy talking, with the same result. The briefing has to be no more than thirty or forty-five minutes with time for questions afterward, so the wall has to be presented in blocks of short, concise, descriptive summaries. If members of upper management want to get into the details of a specific area and go through the individual Post-it tasks, suggest that they do so after the briefing with the appropriate people who are familiar with that specific area. During the day 2 briefing, all that is being presented is the current state, so there may be some surprises, but it's simply a statement of "what is."

And so it goes.

CHAPTER 13

Doing a Baseline, Day 3

Day 3, Wednesday

"Good morning, all. It's day 3; the dog work is almost over, and the fun begins. Today we're going to analyze the current state that you all have so diligently constructed, fool around with some root cause analysis, develop some solutions for the root causes you identify, and begin to apply the solutions to develop an improved future state. It's time to get creative. Before we begin the analysis, let's work up a quick current-state value stream visual that's a bit more conventional than the process map we have on the wall."

The team throws up four large sheets of paper on the wall, and we construct a visual that looks something like Figures 13-1 a–d.

"Let's start by looking at your current state and summarizing the data on the wall. The big boxes that you store the money in are lead time, materials, people, and facilities costs. Remember, all the pieces are tied together. For example, having excessive work-in-process materials extends your lead time, causes additional facilities cost for space required and additional people costs to manage the WIP, increases your finished goods requirements to keep your customers happy, increases your potential rework costs by having larger batches in the system to rework should there be a quality problem, and on and on. Inefficient layouts cause additional people cost in the form of more go-gets and longer transport times. Departmental and uncou-

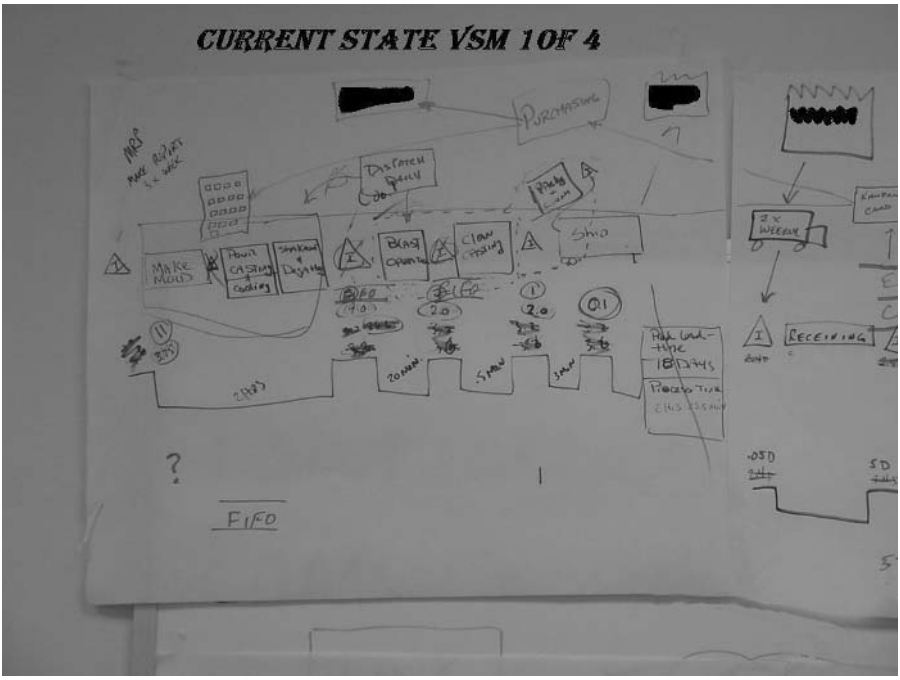


Figure 13-1a

pled layouts and process cause excessive work in process. Inefficient use of people as a result of poor flow layouts increases your lead time. It's one big interconnected circle; everything affects everything, which in turn affects everything else. Keep this in mind as we identify negative effects throughout the system. So, let's summarize, and let's just look at the manufacturing process for now.

"You've established your system lead time by adding the process steps on the wall. You've also broken out each function and put a lead time through the pieces, and you've identified value-added content for each function and as a total. You've put together some data on people utilization, space utilization, and layout effectiveness—distance through the pipe.

"Some quick observations. Your lead time through the manufacturing process is around twenty-two days; your people are working, hands on, only 38 percent of the time; your product is the size of a suitcase, but in order to make a part, you are traveling 1,800 feet, one-third of a mile; you use 30 percent of your production floor to store materials and 14 percent for aisles so that you can move everything around; your average order size is 300 units, which you can

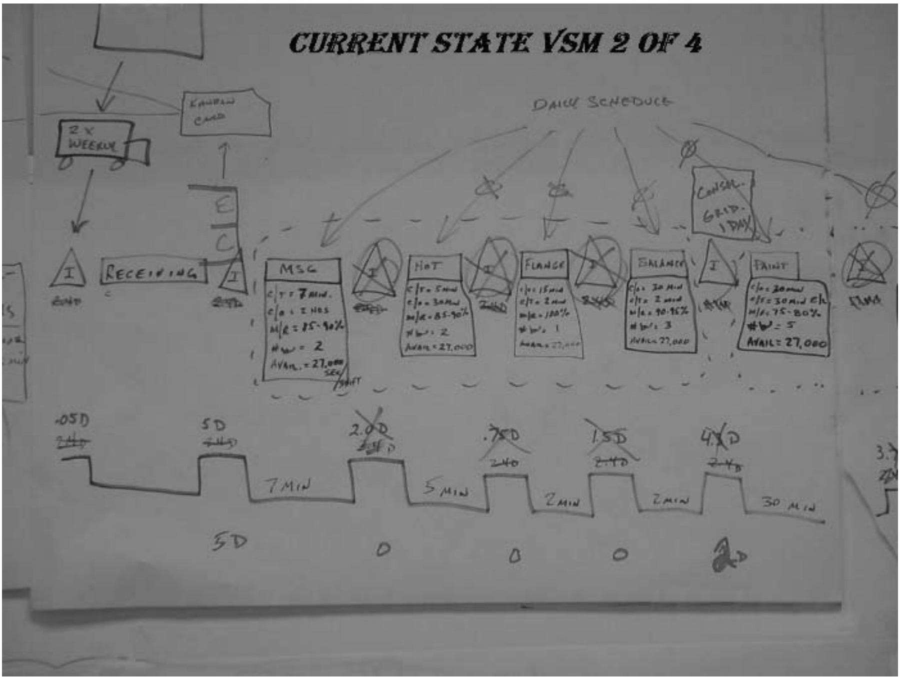


Figure 13-1b

produce in four hours, yet it currently takes seventeen shifts to get an average order out the door; your production process is 281 minutes, yet only 2 percent of that time is value-added, to name a few of your observations from your map."

Undesirable Effects

Me: So here's the first question: When you look at this system or process, what do you see as an undesirable effect, a UDE?"

Bill McDougal breaks the ice: What's your definition of an effect?

Me: Something I can see and measure. For example, looking at your numbers, your people are working only 38 percent of the time. The rest of the time they're walking somewhere, talking, getting tooling and materials, putting things here and there, and so on. The effect I can see is poor people utilization. I don't know the cause. This situation could be, and usually is, caused by a combination of things. How can I say you have poor people utilization? When I look at your sampling data, your people are not working 62 percent of the

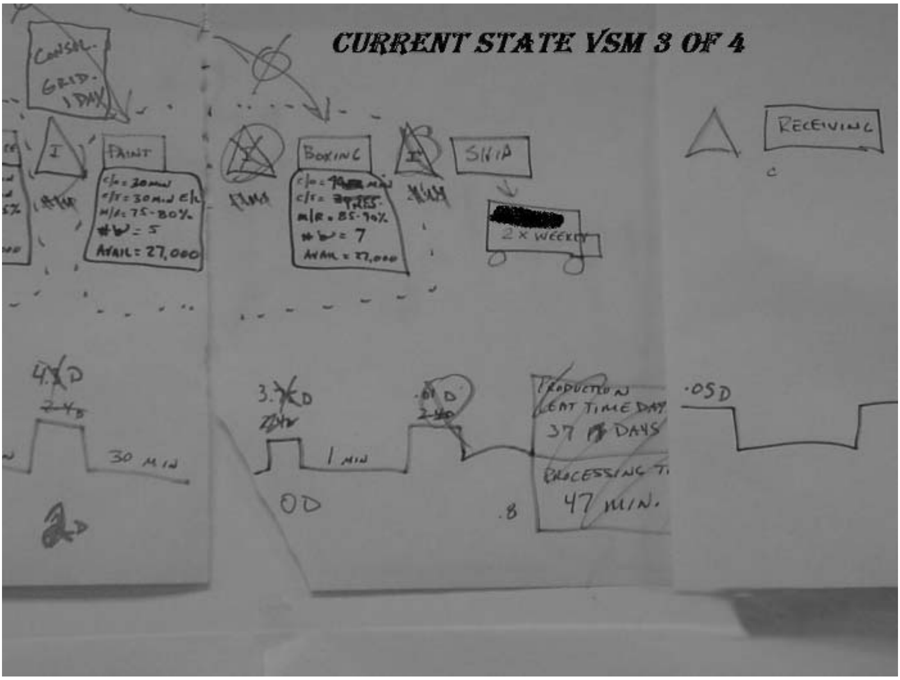


Figure 13-1c

time. I can see and measure this effect; I cannot see or measure the cause. Does that answer your question clearly?

Bill: Yes.

Me: Somebody grab the flip chart and let's start listing UDEs.
(Nate goes to the chart and grabs a marker, ready to go.)

Me: OK, who's up? Bill?

Bill: OK. I guess I'd say we have lead times that are too long.

Me: Good; excessive lead time, there's one.

Julie's next: We have poor flow.

Me: How so?

Julie: Well, we travel all over the shop, we have WIP everywhere. Look at the data.

Me: Where do the data tell you that you have poor flow? They tell you that you travel one-third of a mile to ship an order. They tell you that you have twenty-three triangles on your map where materials stop as they progress through the process. They tell you that one-

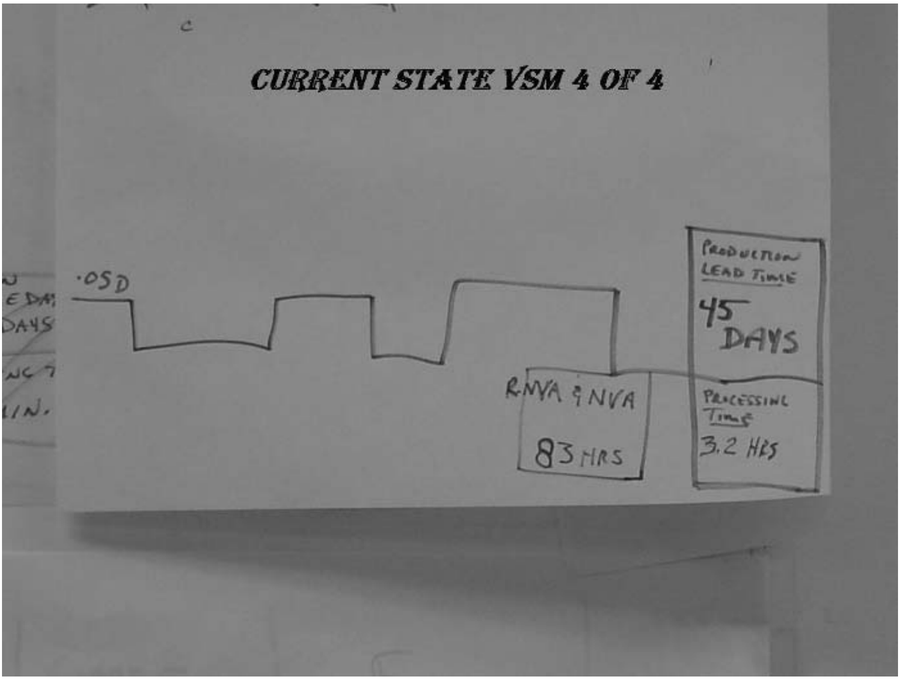


Figure 13-1d

third of your shop is used for storage of waste—sorry, I mean work in process.

Julie: OK, where are you going with this? *(The group is starting to get used to my style after a couple of days of baselining.)*

Me: I'm going here: Be careful not to confuse effects and causes, even though they sometimes are the same. When you say you have poor flow, what you're really saying is that you have excessive travel, or maybe that you have excessive work in process. Yes? No? You need to be very careful how you use the words.

Julie: OK, what I was looking at was the spaghetti. I'll rephrase: We travel excessive distances.

(Nate is writing on the flip chart as we go.)

Me: OK, we're off. Excessive lead times, excessive travel, what else?

Mike: We don't use our people very well—poor people usage from our sampling, and I would add excessive non-value-added activity from our map.

Me: Excellent; what else?

Sid: Poor facility utilization. We're using less than half of the building for work; the rest is storage, aisles, and space.

(Nate is writing as we go. They're picking up steam.)

Nate chimes in: How about excessive inventory? It's everywhere.

Me: Write it down.

Don: How about long setup times?

Me: Where do you see that?

Don: From the setup-to-run graphic we constructed. *(He points to the visual that he and his setup guys put together.)*

Me: OK. That's a keeper. What else?

There is some discussion on details of the process, and the team is slowing down.

"OK," I say, "let's stop with what we have. For UDEs we have:

1. Long lead times
2. Excessive travel
3. Poor people utilization
4. Poor space utilization
5. Excessive inventory
6. Long setup times

"Let's discuss these topics and prioritize them for impact." I take a flip chart sheet and draw a quick matrix of the undesirable effects. "I'd like everyone to rate these in order of which you feel has the greatest impact on the operation, 1 through 6, with 1 having the greatest impact. We'll add across and get a collective priority. Everyone please come up and put your numbers in the matrix."

The team fills in the graph as shown in Figure 13-2.

"OK, if we add up the tally, we have established our collective priorities. Who has done root cause analysis?" I get four hands up, with the majority of the group giving me a no shake of the head and some look-arounds.

Root Cause Analysis

"We don't have a lot of time to spend on this area, but I want to do a couple so that everyone is exposed to the thought process and under-

Rank	UDEs												Totals
1	Long lead time	2	1	1	2	1	2	1	3	2	1	2	18
5	Excessive travel	6	5	5	6	5	4	4	5	4	5	5	54
2	People utilization	3	2	2	1	2	3	2	1	1	3	3	23
6	Space utilization	5	6	6	5	6	6	6	6	6	6	6	64
3	Excessive inventory	1	3	2	4	2	1	2	4	3	2	1	25
4	Long setups	4	4	4	3	4	5	5	2	5	4	4	44

Figure 13-2

stands what it is. We've been compiling effects, and now we want to drill down on causes. It's a curious thing, but most companies aren't very good at using this tool. In most of the operations I go into, if you look at the reject data sheets from any area in the plant, you'll see a list of reject effects that people are keeping track of. If you can find the same data sheets from the past, you'll invariably see the same list of effects. People keep getting the same rejects over and over. They become the focus and will drop or go away for a while, but they keep coming back. People never completely solve the problem areas.

"The reason is that people have a tendency to jump to a solution without really boring down to the root cause and developing a solution or solutions that will resolve the issue for good. I think it's because they never clearly identify the cause/effect relationships. I've heard this common reaction called the ready, fire, aim approach. The guys I used to work with called it 'killing the bear.' They meant that when you are hunting a bear, if you merely wound it, you'll just make it really crazy, and it will return to maul you again and again.

"Properly used, root cause analysis is a very powerful tool. We're just going to skim the surface today in order to develop a reasonably sound logic flow as we go to developing solutions for our future state. There are many popular formats for root cause analysis, ranging from 'fishbones' to 'control barrier analysis' to 'failure mode and effect analysis' to very complicated tools such as the 'reality tree.' These are all excellent tools when they are used by people who understand how to use them, but I like a very simple tool called the 'five whys.' The technique is to ask the question, 'Why do we have such and such?' and keep asking why to each response. It's a fast, easy, flowing tool that is fun to use and subject to manipulation. I want to run through one example together, then split into subteams, take the top three of our UDEs and map the whys. Here's the way it works. Let's say our effect is excessive travel.

"Figure 13-3 could be one leg of a flow down from this effect. There can be several legs from the same cause, and if you don't identify and address them all, you will not kill the bear." I pull an example up from my computer. "The end result could look like this." (See Figure 13-4.)

"As you follow the whys down the logic stream, you reach an answer like the one shown in Figure 13-5.

"You've hit some words that give you a specific action that you can perform to control the cause. This is kind of subtle, but dangerously profound. In this case, the action you can take is, 'develop and implement a cross-training program.' You have successfully killed one leg of the bear. Just be advised that there are several legs coming out of this effect, and you must successfully identify each one and flow it down to a root cause if you are to see a lasting and maintainable result. If you overlook even one leg, you'll continue to see variation.

"All right, let's break into subteams, take the top three effects, and apply this approach to find root causes. Take about thirty minutes; if you go much longer than that, it's because you've gone down a hole and are stalled on your logic flow. I'm going to float around and work with all three groups to keep it going. You folks that are familiar with this technique, please split up so you are in different groups. OK, let's go; throw up some big sheets of paper and get your maps on the wall."

The group splits up and begins to tear down the top three effects that were identified: long lead times, poor people utilization, and excessive inventory. As I float around between groups, I challenge their thought processes, play devil's advocate on word usage, and add ideas for additional legs where I can. And so it goes; the group is hard at

Why do we have excessive travel?

Because we have
long distances
between operations

Why do we have long distances between operations?

Because the plant is laid
out in departments

Why is the plant laid out in departments?

Because we want to
group like machines
because of people's skills

Why do we have to group machines to consolidate skill sets?

Because most people
can't run many different
types of machines

Why can't our people run a wide variety of machines?

Because they are not
cross-trained

Figure 13-3

Figure 13-4

Why can't our people run a wide variety of machines?

Because they are not cross-trained.

Figure 13-5

its root cause analysis. After about thirty minutes have passed, I call the group to a halt.

"All right, everyone, let's stop and present your logic flows to the entire team. It's time to evaluate your legs on these first three effects and reach consensus on their various roots." All three subteams present their visuals, discuss and rationalize the logic flows, and talk about the root causes they have ended up with. This is always a point of lively conversation, and I usually see "management philosophy" as a root across different legs. When you see this wording, you need to back up a step or two and look at where you are. For example, suppose you're following a leg like Figure 13-6.

You could follow that logic and say that the activity required to correct this cause is "change management's philosophy." This would be true in the abstract; however, if you back up two steps, your corrective project would be "change your layout to a coupled, balanced flow layout." This is probably a better definition of the corrective action you will care to undertake. The real root cause would be, "we have a fragmented, disconnected layout." And so:

"OK, folks," I say, "as I probably mentioned before, this analysis tool is fast, fluid, and subject to interpretation. You've reached con-

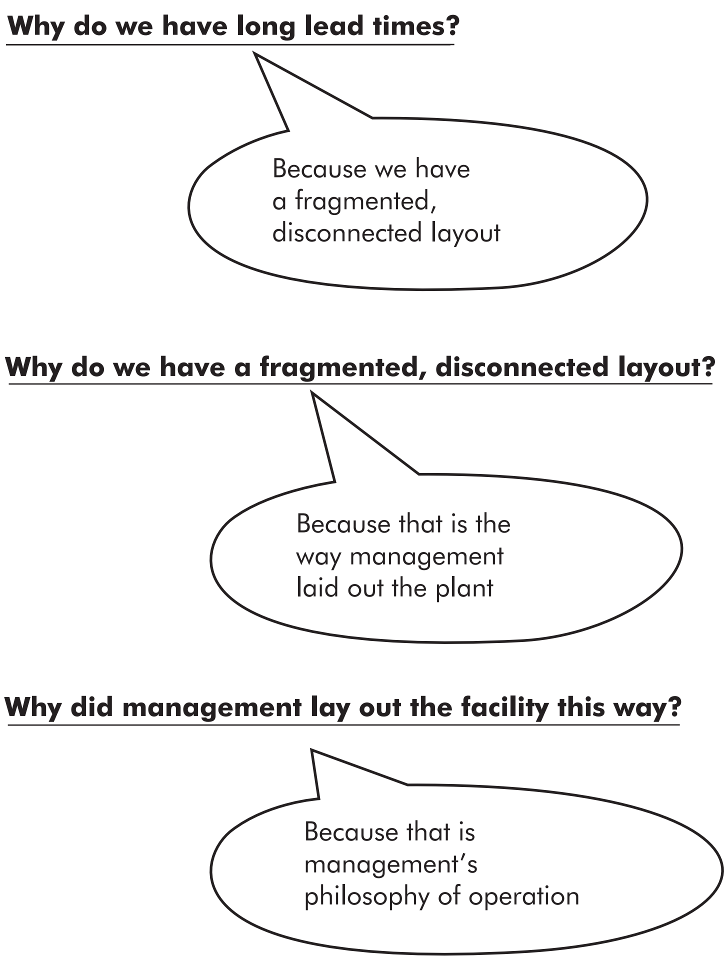


Figure 13-6

sensus on a few roots, and you've all noticed that you see common roots across different effects. That's no surprise; it always happens that way. The point I wanted to make is that if you flowed the last five or six effects, you would see even more overlap of roots. With the exception of very specific or unique effects, depending on your specific product and company culture, you'll generally end up with a half dozen roots that are surprisingly common across many companies and drastically different products. This relates to the simple fact that your roots address your process, not necessarily your product, and processes are similar, if not identical, across very different industries. I'll take you back to my oversimplified view: You buy materials, you hire and train people, you manufacture something with the materials and tools you have purchased, and you ship a product to your customer. You use the same high-level process, whether you're making widgets, vacuum cleaners, or submarines.

"Here's another point to consider when you use this tool: You can have roots at different levels of a leg. This is contrary to logic, in that you would think that a flow-down should be clean and black and white, and should end in a nice, neat package that gives you one root. That's not always the case. You need to pay close attention to how you use your words and recognize when you have a phrasing that allows you to do something that will modify the effect you are examining. Here's a quick illustration. I'll make up a leg just to show you what I'm thinking about (see Figures 13-7 to 13-9).

"OK, you've collectively developed root causes for the undesirable effects you see in your process and actions you can take to address those effects. You have well-developed logic flow visuals to use in briefing people who were not part of this week's activity. Let's discuss some preliminary projects you can launch to improve the process.

"As the first step in jumping to preliminary solutions, and in keeping with my highly irritating habit of obsessive linear clarity, I'm going to ask you to develop written problem statements to address each area of focus. I know this seems a bit much, but my intent is to provide a crystal clear statement for those people to whom you will present these data. Here's the problem; here are the root causes; here's our proposed corrective project. No blur, no noise.

"Here's an example of what I am looking for." I pull up a sample on my laptop (see Figure 13-10) and show it to the group.

The group splits into subteams and spends about thirty minutes

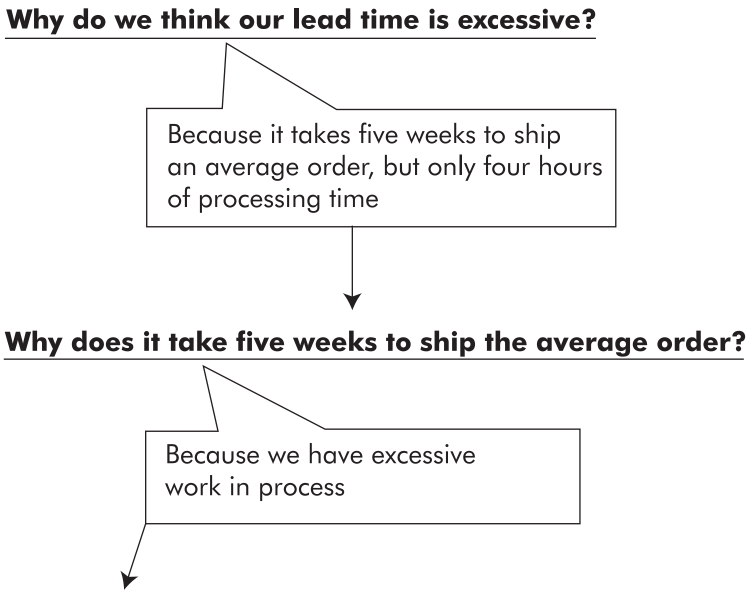


Figure 13-7

developing problem statements addressing each area that will be targeted for a corrective project. The hidden benefit from this exercise, in addition to clarity of presentation to nonmembers of the team, is that by wording statements as a group, the team further solidifies its collective vision and detail definition. The team members are becoming a group of individuals with an extremely well-defined "one mind" vision.

Following the problem statement session, the group has a discussion of various preliminary solution projects and begins a draft list on large sheets taped to the wall. The group has about a half dozen projects and has gone to some level of detail on scope and tasks as we approach the end of the day.

Wrapping Up Day 3

> **Me:** All right, you guys are getting blurry enough that it's time to call it quits for today. Let's organize the data we've assembled today, recompile our wall again in the sequence of the week, and do a quick "walk the wall" dry run before our briefing with management.

The group is getting good at organizing our growing data visuals; all data are reorganized and sequenced in the day 1, day 2, day 3

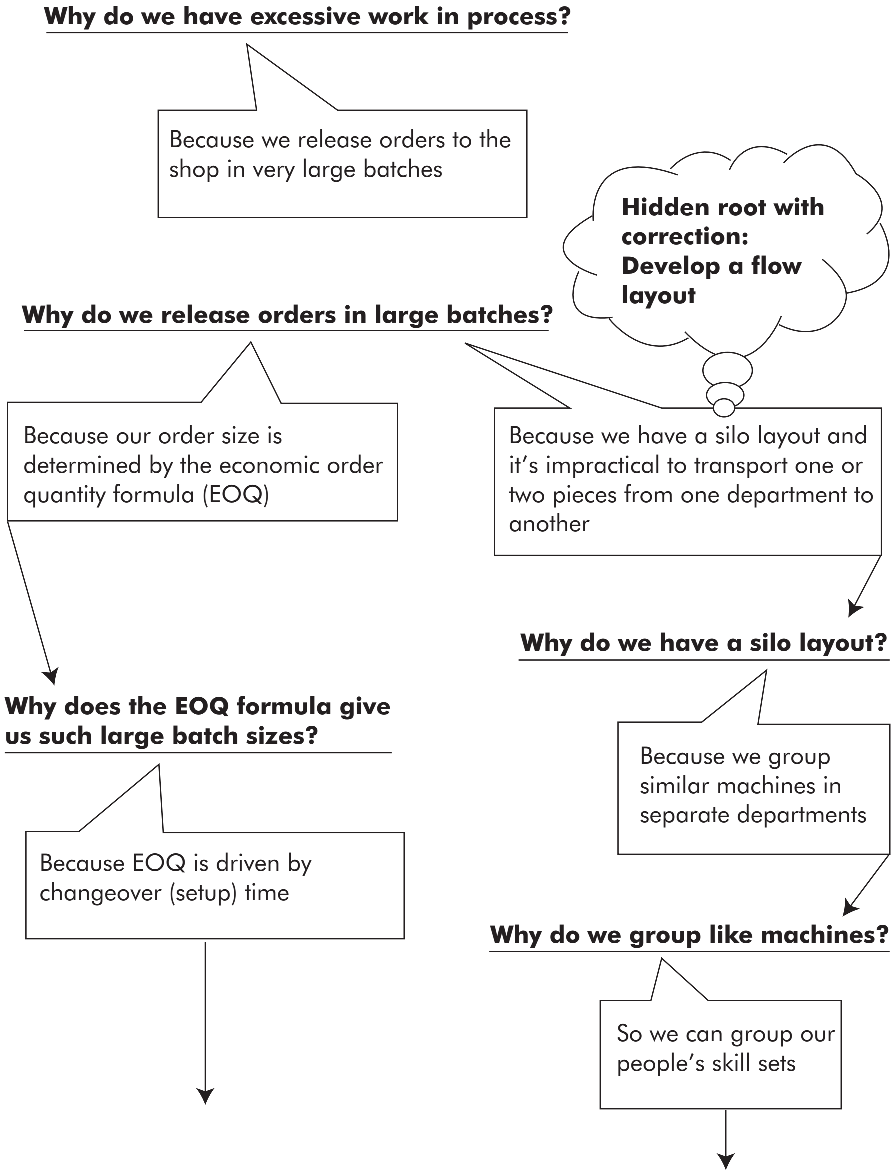


Figure 13-8

linear story flow. I also notice that by now, on day 3, our presentation is becoming increasingly crisp and concise. It's low-level enough to describe broad process groupings, and high-level enough to get through the briefing presentation in about forty minutes. Practice does make perfect. Following our dry run, the executive management

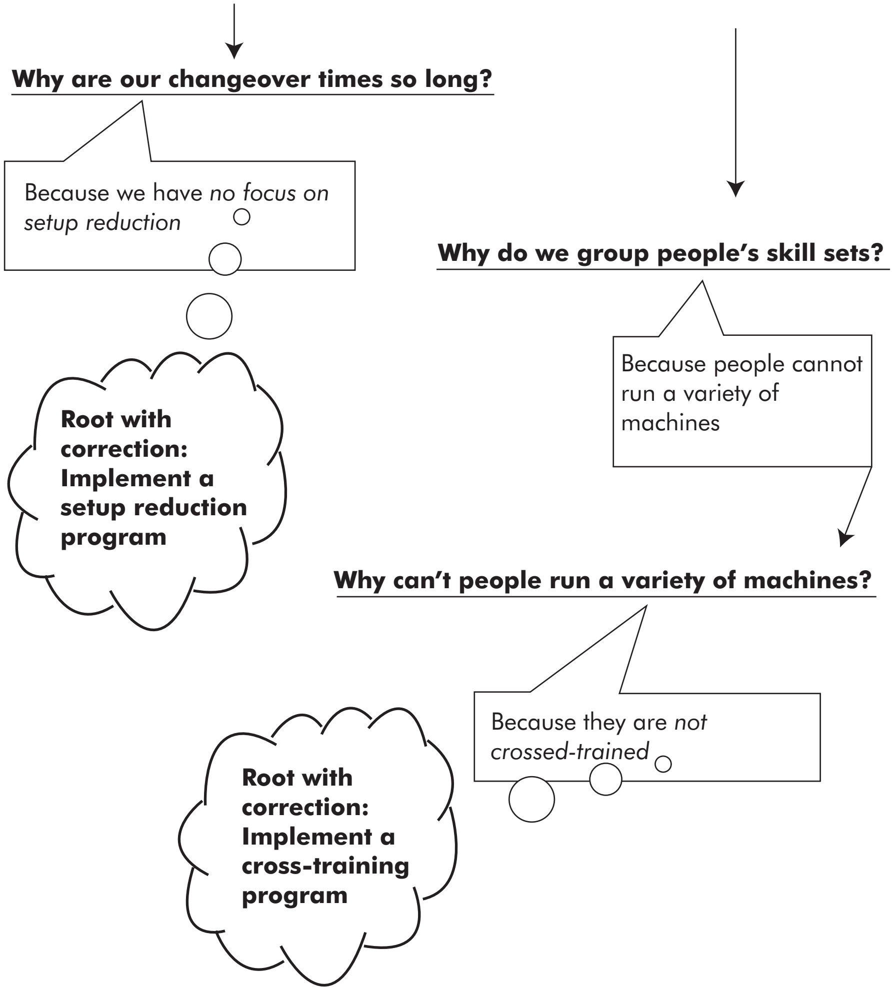


Figure 13-9

team arrives, along with several other company managers. This session is getting some buzz around the company, and interest is developing from peripheral areas. Following our briefing, we open the floor to questions, comments, and observations from the visiting managers. And there we have it; day 3 is a wrap.

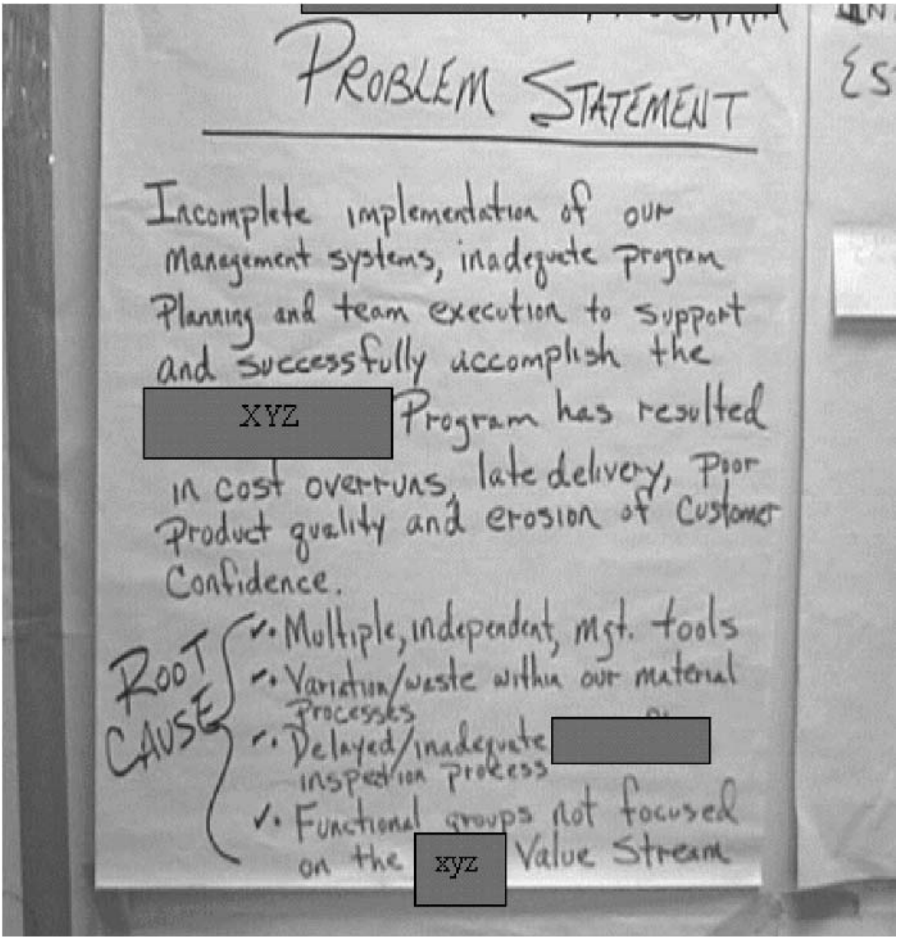

PROBLEM STATEMENT
Incomplete implementation of our Management systems, inadequate Program Planning and team execution to support and successfully accomplish the
XYZ
Program has resulted in cost overruns, late delivery, Poor Product quality and erosion of Customer Confidence.
ROOT CAUSE
✓. Multiple, independent, mgt. tools
✓. Variation/waste within our material Processes
✓. Delayed/inadequate [redacted] inspection process
✓. Functional groups not focused on the
xyz
Value Stream

Figure 13-10

CHAPTER 14

DOING A BASELINE, DAY 4

Day 4, Thursday

"Good morning, everyone; welcome to day 4. Our agenda today is to take the preliminary solutions you worked out yesterday to a fairly well-thought-out stage, develop a proposed future state for your company, and flesh out a first-pass, relatively detailed implementation plan to take you from your current state to your future state. Questions? Comments? Crazy ideas? Yes, no? OK, let's go.

"We're going to be bouncing back and forth between developing the concept of the future state and refining our final solutions, so you should find today to be an interesting day. In addition, we will be 'dollarizing' our projects and figuring out how they affect the future state, so we'll be looking to Fran, our controller, and her people for a lot of help in putting the numbers together. Concerning our approach to project definition, I would like to offer some advice.

"Spend nothing until you absolutely have to. I've worked with a lot of teams, and I frequently see an initial reaction that I call 'the Santa's list syndrome.' We can lay out the plant, but only if we can buy a zillion dollars of new equipment and quick-change tooling. All of the things you have been trying to get for the past few years suddenly become essential to a lean implementation. My reaction is, 'Not so.' You are currently supplying your customers, using your existing equipment and people. The first step is to ruthlessly minimize waste in your existing process. When you start to see money flowing to the bottom line of your financials, then you can negotiate a percentage to fund further improvement. Don't spend it until you earn it. Enough said.

"I'd also like to ask that you approach your future state from two different points of view. We will be working heavily with the tools at hand, but I also ask that you develop a concept from a 'no restrictions' mindset simultaneously. Let's play with this one a bit before you start to develop the details of your activities and future state. You have identified developing a flow layout as one of your projects; let's use that as an example.

"Gather round this center table." The group members all pull their chairs up to the center table of the conference room. I take a large sheet of blank paper and set it in the middle.

Case in Point: Developing a Flow Layout

"Here's the scenario. I am a wealthy investor, and you people represent experts in all functions of producing your high-velocity gizmotrometer. I've invited you to my mansion in Siesta Key, and we are discussing a company start-up. I have not designed a facility yet, and my first question to you concerns the definition of the process required to manufacture the product in question. My primary objective is a very-high-velocity process with minimal to no investment in space, inventory, and wasted time. I do not care about machine utilization, direct labor efficiency, or overhead absorption. I do care about the highest-velocity system, cash to cash, that you can build me. On this blank sheet of paper, I'd like you to build me a process. Start with bringing in raw materials, and lay the equipment in place that we need to make the product. Questions? OK, let's go.

"Fred, as the top manufacturing guy, start us off."

Fred: OK, the first step is to bring raw materials into the building. Are we assuming that the people are in place?

Me: Yes.

Fred: All right, how do we do this?

Me: Sketch it out on the paper as you go. Big boxes will do just fine.

Fred: OK. We bring material in and put it here. That's step 1. The next step is the first step in the process; we need a turning center.

(Fred draws the two boxes and labels them. [See Figures 14-1 and 14-2.])

OK, now we need to bore the inside dimensions, so we need a second machining work center; then we have a key, so we'll need a broach; then we have to put the teeth on the gear, balance it, paint it, assemble it, pack it, and ship it. *(Fred's process flow looks like Figure 14-3.)*

Me: OK, so far, so good. Let's put some times to it. What are the cycle times at these stations?

Don from machining jumps in: The cycle time on the first machining center is fifty-five seconds; that on the second center is seventy-five seconds.

Me: OK, what about broach?

Jimmy: Let's put that one at fifty seconds. Drill and tap, the Haas, on this part would run seventy-five seconds, and balance is forty-five seconds.

Me: Good; what's next?

Jeff: Painting is a continuous process, but we clock the time at thirty-five seconds per part. Assembly would be around three minutes.

Me: All right, how long does it take to pack it and do what needs to be done in shipping?

Jimmy: Well, you have to make a box, pack it, skid it, then shrink-wrap the skid and put the skid on the truck when you have a full skid. Let's say two minutes per part; that's an estimate.

Me: OK, so we have the time to make a unit, without setup times for the various machines—just the time to pass through the cycle. OK, let's arrange this flow a little differently, like so. *(I sketch out a U-shaped grouping like that in Figure 14-4.)*

Raw Materials Staging

Figure 14-1

Turning Center

Figure 14-2

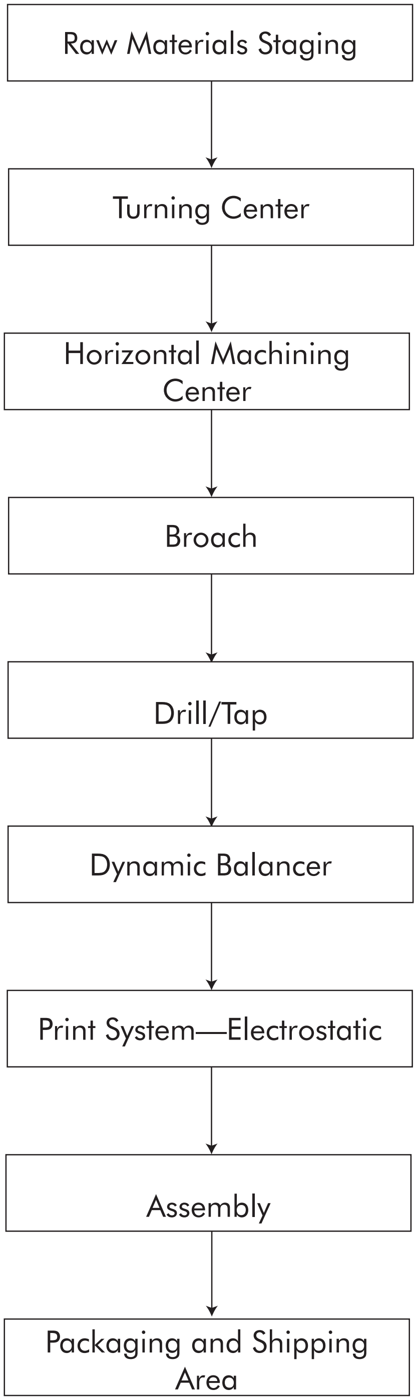

Raw Materials Staging
Turning Center
Horizontal Machining Center
Broach
Drill/Tap
Dynamic Balancer
Print System—Electrostatic
Assembly
Packaging and Shipping Area

Figure 14-3

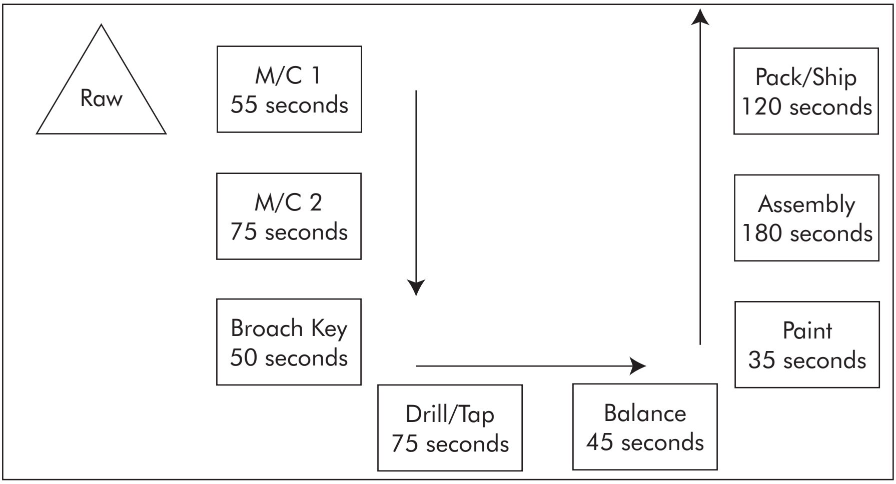


Figure 14-4

If you look at what we have so far, it is the classic U cell. We have not balanced the people or linked our cycle times to our demand; we've simply used the concept of a flow cell, with no thought to real life.

Cell Design

"Let's talk a little about cell design before we go forward," I say. "You folks in manufacturing will already know what we are talking about, but for the benefit of those of you who are in nonmanufacturing functions, we all need to be on the same page."

I hook up to the computer overhead and throw some slides up on the wall.

"These cell concepts are nothing new; you'll see similar illustrations in all the lean books and in most classic industrial engineering books. I've seen slightly different definitions of the various configurations, but we'll run through them quickly. This first layout (Figure 14-5) is the classic birdcage.

"All drill presses are in one department, all mills are in another department, all lathes are in a third department, and so on. Everyone in the system works as fast as he or she can, and when someone has completed a batch, that person sends it to the next department, whether that department is ready for it or not. The build rates do not consider the rates of the operations downstream or upstream, and

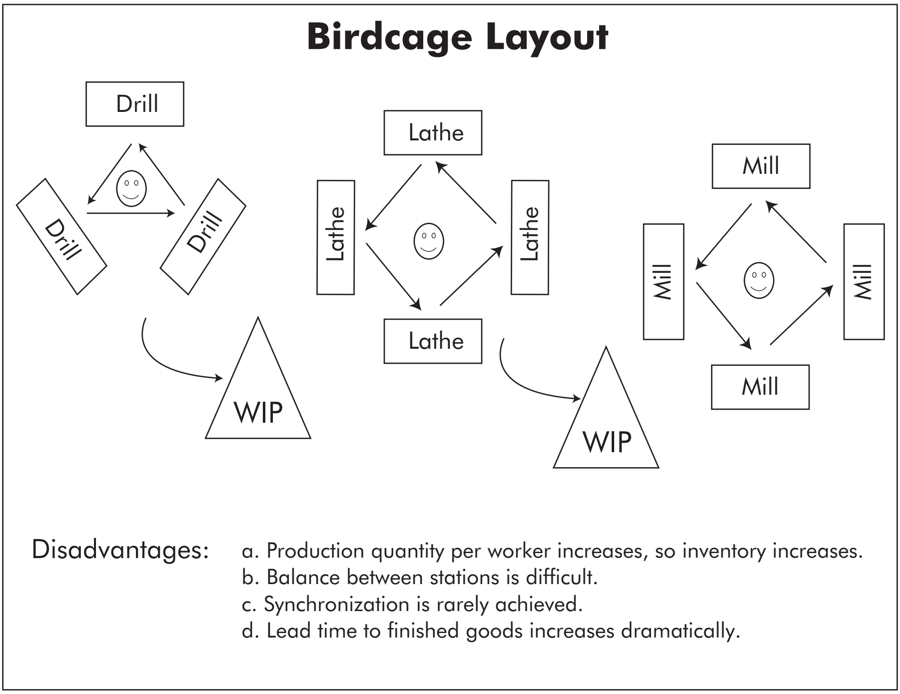


Figure 14-5

they are not balanced to customer demand in any way. They are most efficient if they produce more units per worker-hour paid, even if the result is merely a facility that is choked with BHBs or a stockroom that is filled with unneeded finished goods."

Don jumps in and asks, "What's a BHB?"

"Good pickup, Don!" I reply. "A BHB is a rather sophisticated, highly technical term that I like to use. It stands for *big honker batch*. OK, where was I? Also, this type of system is a scheduling nightmare because of the need to schedule each work center as if it were a separate business. In addition, you'll usually see lots of expediters in this type of environment, tracking progress, expediting batches, and changing priorities as the constant stream of customer phone calls with complaints about late orders pours in. This is not a fun place to work.

"Another interesting point with regard to birdcages is that a quality issue anywhere in the process will cause massive expenditures for rework and move-arounds because of the large amount of work in process in the system. Questions? OK, on we go.

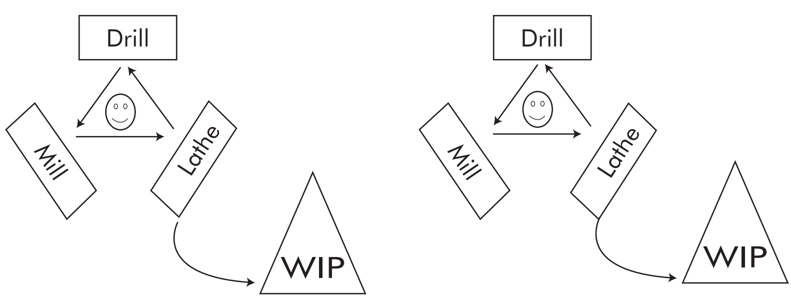
"The next scenario (Figure 14-6) is commonly called the island layout, although some folks call it isolated islands.

"With this scenario, you've grouped a couple of sequential operations together. It's better than a birdcage, but you'll see the same undesirable effects in this system with regard to lead times, balance, quality, late orders, and inventory. I've been in companies that had this type of work areas and been told that their operations were completely cellularized. Make no mistake, these are not cells.

"The third type of layout is a linear layout (Figure 14-7); again, this is better, but it still has limitations. You will see a much improved inventory position, but there are difficulties with people balance when your demand pattern changes quickly and often, and it is not the ideal layout if you are concerned with balance across your total facility. This is a good layout if you are making very large products—for example, submarines or airplanes.

"The next transition is usually from a linear layout to a U-shaped cell (Figure 14-8). This type of layout has many advantages with regard to flexibility among operators, improved operator communica-

Isolated Islands



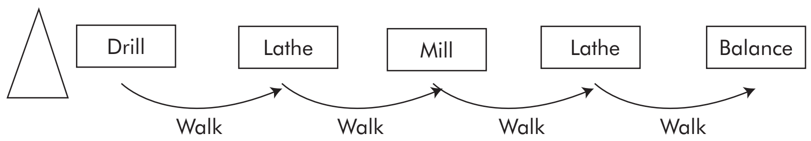
Advantages:
a. Continuous, smooth flow of sequential operations.
b. Provides a continuous walking route with short distances.

Disadvantages:
a. With total factory layout, workers cannot help each other.
b. Difficult to obtain total balance between various processes.
c. Unnecessary inventory still occurs between different processes.
d. Since unnecessary inventory exists, wait time will be absorbed by producing this inventory. Reallocation of operations to meet change in demand is difficult.

Note: According to classic methods engineering, people should never walk while at a position—this is correct in terms of the efficiency of individual workers, but incorrect when viewed in terms of the balance of the entire facility workforce.

Figure 14-6

Linear Layout



Advantages:

a. Overcomes the demerits of isolated islands, e.g., unnecessary stock between stations goes away and flow is quick and smooth. Good with large product.

Disadvantages:

a. Cannot reallocate operations among workers in response to demand changes.
b. Each line is independent from other lines.
c. Repositioning of operators for demand change often requires fractional numbers that must be rounded up, resulting in wait time or overproduction.

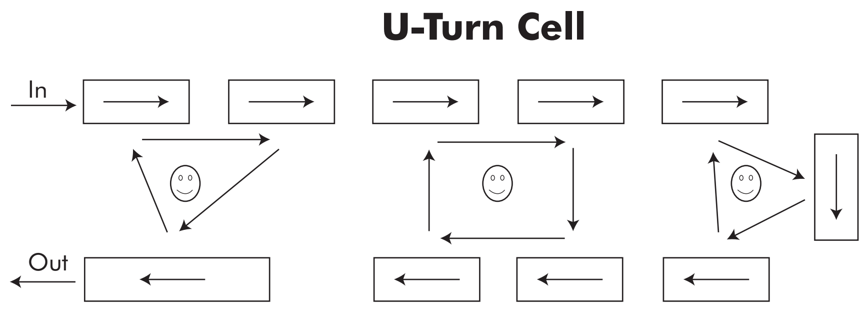
Examples:

1. One unit is produced in a 2-minute cycle by 1 person.
2. Demand increases and takt time goes to 1.5 minutes.
3. One worker can finish half the total job (one unit) in 1 minute, but an additional person must be placed to complete the other half.
4. Each of the two workers must have 1 minute wait time within each cycle.

Figure 14-7

tion through close physical proximity, and a controlled-flow pull process. This type of layout requires good cross-training of your people and an effective maintenance program. If you link all your processes together, a breakdown will shut down the entire system. You don't want to play this game unless you're a serious manufacturer. No amateurs allowed.

"I see a lot of operations that have reached this point and think they're at the end of the process. Granted, this level of operating is light-years ahead of a birdcage company, but I have seen an additional level. It's rare, but it exists. I believe I first saw this cell theory in one of the Toyota engineering books, and I have since seen it put into practice in one or two operations. It is a combined U-cell flow. It has lots of advantages: pull systemics, high flexibility potential across a large work area, and huge potential for balancing across the total area as opposed to a single cell. Figure 14-9 shows four people working across four separate product lines.



Advantages:
a. Can increase or decrease number of people with demand changes.
b. JIT pull.
c. Constant work in process.
d. If standard inventory is kept at each machine, imbalance is visible.
e. Allows regions or areas developed for specific worker operations.

Flexibility in Workplace Prerequisites:
1. Proper design of machinery layout.
2. Versatile, well-trained people—multifunctional and cross-trained.
3. Continuous evaluation and revisions of standard operations routine.

Figure 14-8

"Figure 14-10 illustrates six people operating the same cell in response to an increase in demand. Pretty wild stuff!

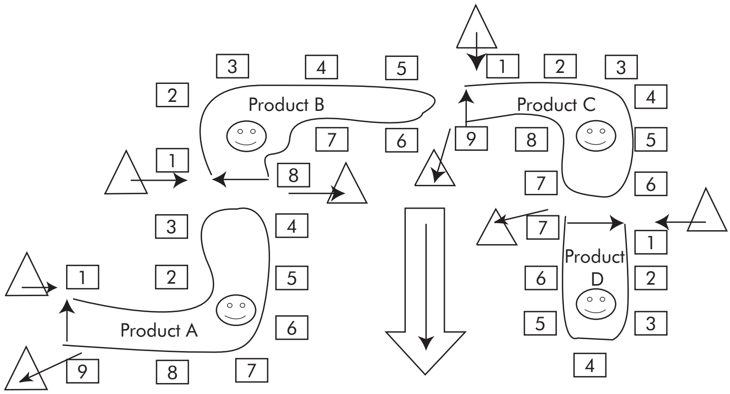
"Again, this type of operation requires a good investment in cross-training, preventive maintenance, and the development of standardized work data at various levels of demand to preplan your people balance."

Mike: Our company doesn't have a formal cross-training program. We train only when we have to, when someone quits, retires, or moves away to follow their husband or wife. I can't see our management investing in training. It's all about making the numbers.

Me: Maybe investing is a misleading word. Can you make the numbers with an untrained population?

Fred: OK, people, it's not as bad as Mike makes it out to be. We accept the responsibility for training our people; we just don't throw our money away. We can't afford to have two people on the same job, one working and the other training.

Combined U-Turns 1

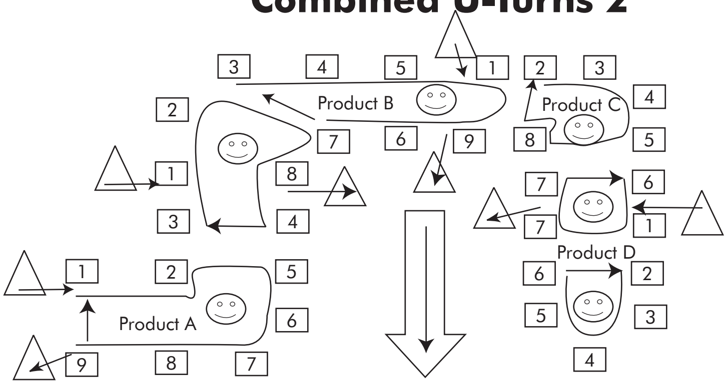


Advantages: Ability to flex entire area in response to demand changes.

<u>Flexibility in Workplace Prerequisites:</u>
1. Proper design of machinery layout.
2. Versatile, well-trained people—multifunctional and cross-trained.
3. Continuous evaluation and revisions of standard operations routine.

Figure 14-9

Combined U-Turns 2



Advantages: Ability to flex entire area in response to demand changes.

<u>Flexibility in Workplace Prerequisites:</u>
1. Proper design of machinery layout.
2. Versatile, well-trained people—multifunctional and cross-trained.
3. Continuous evaluation and revisions of standard operations routine.

Figure 14-10

The team begins a slightly heated debate on the lack of focus on training. I let them go on for a few minutes and then interrupt.

Me: OK, folks, in response to Fred's concern, and without getting into a detailed cost analysis, I would argue that in most companies, the money that could be allocated to cross-training is already being spent; unfortunately, it's being spent in an unplanned manner and is generating none of the benefits associated with a well-cross-trained, highly flexible workforce.

Fred: Vague, vague, vague. Or was that a hook I just heard whiz by my left ear? Please, do expand.

Me: I knew you'd ask, Fred; thanks. Let's take a small company, Company ABC, with sales of $50 million. I'm going to make up the numbers using the Carreira lightning arithmetic model, so don't start nitpicking me on proportions. OK, ABC has 300 employees, 200 on the floor—call them direct if you wish—and 100 in support functions, indirect and salaried, AS&E (administration, sales, and engineering). The lead time is eight weeks, which is standard in that particular industry. ABC is no worse than its competition, and no better. The production process is a batch-and-queue flow, departmentalized, with raw inventory at $1.6 million, work in process at $3.2 million, and finished goods at $2.4 million. The big splits as a percent of sales are labor at 12 percent of sales, materials at 48 percent, and overhead at 33 percent, which leaves 7 percent for operating income before taxes. Again, this is about average for this product configuration and this industry. ABC tracks market share as best it can, since this number is important to the company president. ABC's current market share is 18 percent; it's a big player in its segment.

Questions? OK, ABC decides to change its operating philosophy and introduce lean theory to its processes. It links its manufacturing processes into flow cells, it performs lean-engineering analysis on its activity, and it rebalances its workforce with a close eye to the definition of value-added activity and flexible staffing theory. Lead time has dropped to two weeks from eight weeks, which has a corresponding impact on the amount of finished goods ABC needs to stock. Balanced cellular flow results in an 80 percent reduction in work in process and a 25 percent reduction in labor requirements per unit produced. The demand flow layout, lead-time improvements, and reductions in work in process improve ABC's on-time delivery from 72 percent to 98 percent. Greatly enhanced customer satisfaction results in an increase in sales of 20 percent, from $50 million annually to $60 million. Since ABC has reduced its labor hours per unit produced, it is able to take this increase in sales (and market share) without adding additional people, and still have 5 percent of the workforce available to engage in a formal cross-training program.

Let's summarize. (See Figure 14-11.)

Benefits of Shifting to Demand Flow

"I made this example up, but having seen various companies, across very different industries, go through the operating shift from batch against forecast to demand flow, the percentages and proportions in this illustration are reasonable and realistic. You see large reductions in carrying cost, labor content, and space requirements, and dramatic improvements in lead time and on-time delivery performance. These improvements result in interesting increases in operating income and cash generated.

	Old Model	New Model	Delta	
Finished goods	$ 2,400,000	$ 600,000	$ 1,800,000	Favorable
Work in process	$ 3,200,000	$ 640,000	$ 2,560,000	Favorable
Raw materials	$ 1,600,000	$ 1,600,000	$ –	
Lead time	8 weeks	2 weeks	75%	Favorable
On-time delivery	72%	98%	26%	Favorable
Lab or % per unit	12%	9%	25%	Favorable
Sales	$ 50,000,000	$ 60,000,000	$10,000,000	Favorable
Number of employees	300	300	–	
Workforce reduction	0	0	0	
Market share	18%	21.6%	3.6%	Favorable
Sales per employee	$ 166,667	$ 200,000	$ 33,333	Favorable
Carrying cost @ 18%	$ 1,296,000	$ 511,200	$ 784,800	Favorable
Operating income before taxes	7%	10.5%	3.5%	Favorable
Cash generated	$ 3,500,000	$ 6,300,000	$ 2,800,000	Favorable
Margin generated per employee	$ 11,667	$ 21,000	80%	Increase

Figure 14-11

"I also prefer metrics that relate to cash in and cash out. This eliminates the noise of all the variances that most companies spend so much time trying to explain. The lean philosophy will cause you to measure performance differently from the way your current standard cost system measures it. For example, optimizing efficiency and machine utilization locally, as opposed to globally, will probably result in increases in work in process, high quality costs, and long lead times. Measuring materials variance locally, as opposed to systemwide, will usually result in higher labor and rework costs, as the lowest-price components usually come with a production trade-off in the areas of quality and ease of manufacturing. In the illustration we used, the bottom-line impacts that are important are the increases in market share, margin generated per employee, and cash generated. These areas showed huge gains and represent 'real' money. OK, we got off on a tangent with this one. Let's get back to our theoretical model cell design. Where were we? Ah, yes, take a look at Figure 14-12."

Calculating Lead Time

"Let's go back to the construct we started earlier. We want one-piece flow through the cell, but we need to consider our average order size

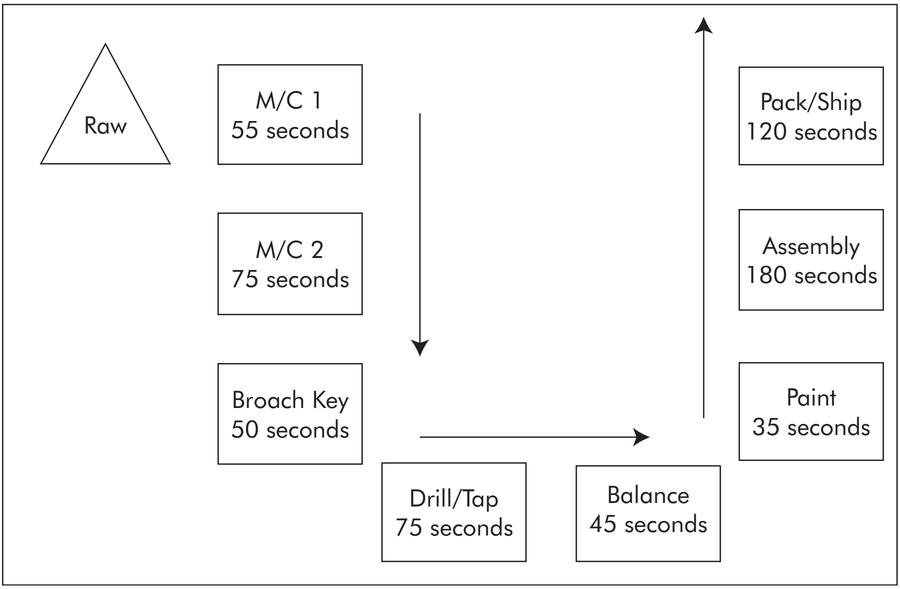


Figure 14-12

in order to calculate the lead time for a completed order to a customer. Let's play with the math a bit. The first question is, what's our PV (pure velocity) through the cell? Let's add the times:

1.	M/C 1	55 seconds
2.	M/C 2	75 seconds
3.	Broach	50 seconds
4.	Drill/tap	75 seconds
5.	Balance	45 seconds
6.	Paint	35 seconds
7.	Assemble	180 seconds
8.	Pack/ship	120 seconds
Total		635 seconds, or PV = 10.58 minutes

"As you can also see by the numbers, our throughput, as is, is 180 seconds (3 minutes), which is the time required by our unadjusted high station, assembly (see Figure 14-13). When the system is full, we'll get a part out of this cell every 3 minutes.

"The next question is, since we're building a theoretical cell and we have no equipment constraints, what's our AAV (adjusted activity velocity)? First let's look at the distribution.

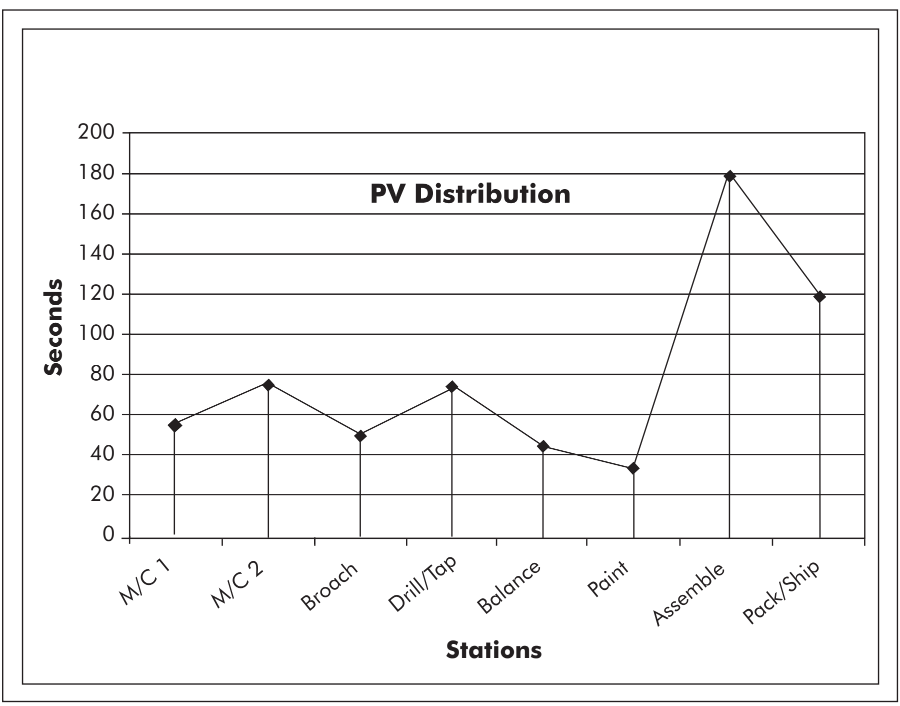


Figure 14-13

"Let's flatten the distribution by adding some machines and people (see Figure 14-14). We'll add two assemblers and one packer/shipper. Now the distribution looks like this:

1. M/C 1	55 seconds	~55 seconds
2. M/C 2	75 seconds	~75 seconds
3. Broach	50 seconds	~50 seconds
4. Drill/tap	75 seconds	~75 seconds
5. Balance	45 seconds	~45 seconds
6. Paint	35 seconds	~35 seconds
7. Assemble (3)	180 seconds	~60 seconds
8. Pack/ship (2)	120 seconds	~60 seconds
Total	455 seconds, or AAV = 7.58 minutes	

"Our throughput has improved to 75 seconds, or 1.25 minutes, down from 3 minutes. Our new high stations are M/C 2 and drill/tap (Haas). When the system is full, we'll get a part out of each of these cells every 1.25 minutes.

"Let's look at lead time. What's your average order size?"

John: For the units you are discussing, our average order is around 140 units.

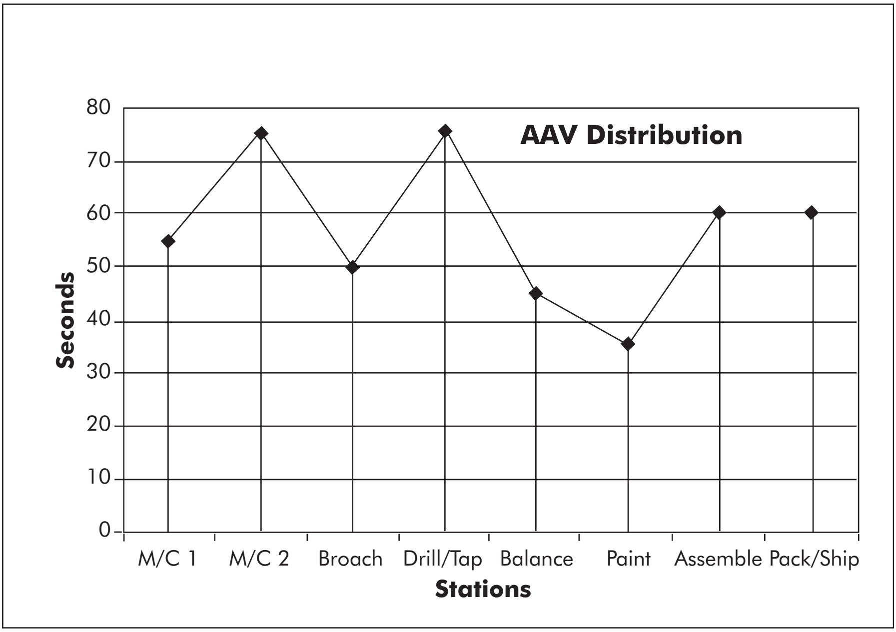


Figure 14-14

Me: Is this a repetitive product? Do you get orders for these units over and over, month in, month out?

John: Yes, it's very repetitive and there's not much in the way of cycles; there's a pretty flat demand pattern over the course of a twelve-month year.

Me: OK, let's plug in an average order. You set up the cell, and we haven't considered setup time yet, and run 140 units. Once this cell is running, you get a part every 1.25 minutes, so what would an order of 140 units take? Who's got a calculator? Julie?

Julie: It would take 175 minutes, or, let's see, 2.92 hours.

Me: And Fred, your current time required to get an order of this size through the shop is?

Fred: It currently takes about seventeen shifts to work the order through the shop, with the various departments.

Me: So this would be better. You would go from seventeen shifts to roughly one-third of a shift.

Fred: This is all theory, but yes, it'd be a huge improvement.

Me: OK, so far, so good. Let's put some people in this cell. Our AAV is 1.25 minutes, so we want to add people in a way that allows us to meet that velocity. But first we need to bore down on the detail a bit. Don, when you say that the first machining center has a cycle of 55 seconds, what is the man activity involved in running this station?

Don: Well, once the center is set and running, it's load a part, activate the center, wait for the machine to perform the cuts, unload the part, and set the part aside.

Me: So, it's largely load and unload—the machine does the work and the man waits?

Don: Yes. That's why we set up our cells with two machines, a vertical and a horizontal, and have one guy run both.

Me: What's the balance logic? Why two machines? Why not three or four?''

Don: We balance machine cycle times; we want the machines to be running all the time. Highest machine utilization is our key measure.

Me: Got it. Looking at your people utilization data on the wall, your people are in the idle/machine running category 24 percent of the time and in the idle/machine not running category 8 percent of the time. They are available to do additional work for one-third of their workday, but they are trapped in your birdcages. Let's continue. Walk us through the man activity in this cell and put some times to each. Assume these people can perform all the operations in the cell. So I load the first machine; how long does it take?

Don: The operator unloads the part that's in the machine after it completes the cycle and sets it aside, 10 seconds; he gets another part and loads and activates the machine, the same, 10 seconds.

Me: So the first guy is 20 seconds into a 75-second window. Give him 55 seconds more work, keep going.

Don: The first machine is 55 seconds; he has to be back to unload that machine and put in another piece in 35 seconds.

Me: If he unloads the first machine in 55 seconds, where's he going to put the part? The second machine has a 75-second cycle.

Don: OK, I see where you're going. All right, he unloads and loads the second machine, 20 seconds total; he unloads and loads the broach, 15 seconds; he unloads and loads the Haas (drill/tap), 10 seconds. How much is that so far?

Julie: It's 65 seconds.

Don: OK, he unloads and loads the balancer, 10 seconds.

Me: OK, the first guy has 75 seconds. He's done and we still have more cells to run; let's add the second guy (or gal, sorry).

Don: Mike, what goes on in assembly?

Mike: Well, we're using 180 seconds here as our assembly time, and that would be largely as is. We've got three assemblers plugged in to get a part every 60 seconds, so I'd say just put in three assemblers for now.

Me: Close enough. How about packing and shipping?

Mike: But don't forget paint; we've got to load the paint line and unload it into assembly.

Me: How much human activity?

Bill McDougal from shipping jumps in: The paint line is hang and remove, but they have to do a little maintenance on the hooks to keep them in good shape, and they do some inspection to make sure the bores are OK after painting. I'd say load, unload, and inspect is around 50 seconds. With my area, we said that packing and shipping takes about two minutes per unit, and that's not exact, but with two people to get us to one minute per, I'd say we're good.

Me: OK, so what do we have? We've got a seven-person cell with an AAV (adjusted activity velocity) of 7.58 minutes, a throughput time of 1.25 minutes, and an average order lead time of 2.92 hours, or about a third of a shift. Like so (Figure 14-15).

Adjusting the Figures

As I'm looking at the group, I see some body language going on with the manufacturing guys. "So, what do you think so far?" I say.

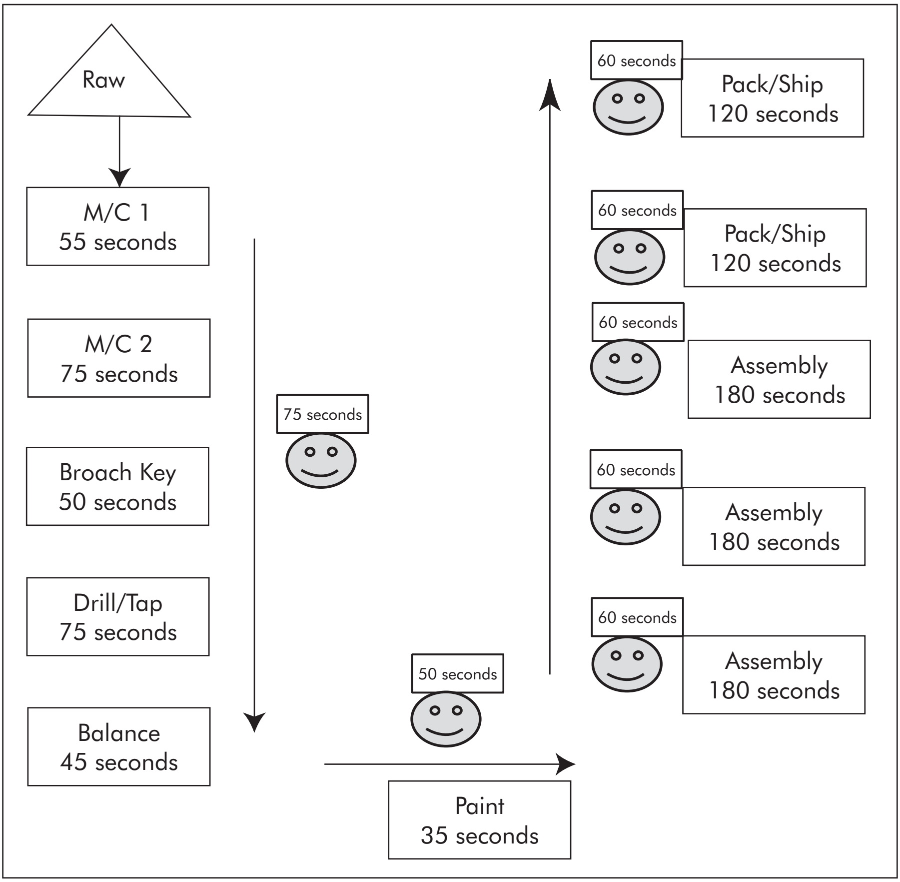


Figure 14-15

Jimmy speaks up first: You'll never get a part through that cell in 1.25 minutes. The guys just can't do that.

Me: You lost me. You gave me the numbers, and now you say it can't be done. Why not?

Don jumps in: There's not enough time to get everything done.

Me: What do you mean everything? Again, these are your numbers, not mine. Here's what it takes, but it can't be done?

Don: Well, the guys have to inspect certain things after different operations. And they have to walk to the next machine and back. Those times are too quick.

Me: OK, I'm with you. You left out steps that we need to add in. Give me the tasks that we left out and assign a time to do to each one. We're not concerned with being fast; we want to identify what it takes to get the job done, done meaning *done*, correctly the first time through.

Fred: There's more to it than that. Our paint process is continuous, and the time to get a part out is correct, but the total process time through the paint system is more like 45 minutes. We get a part off the line every 35 seconds, but we gave you a bad number for your velocity definition. Plus, we have twenty machining cells that feed into the paint system. I realize that you are asking us for a ''concept'' cell, but in real life it won't work that easily.

Me: All right, I hear you. We've fleshed out a fairly good flow-concept process that shows us that you can reduce your lead time from seventeen shifts to one-third of a shift with the same machines and the same people that you currently have in house. Let's go to real life and see what the concept would be. We'll make the paint process a first-in, first-out monument coupled with the assembly and pack operations that you have identified. We'll also create machining cells that are complete cells, meaning that they'll include broach, drill and tap, and balance, unlike your current machining areas, which are a couple of turning centers with a guy in the middle. Since this product is highly repetitive, we'll pull from kanban supermarkets into the machining cells and trigger back replenishment by your central foundry operation. What would it look like? Throw up a value-stream sketch.

(Fred grabs a marker, and Don starts taping four clean sheets of

flip chart paper to the wall. The ops' part of their sketch looks something like Figure 14-16.)

Me: Excellent. Let's go back to the concept flow. Now it will start to look like so (Figure 14-17).

OK, let's go back to the machining cell (see Figure 14-18). You didn't like the times; let's expand on the activity. What else do we have to do?

Don: Let's start over.

Me: OK, go.

Don: Step 1, get a raw casting, go to M/C 1, unload the finished part, load the new part, hit go. OK, M/C 1 is running; that's the 20 seconds I gave you the first time through. Now we need to inspect the O.D. and the flange.

Me: What type of inspection equipment do you use?

Don: Hand mics.

Me: How much additional time?

Don: Say 15 seconds additional to inspect. Now we walk to M/C 2, unload the finished part, load the new part, hit go. M/C 2 is run-

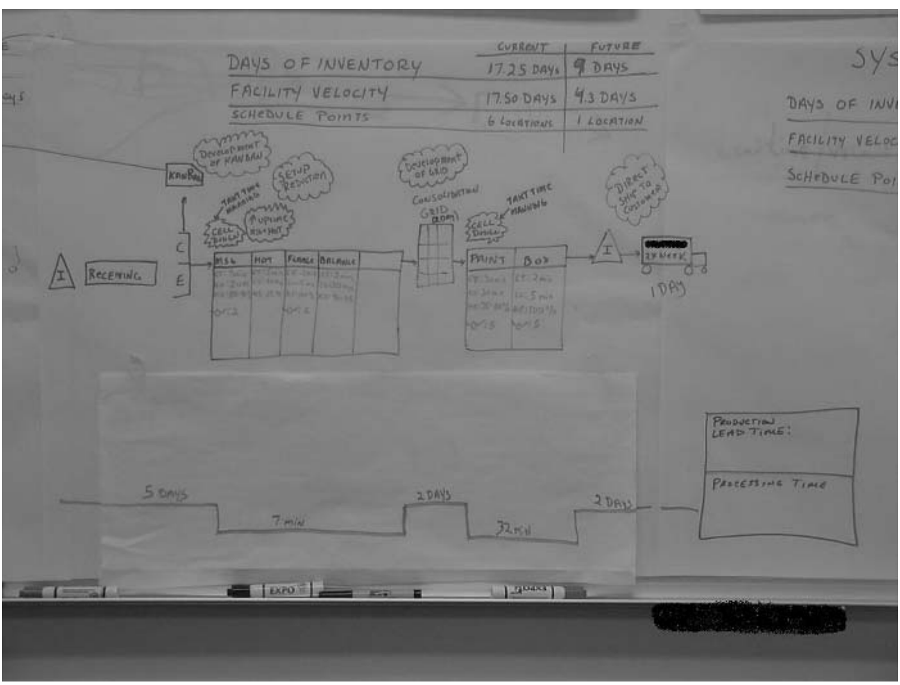


Figure 14-16

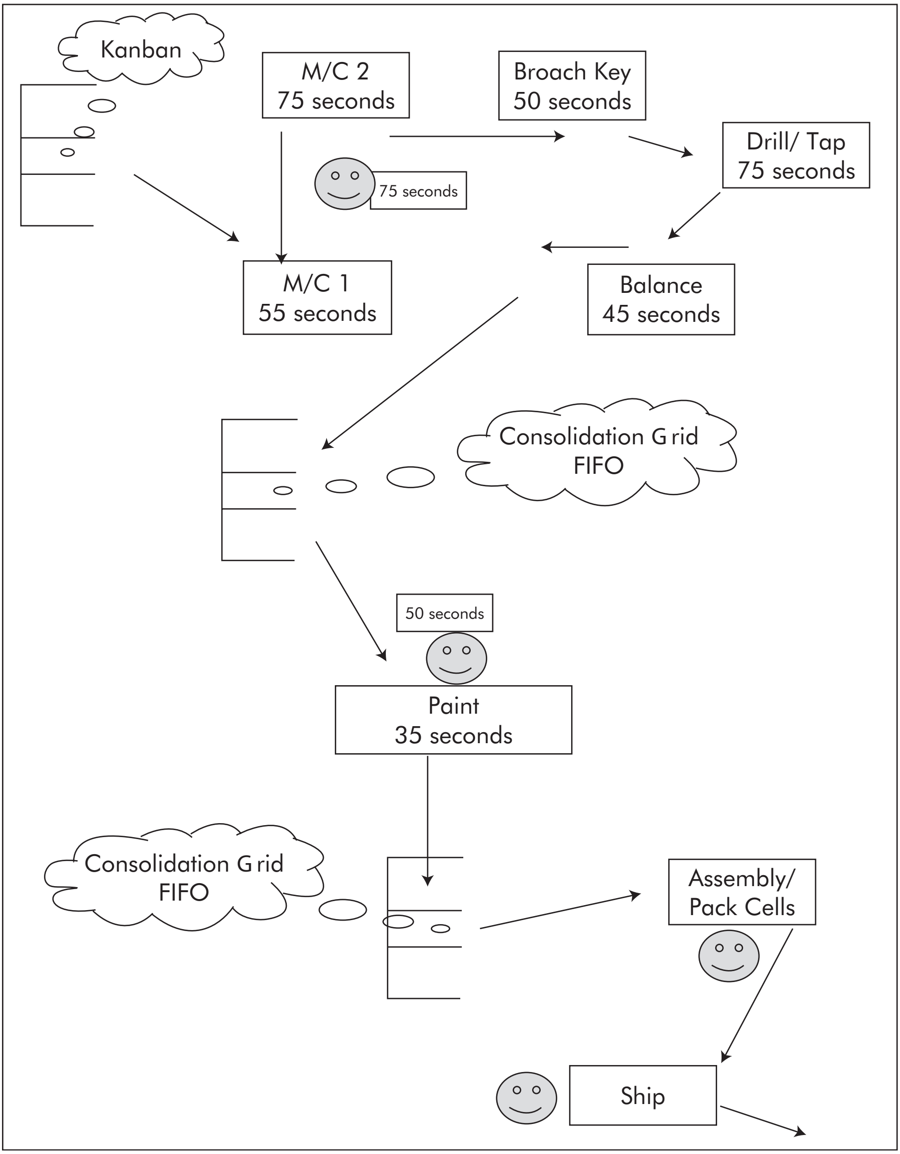


Figure 14-17

ning. The inspection here is the bore. It's critical and tight, plus or minus 0.001; let's give him an additional 15 seconds for inspection.

Me: OK, what's the new total?

Julie: It's 70 seconds.

Me: So person 1 is full. He has 5 seconds to return to M/C 1 and start the cycle over. Does everybody agree that's a go?

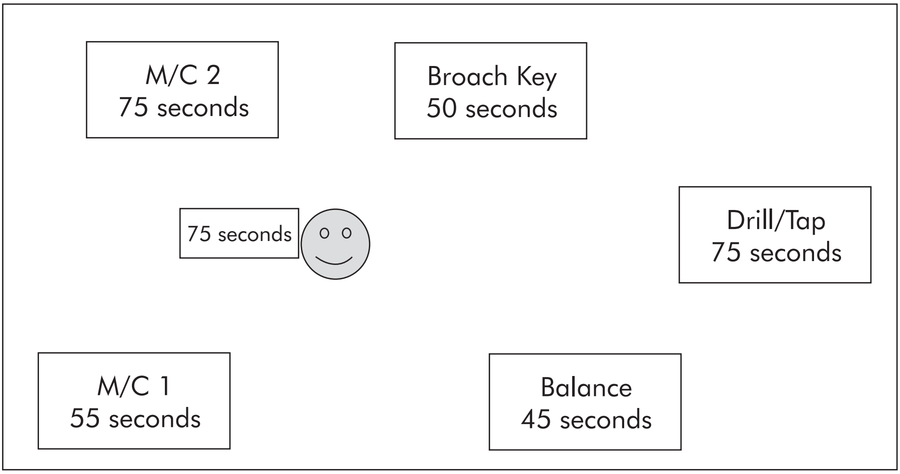


Figure 14-18

(Lots of yes nods from the group.)

Me: Let's go to person 2.

Don: The second person walks to the broach, unloads the finished part, loads the new part, and hits go. Now we deburr the key.

Me: Additional time?

Don: Add 15 seconds for deburring, then unload and load the Haas drill/tap; check the threads with a thread gage, go/no go, I'd add 15 seconds; walk to the balancer and unload and load the balancer (it's an auto, so there's no touch time here); and put the part in the outgoing bin.

Me: What's the time for person 2 so far, Julie?

Julie: It's 65 seconds.

Me: So we end up with a concept machining cell with two people to run the machines and inspect the work, which gives us a completed machined part in 1.25 minutes or a completed average order to paint in one-third of a shift (Figure 14-19).

(Everyone is thinking hard as they look at this flow sketch. After a few minutes of discussion, everyone reaches agreement that this is very doable.)

Current Process vs. Future State

Me: This is as far as we need to go with our flow concept. The intent of this piece was to go far enough for you all to be able to see the

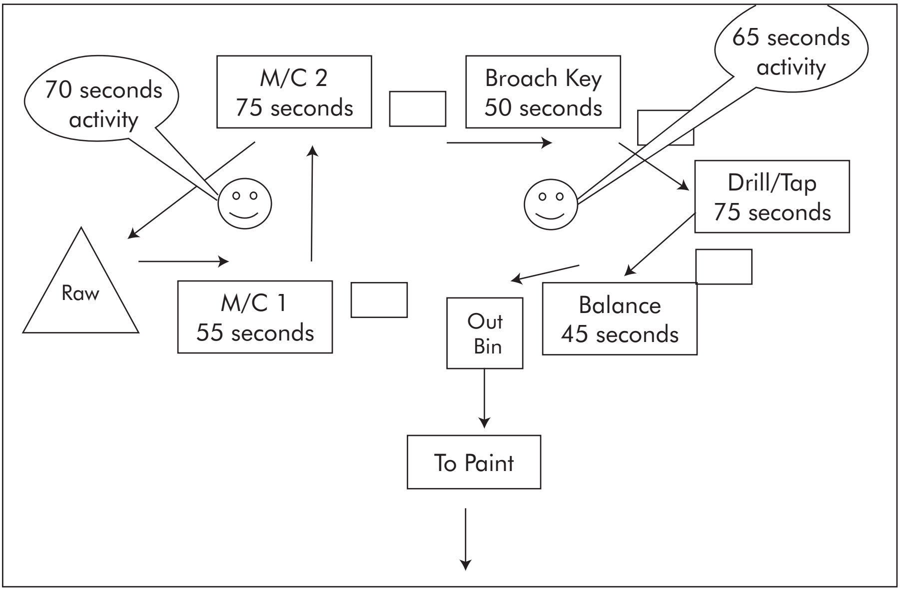


Figure 14-19

potential at a level of detail where you can roughly dollarize the impact. If you look at your concept machining cell, you have a two-person cell with a 1.25-minute throughput. The first person has 70 seconds of activity inside of a 75-second cycle. He is engaged in touch activity 93 percent of the time. The second person has 65 seconds of activity inside of the 75-second cycle. He is engaged 87 percent of the time. If you average these two people, this tells me that they are engaged in touch work 90 percent of the time. When I look at your people utilization chart, your people are currently engaged in touch activity 36 percent of the time. This tells me that you can get 100 percent of your current product made with about 40 percent of your current workforce. Remember, a flow cell with materials and tooling at the point of use has an amazing effect on walking, talking, go-gets, and so on. By coupling these processes together, you have driven the level of work in process in your plant down by roughly 80 percent. That's whatever the value of that material is times the dollars in carrying cost, plus the elimination of all the move-arounds and go-finds. You guys are racking up some big bucks on the opportunity side of our equation. Your current process looks like this.

(I go to the board and begin sketching Figure 14-20.)

If we look at your system totals, you are choked with inventory,

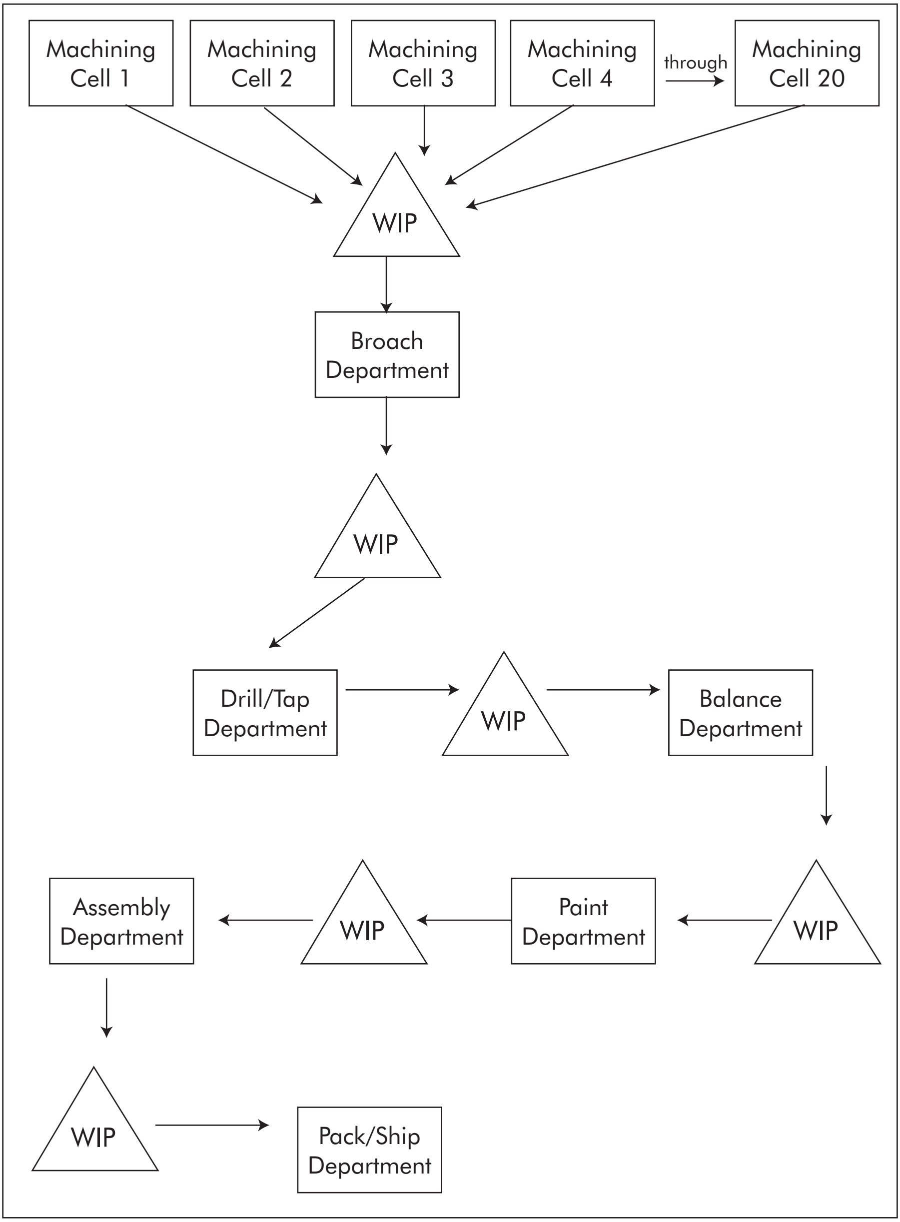

Machining Cell 1
Machining Cell 2
Machining Cell 3
Machining Cell 4
through
Machining Cell 20
WIP
Broach Department
WIP
Drill/Tap Department
WIP
Balance Department
WIP
Paint Department
WIP
Assembly Department
WIP
Pack/Ship Department

Figure 14-20

your lead times are long, and you have to schedule each work center as if it were a separate business (see Figure 14-21).

Your preliminary future state will look more like Figure 14-22.

Your people utilization almost triples, your work in process drops like a rock, your lead times go to a day or less, and your scheduling blizzard goes away. You simply schedule a cell, and it pulls from kanbans and pushes through to shipping.

Sid: I have two questions. The first is in regard to pull versus push. I thought push was bad, that you want to pull at the demand of the customer, if I heard you correctly a couple of days ago. And my second question is about kanbans. Where do kanbans fit into the equation? Can you address those two areas?

Me: Sid, you've got to stop reading all those pesky ''lean'' books. I wasn't ready to go there yet, but your questions are to the point, so let's go there now.

Pull vs. Push

Me: Let's start with the ''pull versus push'' concept. Who is familiar with what this means?

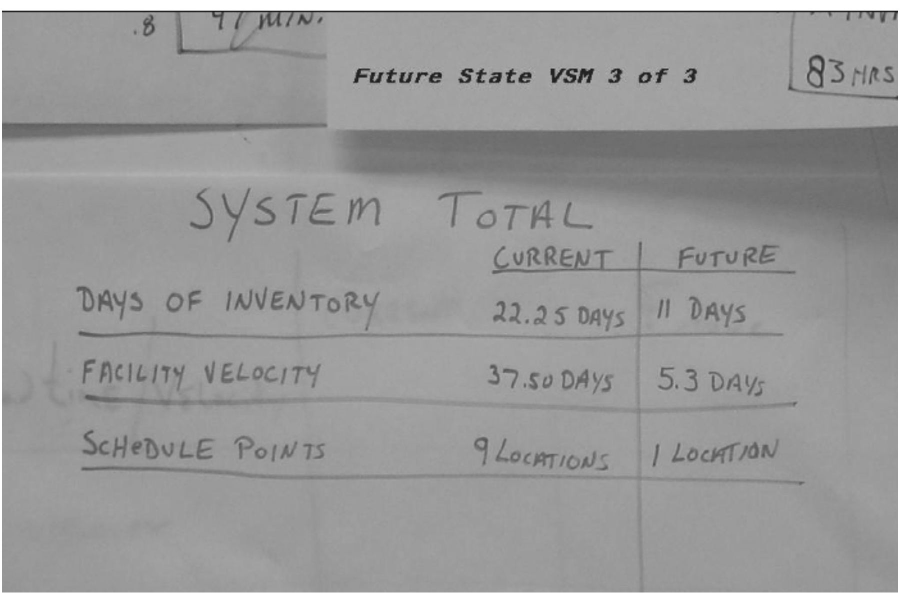


Figure 14-21

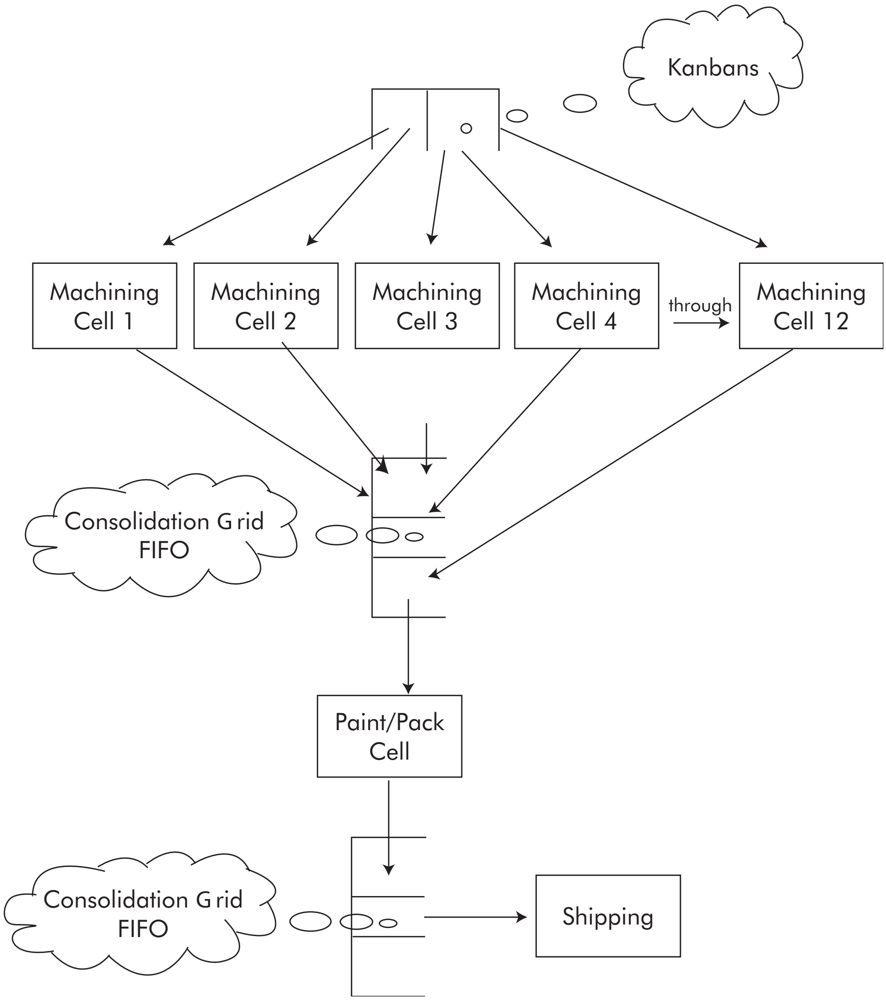


Figure 14-22

(I get lots of hands up and head nods on this one.)

Me: Great; start me out.

Tony: Push is when you process a batch and send it to the next operation, whether that operation is ready for it or not. Pull is when you build to customer demand.

Me: I agree, kinda. Anybody else?

Frank: Push is when you just launch orders into the shop without considering balance or capacity. Then you expedite like crazy to manage a couple of hundred orders as they are forced through the process. Pull would be controlling the orders so that downstream work centers would not produce unless the upstream operations were available to work on them. What do you guys think?

(Lots of yes nods.)

Me: That's more of an operational definition, but it's also very good, I agree. But what does it actually look like on the shop floor? How do you put this system into place? How do you ''do'' it?

(This is always an unfair question. It is clear that most of the group has a good understanding of the push/pull concepts, but it's always difficult for people to really bore down on a concept to a level of detail that allows actual implementation.)

Me: I think you guys understand the concept, but let's play with it from an implementation viewpoint. Let's design a process.

Suppose we have a process like Figure 14-23, a simple three-person batch-and-queue—a classic ''push.''

Our order size is 200 units. Operator 1 can set up his station in 15 minutes. After he's set up, his run rate is 1 unit every 2 minutes. This is classic push, so these guys represent different departments. Operator 1 completes this 200-piece order, and it is transported, via forklift, to the next department, where it is placed with the other seventeen orders that are stacked up in front of operator 2. So far, so good? OK, operator 2 can set up his station in 35 minutes, and

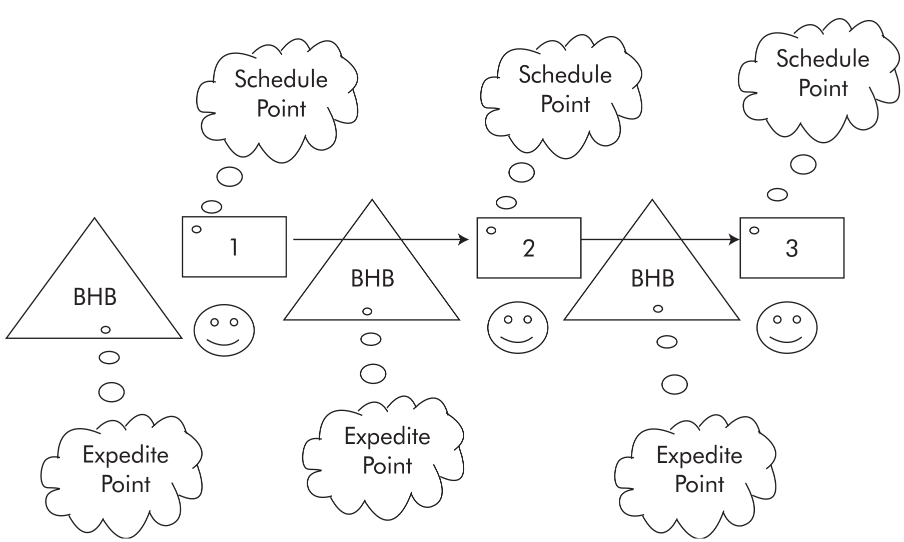


Figure 14-23

his run rate is 1 unit every $3\frac{1}{2}$ minutes. When the order's done, it's the same game: It goes on to the next department. Operator 3 can set up in $1\frac{1}{2}$ minutes and has a run rate of 1 minute, then the units go off to shipping or stock, or wherever they're going. So here are the stats.

	Setup Time	*Run Time*
Op. 1	15 minutes	2 minutes
Op. 2	35 minutes	3.5 minutes
Op. 3	1.5 minutes	1 minute

And here's the timeline for a 200-piece order (see Figure 14-24).

What UDEs do you observe with this system?

John: Long lead time. . . . Lots of scheduling and expediting all the open work orders as priorities change.

Me: Good observation.

Fred: Imbalance between operations.

Me: Can you see it? Is it visible?

Fred: I can see your assembly cycle times, and they show a big discrepancy from operator to operator.

Me: True, but in a departmentalized push operation, everybody is working as fast as they can, jamming more inventory into the system whether it's needed or not. There is no visible idle time. That's what makes it so tough to correct.

Fred: Point taken. We usually consider everyone working to be a good thing.

Me: It is a good thing if people are working on the right things. How effective are you at managing materials velocity?

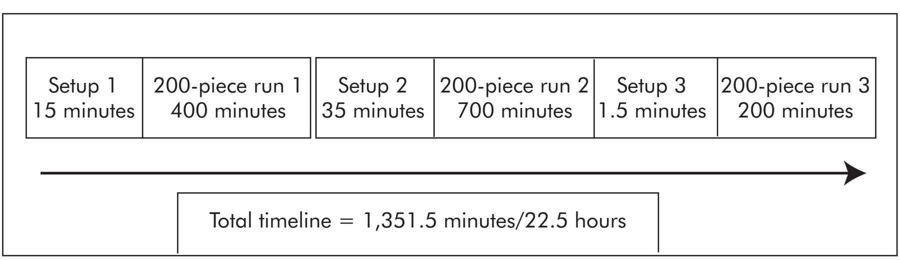


Figure 14-24

Julie: Lot's of WIP, or big honker batches, as you like to say.

Me: And?

Julie: What?

Me: At the risk of being accused of being a micro thinker, how much inventory is unnecessary?

Julie: I'm listening.

Me: Well, we're running a 200-piece order, and since operator 1 has the entire 200 pieces, the operators must be working on three separate orders.

Julie: So?

Me: So, how much inventory is there in the pipe that nobody is touching, that's unnecessary? If the inventory is not being worked on, it's not needed—yet.

Julie: We don't know how much is in the queue between departments; you haven't defined that.

Me: OK, so forget that; just look at the orders that are being worked on.

Julie: OK, I'm with you. There are three operators, each working on one piece at a time. With 600 pieces in play, 597 pieces are idle at all times; that's a crazy way to do things.

Me: Exactly—the hidden material velocity waste of a batch-and-queue system. If I were a mathematician, I'd divide 597 by 600 and make the statement that at any given time, 99.5 percent of my materials are idle. Nobody is touching these parts; they are waiting. How about setup times?

Mike: We can't say if they are excessive or not; we don't have that information, either.

Me: True, but how do they affect the timeline?

Jeff: I see it; they are one after the other in the timeline.

Me: How so?

Jeff: If this were a balanced cell, the changeover of the entire cell would happen all at once. The longest setup would be in the timeline, and the shorter setups would be inside of the longest.

Me: Exactly; that's an interesting observation! I'm not even going to discuss the people issues, but I'll drop the point that if your people are out of balance across a system, they will either work on work, work on WIP to stay busy, or pace themselves to appear busy—usually all three. Let's go to a ''pull'' system and see what it looks like (Figure 14-25).

OK, the customer calls and places an order, so we're building to hard demand; there's money involved. We build our setup pieces and set up the entire cell all at the same time. As operator 1 runs, he places his finished part in the location identified between operations (the dots are parts in the system). All operations are physically linked; they can be side by side if it's a small assembled part, or they can be connected by a conveyor with a specific placement location to control quantities if it's a larger part across larger machines. But the point is, ''build one, place one.'' If you complete your cycle and the location where you are to put your completed part is full, you stop working and wait for this space to become empty. You are now pulling parts through this pipe, in that you cannot forward a part until the upstream operator has cleared a location where you can place it. And so, what do you see with this system?

Julie: Better materials velocity.

Me: Absolutely!

John: Hugely simplified scheduling activity, and if you want to move an order ahead of another, you just slot it in after the order that's being run. This is a big advantage in response time if something changes.

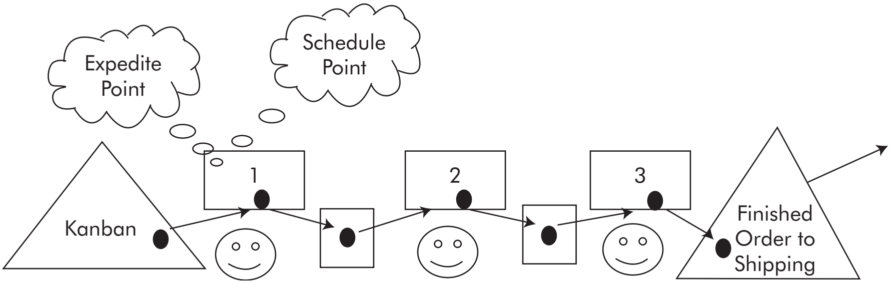


Figure 14-25

Me: You bet!

Fran: Shorter lead times.

Sid: You still haven't addressed the imbalance.

Me: Nope, but I've made it painfully obvious. People have to wait for the material to move before they can proceed with their work. All imbalance is now visible as wait time. I'll leave it to your team to rebalance the workload at their leisure.

(This gets some laughs.)

Me: Let's look at the timeline. Setups are now internal to each other, and once the pipe is full (2 minutes + 3.5 minutes + 1 minute), you get a part every 3.5 minutes—your high station is 2, and we haven't bothered to fix the balance or reduce the setups. The process is as it was, unimproved, but changed to a flow layout.

So, the timeline is, setup @ 35 minutes, first piece through the system @ 6.5 minutes, and the remaining 199 pieces @ 1 every 3.5 minutes, or 696 minutes, and I won't split hairs about the time it takes to process the last piece through the sequence. In practice, as the last piece leaves the first station, that operator would begin the setup for the next order.

Figure 14-26 shows what it looks like.

You haven't really improved anything, you're just running with a different philosophy, and you've reduced your inventory position by 67 percent, from 600 parts in the system to 200, and reduced your

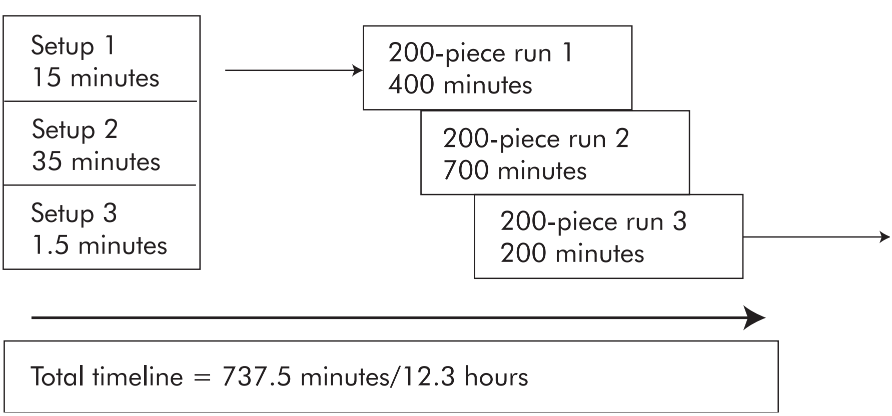


Figure 14-26

lead time from 22.5 hours to 12.3 hours, or just about cut it in half. As an afterthought: If operator 2 has a 3.5-minute elemental activity sequence, and this satisfies your demand, you can think about combining operators 1 and 3 for a 3-minute cycle and reduce your labor content by 33 percent, geography considerations aside. Regardless of the specifics of your operation, a well-designed pull system will look like this illustration. Airplanes to widgets, it doesn't matter; it's the same concept and practical application.

Questions, comments? Imagine the first example of batch operations if you had 300 or 400 operators across three shifts in an 800,000-square-foot facility. You are scheduling all work centers separately, you have several hundred active work orders on the floor, and your demand is changing several times a day as you juggle customer requests and late orders. You expedite constantly, and you consume huge amounts of antacids. I call this type of operation the ''alien model''—the only beings smart enough to successfully and efficiently manage this model of operation would be those capable of mastering time travel and interplanetary teleportation.

There is a good bit of discussion within the group on the various specific areas in the process. After a few minutes, we're ready to proceed.

Kanban

''OK, everybody, c'mon back, let's move on. Kanban's up.

''Sid, you brought up kanban, and Bill, you had a couple of questions on kanban in the hall. Let's talk about it a bit. Here's the premise. We'll keep it simple. Essentially, kanban is a visual information system that controls what you produce, how much, and when, throughout your value stream. In a lean production system, accurate timing and quantities required are essential. And here's the first question, how do you know what to make and when?

Let's illustrate a simple kanban system using a machine shop and foundry scenario. We have a foundry, a kanban supermarket containing castings A, B, and C, and a machining cell that produces a finished product for our customers (see Figure 14-27).

''Here's the sequence of activity:

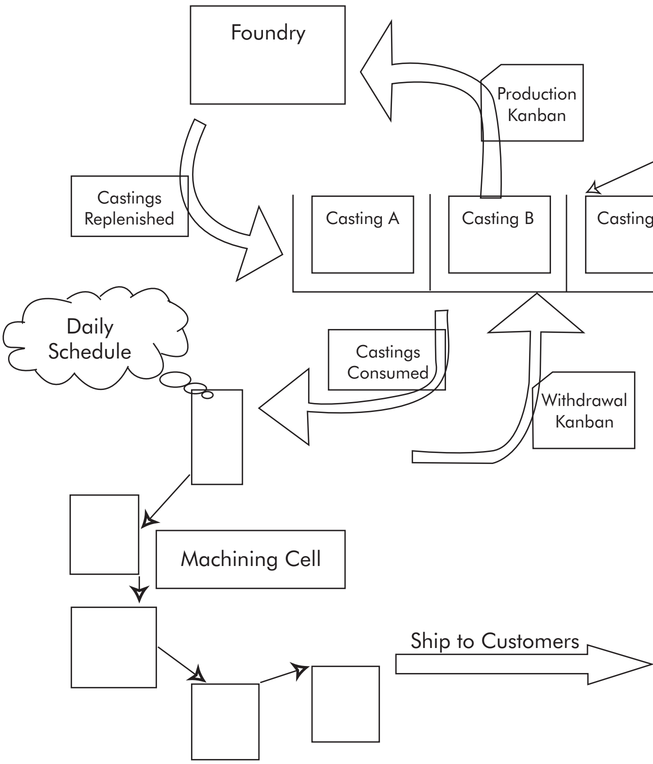


Figure 14-27

1. The cell receives its daily schedule based on demand from the customer.
2. It pulls the required amount of castings of the required type from the kanban market and produces the parts that were ordered.
3. As the castings are pulled from the market, a production kanban is triggered to the foundry to produce (replenish) the castings that were consumed.
4. The foundry produces in response to the production kanban and replenishes the market.

"It's a very effective, visual, closed-loop system that replenishes in response to consumption. So, the next question is, how does the math work? Here's the classic formula:

$$\text{Kanban} = \text{Period Usage} \times \text{Replenishment Time} + \text{Safety Stock}$$

"The period can be a day, a week, a month, whatever you choose. Some people choose to add safety stock to cover anything out of the ordinary that might occur: a snowstorm, a truck breakdown with a one-day delay or so, and so on. Let's play with the math.

"You have looked at history and the forecast for the near future, and you have determined that you use 1,800 of casting A annually. Your period usage for casting A is 1,800 divided by the number of workdays you have a year; let's call it 240 days for the sake of round numbers. So 1,800/240 = 7.5 of casting A a day, and we'll round up to a whole casting, so call it 8 a day. There's the first piece, period usage. When you place an order to your foundry, you can get delivery of castings in 2 weeks, so your replenishment time is 10 days. The pure kanban calculation is 8 (usage) × 10 (replenishment time) = 80 (kanban quantity). Let's roll out an oversimplified two-week production run and see how it works.

Day 1: Pull an 80-piece kanban bin to the cell, trigger a production kanban to the foundry, use 8 units. We have 72 units remaining.
Day 2: Use 8 units. We have 64 units remaining.
Day 3: Use 8 units. We have 56 units remaining.
Day 4: Use 8 units. We have 48 units remaining.
Day 5: Use 8 units. We have 40 units remaining.
Day 6: Use 8 units. We have 32 units remaining.
Day 7: Use 8 units. We have 24 units remaining.
Day 8: Use 8 units. We have 16 units remaining.
Day 9: Use 8 units. We have 8 units remaining.
Day 10: Use the last 8 units; the replenishment kanban arrives. We have 80 units remaining.
Day 11: The cycle starts over. If we added a two-day safety stock to the equation to cover any unforeseen delays, on the last day we would have 16 units left.

"With that illustration in mind, you can see that a kanban system is a visual replenishment tool that tells you the minimum level of inventory you need, mathematically, to supply your demand without experiencing parts shortages. It is also a self-managing tool that results in the elimination of non-value-added activity in planning and scheduling, and allows those individuals to spend their time on activities that add profit as opposed to simply adding cost—materials cost reduction activities and such.

"Let's digress for a minute and discuss MRP (material requirement planning). MRP is the most common tool that I see in the majority of companies I work with. This is a system that uses bills of materials, inventory, open work orders, lead time, and master production schedules to calculate the materials you'll need for future orders. In using MRP, the concepts of *time buckets* and *time phasing* are important. A time bucket is usually at least a one-week period, within which a certain number of units need to be produced. The time phasing piece comes into play in making up interbucket schedules that dispatch parts by using lead-time data.

"This octopus of activity is controlled by a master schedule, which must be completely maintained if you hope to have all the pieces come together in the planned time frame. At the end of every planned production interval, or bucket, you must compare the actual performance of production versus the planned performance, and if the two don't match (and they never do), you need to jump into a corrective activity mode. As you can imagine, the master schedule must be revised after every bucket occurs, usually weekly at the least. It isn't uncommon to see hundreds of exception items spitting out of the MRP system on a daily basis.

"With this type of system, every change, adjustment, or correction following a bucket review causes each point in the entire system to receive a revised schedule. This can take days or weeks, and will usually end up with overlapping activity on parts that are already in process on the floor. It's a classic push mentality. There's lots of noise. Being a master scheduler in this model is about as stress-free a job as being an air traffic controller at LAX during convention week.

"With our kanban illustration, you'll note that only the pacemaker needs a schedule; all other production is "pulled" and controlled through the consumption activity at the point in the system where you establish your pacemaker. Kanban is a classic pull system. In real life, you will want to use both systems, with MRP used for long-range planning, which it is very good at, and a kanban system to control shop floor execution, which it is also very good at. The right tool for the right job.

"Another advantage of a good kanban is that it is a system that generates replenishment on the basis of consumption, as opposed to forecast, assuming that you are building to demand and not building to finished goods just to stay busy. It works best with repetitive parts, products that run over and over, every week or every month. It's also a great way to artificially reduce your lead time to the customer.

"Here's an example.

"Let's take the same theoretical company. You have a central foundry that supplies several machining facilities. With conventional order launch at the beginning of the process, your foundry, the situation looks like Figure 14-28. Lead time to the customer is 37 days.

"You make your castings in your central foundry and ship them to your outlying machining facilities, which in turn do their work and ship products to customers and distribution centers across the country. Your machining facility 3 produces your high-volume, repetitive products. You now implement kanbans for your repetitive castings in facility 3 and trigger an order to your foundry for replenishment based on consumption. Figure 14-29 shows the new model.

"By establishing kanbans in facility 3, you move your order launch to the machining cell in facility 3, and your lead time is cut in half. I would make one final point. Kanban systems can range from fairly simple to very complex, depending on the nature and size of your company; however, the only reason to have a kanban in place is because you can't figure out how to balance your process. It is not a

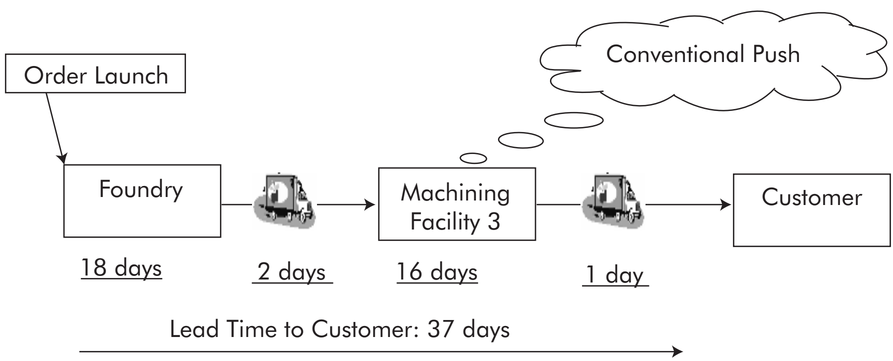


Figure 14-28

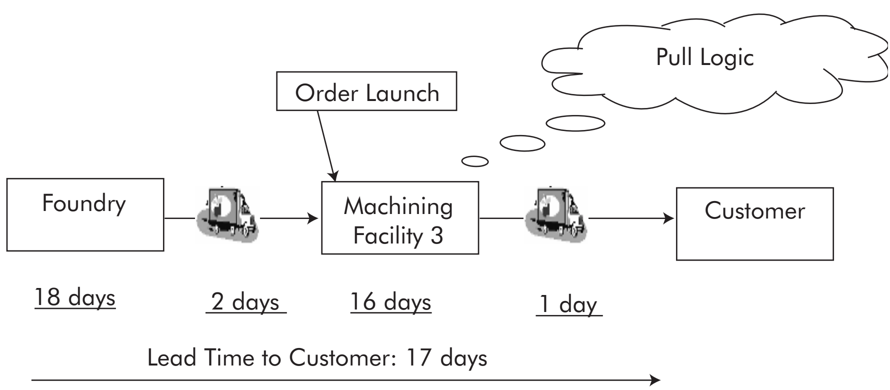


Figure 14-29

required tool; it is a tool based on necessity. When you see a kanban, you should see the waste of inventory that is not being used. As you improve your process flow and linkage, and reduce your setup and replenishment times, your kanban quantities will become smaller, and your inventory levels will continue to drop. Does that cover all your questions on how and what kanban is?''

There are lots of yes nods.

''OK, back to our project definition.

''The primary projects you have identified so far are:

1. Implement a lean flow layout.
2. Implement kanbans.
3. Implement a TPM program.
4. Implement a cross-training program.
5. Implement a formal setup reduction program.
6. Develop metrics.
7. Train all in-house people in lean philosophies.

''It's been a very long day, so let's clean up the wall and get ready for our briefing. We'll continue with project definition and quantification tomorrow.''

The team reorganizes today's new visuals on the wall, we conduct our briefing, and day 4 is done. Day 5 is coming up.

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CHAPTER 15

Doing a Baseline, Day 5

Day 5, Friday

“Good morning, everyone; welcome to day 5. Our agenda today is to finalize our projects with projected savings and cost to implement, define the timeline for implementation, and prepare our ‘story’ so that we can walk the wall during our final baseline presentation this afternoon. The final briefing is scheduled for around 2:00, so we should be done and wrapped up by 4:00 or so. You get to have dinner with your families tonight. I’m going to ask you to split into subteams and continue putting together the broad steps of your various projects, with Fran floating between teams and doing a sanity check on the numbers. You’ve been through a briefing every day, and you’re getting really good at presenting the logic flow of our visual wall story, so the final briefing today will be more of the same, with Fran presenting the final visual, which will contain costs and benefits. This sheet will be the summary, and we’ll keep it covered until the briefing on the current and future states is complete.

“Two points. First, we need to have our controller present the numbers to avoid the psychological pitfall of ‘MGAC syndrome’ (manufacturing guy’s accounting credibility). It has been my experience that a manufacturing team presenting financial projections to an executive management team at a briefing is highly susceptible to disbelief, doubt, and skepticism, whereas a member of the financial team will have the credibility to present these data with confidence. So if Fran doesn't like your numbers or feels that they will not actually occur in real life, for whatever reason, this team will wrestle that out this morning. When you present this afternoon, you will have a plan and associated dollars that everyone can stand up to and say, 'We can do this, and these are what the results will be.' No questions, no hesitation; complete collective confidence.

"The second point is, when you hand an executive team a financial package, you'll notice that they immediately flip to the last page. They can't help themselves; it's the nature of the position. If you expose the numbers anywhere in this room, your management team will take you there immediately and most likely will not hear any of your presentation as you walk through the week's activity story.

"OK, questions? Comments? Observations? Let's split up and draw out the details of your various projects as best you can for the next hour or two. While you guys are working, I will walk around from group to group, looking very thoughtful, and will eat quite a few donuts. Day 5 is good when you're the navigator! Only kidding. OK, let's go."

And so the team is in the endgame of the baseline. It has developed an excellent current-state task-level process map; calculated percentages of value-added and non-value-added content; defined system and subsystem lead times, people utilization, space utilization, distances traveled, and materials quantities and queue times; done some root cause analysis; and developed a proposed future-state process with quantified improvement deltas, projects, resource requirements, and timelines to implement.

I have described the manufacturing team in these baseline chapters; however, in actual practice, a baseline has two subteams working concurrently. The team I did not break out the detail on is the information team. Those individuals work through the same process from initial customer contact through sales, order entry, purchasing, engineering, scheduling, and all materials and information functions—in short, all supply-chain future-state potentials that will support the manufacturing team's future-state shop floor activities.

At the end of day 5, the plan is presented to management, and the approval to proceed is requested. In the daily briefings, management has had the opportunity to provide input several times throughout the week, so the final briefing holds no surprises.

The team has also requested input from management during the course of the week with regard to the numbers that are being used—the financial rules of engagement, if you will. *It is critical that this game be played with an eye to real money savings*. If it's not going to show up on your financials, we don't use it. No accounting gymnastics are allowed. For example, if large amounts of finished goods are involved, what's a day of lead time worth, in dollars, as a cost reduction resulting from lead-time compression? I've seen numbers as high as $250,000 given out by financial executives for a day of lead-time reduction, in terms of a corresponding reduction in finished goods.

For work-in-process reductions, what is the allowable dollar amount for carrying cost? While we argue that carrying cost is in the 30 percent range, the number that we will actually see appear on the financials is the number we want to use. A common carrying cost number given to a baseline team is in the 14 to 16 percent range.

If headcount reduction is being considered, what is the real money impact? I have seen people try to use fully burdened labor costs, and the question is, if five people leave the building, show me specifically how your overhead will be reduced. Give me the names of the individuals in overhead positions that you will eliminate as a result of direct labor reductions. This usually takes us back to quantifying labor reductions at simply the hourly rate plus fringes. I recall one management team that was in the habit of taking departmental cost reductions as it transferred people to different departments. The management team was actually accepting this practice as it built its companywide cost-reduction package. It's enough to make you shake your head. Our point is, unless someone leaves the building and comes off payroll, the bottom line doesn't change. It doesn't count.

Dollar amounts associated with returns, warranties, and rework activity are usually pretty straightforward, and the backloop activities on the process map show us real opportunity.

At any rate, we've been given the acceptable dollars, by management, for all activities being considered in the future state. There are no surprises and no last-minute disagreements. Day 5 is a wrap.

Figures 15-1 through 15-4 are some sample summaries of base-

Figure 15-1

line team activity. I've changed the names to retain confidentiality, but the summaries are real.

Baseline Summaries and Observations

Client 1: Mentored and Facilitated the Baseline Event for Test Development Process

Initial activity began with introductions and a quick overview of the daily agendas and the scope of and expectations for the baseline. We discussed cost, cycle times, quality, current-state definition activity, associated backloops in the process, queue times, the various types of waste, customer definition, and perceived areas of opportunity with regard to the customer. We reviewed the process map and all collected data and assigned additional detail definition.

With regard to the process map, at this level we moved to brainstorming of undesirable effects, with group discussion of what constitutes an effect versus a cause, and the overlap in semantics in each

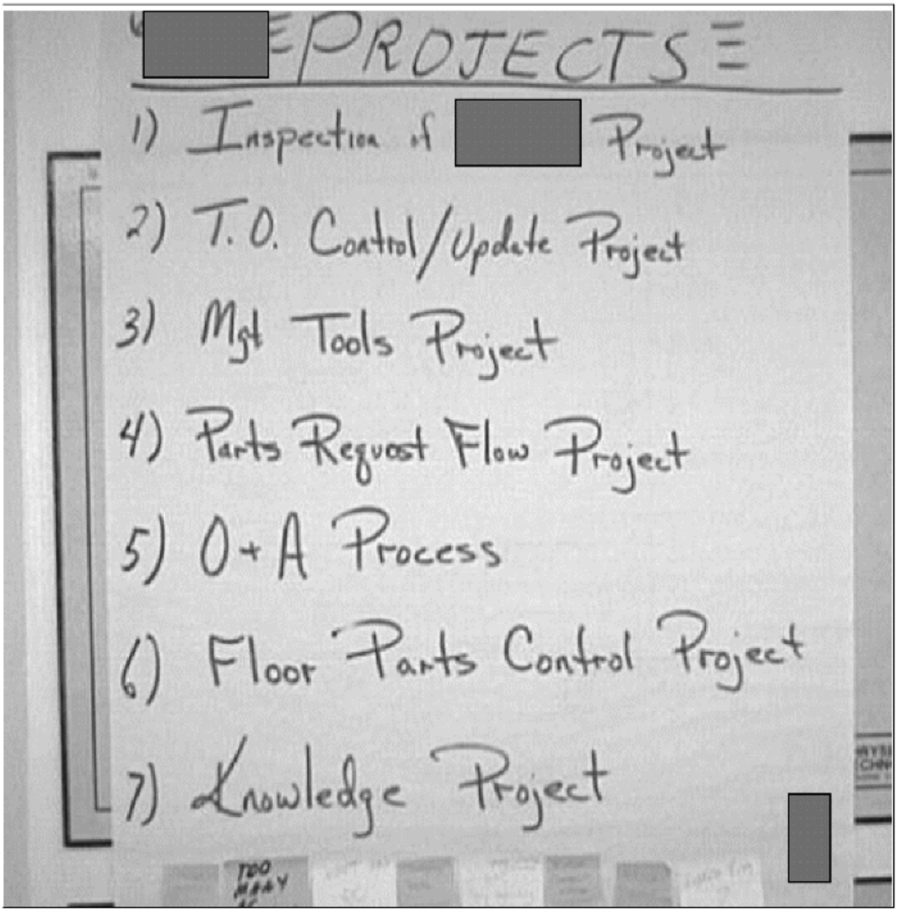

Figure 15-2

area. A matrix of UDEs was constructed, and all team members prioritized these UDEs individually. Collective data were constructed, and the weighted UDE priority list was finalized and discussed, with consensus being reached. We returned to the process map to analyze the points in the process where the undesirable effects occurred. At this point we assigned additional work on the process map to detail and quantify all backloop activity and time additions that occurred as a result of the UDEs assigned at each area of activity. In addition, we assigned times to the process map, defined as touch time and queue time. UDEs identified, in descending order of priority were, technician cannot run test (internally and/or externally), customer dissatisfaction, rework, bad units pass test, cost overruns, schedule delays,

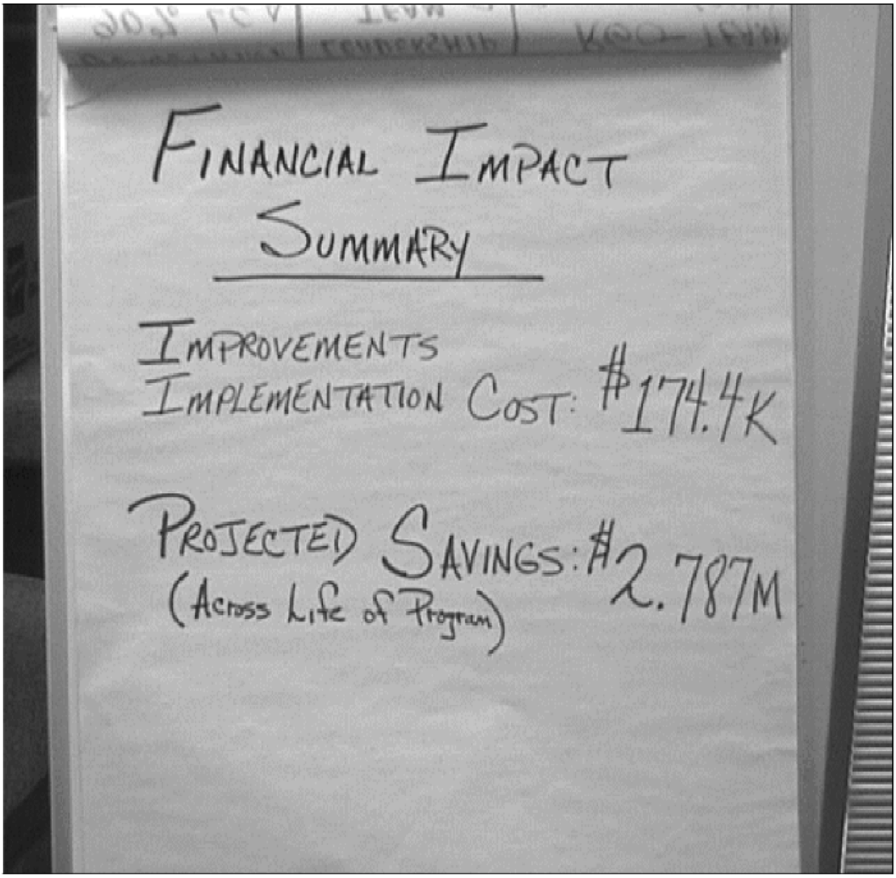

Figure 15-3

retest, wasted time, loss of future contracts, and emergency contracting.

The group reformed into three teams addressing functional areas: operations, materials, and planning systems/engineering. All three teams began finalizing and organizing the process map and flow, applying additional data that had been gathered in the process where appropriate. The map was expanded at task level for applicable paths of bid/estimating, planning and engineering/systems, CNC programming, materials, and the primary production paths: doors, cabinets, amenities, bulkheads, and decos. Time estimates were assigned for each task.

Following completion of the maps and time assignments, the entire flow was analyzed and tasks were assigned to the categories

SUMMARY Company XXX BASELINE

Waste—value add defs

Map		Current		Future
	Prod. lead time	18.8 days		5 days
	Processing time	281 minutes		
	VA	5.5 min	2%	
	NVA	84.5 min	30%	
	MVA	191 min	68%	
	Distance	900 ft avg.		
	Days inv.	18		7
	Facility velocity	19		5
	Schedule points	3 to 7		1

Avg mach time @ 400-piece order	Current: 16 shifts	Future: 1shift

Metrics

Operator @ 191 data points — Current work @ 37%

Projects

1. WIP reduction—drain the swamp
2. Training—operators lean/baseline results & logic
3. TPM
4. Kanban
5. Setup reduction
6. Develop metrics
7. Flow layout design

Potentials—Plantwide

1.	Labor reduction	30%	
2.	Space reduction	30%	
3.	Velocity increases	93%	
4.	WIP reduction	92%	
5.	Changeover reduction	66%	(90 min to 30 min)
6.	Downtime expense/maintenance	25K	

Figure 15-4

value-added, required non-value-added, and non-value-added. The total process throughput time was documented for each flow based on a sampling of actual orders through the process and interviews with highly experienced individuals. Total process activity time was compiled from the process map. These data were used to construct a visual showing value-added, non-value-added, and required non-value-added, with the delta between the process map time and the total measured throughput time being shown as queue time in both administrative and production areas.

Following the expansion of the map, with the associated quantified detail, the team regrouped to take a second look at the UDEs, with extended discussion and examples of what was an effect and what was a cause. The major UDEs as redefined through this process (not listed in order of priority) were excessive travel time, excessive work stoppages, high rework, excessive manual processes, excessive cost, wasted materials, wasted space, high inventory, high overtime, late deliveries, poor employee morale, high scrap, damaged or lost parts, long lead times, outsourced work, poor customer satisfaction, and material shortages.

This led us into root cause analysis of the major areas of opportunity identified. During this phase of the process, the group formed subgroups to brainstorm root cause analysis and reformed into the main team to obtain feedback and consensus, while discussing results and methodology, and to respond to questions that arose and difficulties experienced. At this point we had a representative from the finance department join the team to assist in finalizing the cost impacts and to represent the team for the financial impact portion of the leadership briefing.

We split into the three subteams and began developing problem statements, followed by developing preliminary solutions and alternatives. The team met as a whole and discussed each subteam's work and recommendations in detail, with consensus being reached before proceeding to the next step. The next step in the process was to expand the detail of the preliminary solutions and create first-draft plans. Tasks were detailed; the resources needed to implement the solutions were roughly defined by skill set, time, and cost; and the anticipated cost-reduction impact was developed.

For all projects, details of the cost savings impact, cost to implement, resources required, and timelines to completion were prepared. The process maps and visuals were arranged in order of operational flow to allow a logical, sequential order for the executive briefing, and financials were constructed and verified by our finance representative. The group worked on the presentation detail and format. A contract for change was constructed.

The leadership briefing was given, and the reaction was very positive, with spirited discussion on the part of the attending leaders. Projects resulting from this baseline are:

1. Implementation of a pull flow in the manufacturing areas, resulting in elimination of non-value-added labor activity—moving, sorting, and so on—and resulting work in process
2. Engineering liaison development
3. Obsolete materials reassignment
4. Integrated cabinet shop schedule development
5. Training of direct labor and engineering with regard to model development and program management
6. Purchasing detail—material savings/elimination of drop
7. Parts control
8. Engineering change notice (ECN)/manufacturing engineering process improvements—non-value-added

Total cost reduction opportunity identified = $1,300,000 annually, offset by a cost to implement of $250,000. Timelines to completion targeted year end 20XX. Quantifying the savings potential was difficult because of a lack of supporting data, which led to a very conservative estimate of savings potential. In looking at throughput times, direct and indirect labor, inventories and work in process levels, vendor costs, and so on, the actual savings should greatly exceed the amount presented in the leadership briefing. The XXX Shop Team is a highly experienced group of individuals, and I anticipate that they will take the tools and data provided by this baseline (with support from six-sigma experts) and implement the identified projects effectively and enthusiastically.

Client 2: Mentored and Facilitated the Baseline Event in Facility XXX, XXX Department

Initial activity began with introductions and a quick overview of the daily agendas and the scope of and expectations for the baseline. We reviewed the seven types of waste and discussed examples of each. The team conducted a department tour and collected observations with the seven types of waste in mind. We reconvened in the war room, brainstormed our first impressions, and reduced all observations to Post-its with a discussion of what had been observed and in what areas. At this point we discussed what additional data would be required to quantify our areas of observation. Additional data collection was assigned: Define the costs of active and slow-moving inventory, define WIP costs by department, define manufacturing throughput time—process specific, define number of ECNs in process, define the average ECN process time, define the activity associated with processing an ECN and dollarize it, define scrap costs, define rework hours during a sample time frame, develop a spaghetti chart of materials and people flows, and develop space utilization efficiency.

The group reformed into three teams addressing functional areas: operations, materials, and planning systems/engineering. All teams began finalizing and organizing the process map and flow, applying additional data that had been gathered in the process where appropriate. The map was expanded at task level for the four paths of work order development and the five primary production paths: electrical assembly, mechanical assembly, sheet metal fabrication, composites, and machine shop. Time estimates were assigned for each task.

Following completion of the maps and time assignments, the entire flow was analyzed and tasks were assigned to the categories value-added, required non-value-added, and non-value-added. Total process throughput time was documented for each flow based on a sampling of actual orders through the process. Total process activity time was compiled from the process map. These data were used to construct a visual showing value-added, non-value-added, and required non-value-added activities, with the delta between process map time and total measured throughput time being shown as queue time, in both administrative and production areas.

The team brainstormed UDEs and had an extended discussion and examples of what was an effect and what was a cause. This led us into root cause analysis of the major areas of opportunity that had been identified. During this phase of the process, the group formed subgroups to brainstorm root cause analysis and reformed into the main team to obtain feedback and consensus, while discussing results and methodology, and to respond to questions that arose and difficulties experienced. The major causes identified through this process were no master schedule, inventory not purged, imbalance of production flows, underutilization of systems, not producing to demand, physical layout not set up for flow, excessive amounts of ECNs, insufficient preventative maintenance activity, and lack of vendor certification.

We split into the three subteams and began developing problem statements, followed by developing preliminary solutions and alternatives. The team met as a whole and discussed each subteam's work and recommendations in detail, with consensus being reached before proceeding to the next step. The next step in the process was to expand the detail of the preliminary solutions and create first-draft plans. Tasks were detailed; resources to implement the plans were roughly defined by skill set, time, and cost; and the anticipated cost-reduction impact was developed. At this point we had a representative from the finance department join the team to assist in finalizing cost impacts and to represent the team for the financial impact portion of the leadership briefing.

For all projects, details of the cost savings impact, cost to implement, resources required, and timelines to completion were prepared. Process maps and visuals were arranged in order of operational flow to allow a logical, sequential order for the executive briefing, and financials were constructed and verified by our finance representative. The group worked on the presentation detail and format. A contract for change was constructed.

The leadership briefing was given, and the reaction from the attending leaders was very positive. Projects resulting from this baseline are:

1. Implement a pull flow in the following manufacturing areas, resulting in elimination of non-value-added labor activity and resulting work in process:
   - ❐ Electrical assembly
   - ❐ Mechanical assembly
   - ❐ Composites
   - ❐ Fabrication
   - ❐ Machine shop
2. Implement a pull flow in the administrative areas that create work packages.
3. Identify and purge obsolete and slow-moving inventory from stock, resulting in greater space availability and elimination of moves and tracking of unneeded materials.
4. Create a new layout for the stockroom, decreasing non-value-added labor to move things out of the way in order to get the materials that are needed.

5. Analyze causes and decrease scrap—error proofing, training.
6. Analyze causes and decrease rework—error proofing, training.
7. Define what metrics will be used to monitor activities and implement them facilitywide.
8. Reduce the number of ECNs processed within the plant.

Total cost-reduction opportunities identified = \$4,500,000 annually, offset by a cost to implement of \$300,000. Timelines to completion were from two months to one year. In looking at throughput times, direct and indirect labor, inventories and work-in-process levels, vendor costs, impact on production, and so on, the actual savings should greatly exceed the amount presented in the leadership briefing.

Finally, here's an example of a departmental baseline coupled with implementation the following week.

Client 3: Mentored and Facilitated Week 1, Electrical Department Flow Layout Project

Initial activity began with introductions and a quick overview of the daily agendas and the scope of and expectations for the week's activity. The shop team consisted of Susie XX, Eva YY, Norma ZZ, Lou AA, Carol BB, and Jim CCC.

We reviewed the six-sigma concepts and objectives and the common types of waste found in a manufacturing department, and we discussed methods of improving profitability and reducing waste. We discussed the concepts of the impact on cash flow of inventories and work in process, return on assets employed, true cost versus actual cost as related to activity required as a result of overproduction, inventory turns, line balance concepts and lean flow logic, and value-added concepts. We identified parts families as coax, twisted, combos, multi, single, and braided. We discussed equipment and operations and developed a process map of the coax product to illustrate mapping concepts and the purpose of mapping. The coax process map was analyzed from a value-added viewpoint, and a future map was developed that eliminated the majority of the non-value-added steps. A spaghetti diagram illustrating the current process was constructed, and we returned to the process map to compare time percentages affected by the distances highlighted in the spaghetti. We then dollarized the process map. With this illustration complete, we mapped the remaining five product families. We developed a matrix of current cycle times per family with percentages of value-added times.

We next analyzed the process maps and eliminated steps that we felt were non-value-added and could be modified immediately. Using the layout grid and templates, we began developing a concept flow for the first cell (coax), using the shortest physical path for materials and people, sequential build, and no work in process as criteria. Using this concept flow as an illustration, we developed concept flows for the remaining cells. We then composed an equipment grid and identified all equipment used in the various families to illustrate common paths and constraints.

Modifications that required improved process flow from support groups were (1) a modified layout of the wire/stock area directly adjacent to the Electrical Department, with improved kitting and support recommendations, and (2) modification of the work package format currently used. We contacted Linda (the stockroom supervisor) and Big Mike (the planning supervisor) to discuss our proposals and were met with agreement and positive input in support of our suggestions.

The concept flows were then inserted into the departmental layout grid, and the final layout concept was detailed and agreed upon by the team, with templates in place to transfer requirements to facilities. We toured the floor at several points in this process to review details and clarify points of discussion. With the flow layout in place, we then worked through the details of locating drops for power, air, and so on, and located scanners. With the layout in place, we revisited the process map and finalized improved flows and cycle times.

We then moved to balancing concepts and one-piece flow techniques. Illustrations of several types of product were developed, with what-if scenarios discussed. We flowed product through the model cells and discussed specific staffing requirements and operator moves to accommodate sequential flow with no batching or work in process. The resulting detail had a major impact on velocity compared to the current batch operational philosophy. We discussed metrics in detail, with emphasis on (1) on-time delivery, (2) productivity, (3) downtime, (4) velocity (throughput), and (5) quality. Topics covered were collection techniques and formats, visuals in the department, what is important and why, what formats operators will respond to and why, communication techniques, and an ongoing focus on continuous improvement.

The Facilities and Information Systems Departments were contacted, and we reviewed our requirements with the team to begin support activity the following week in order to allow departmental implementation to begin on 3/18/XX.

The results were an anticipated reduction in labor of 18 to 43 percent, depending on the product family, with the average being in the 33 to 35 percent range overall; a reduction in work in process that was estimated to be in the 90 percent range; and an increase in throughput (velocity) ranging from 100 to 400 percent, again depending on product family characteristics.

Quantification of the product mix with the proposed improvements provided a summary cost-reduction target of $1,045,000 in direct labor annually, with an increase in available capacity, representing additional margin available to bring in house, of 30 to 40 percent.

The team assimilated the concepts presented and developed the proposed lean flow with enthusiasm, coupled with extremely strong support and participation from management (represented by XXX and YYY). I anticipate a very effective departmental transition and solid cost-reduction results.

And here's the second week.

Client 3: Mentored and Facilitated Week 2, Electrical Department Flow Layout Project

Week 2 of the electrical department flow layout project consisted of execution of the physical move and support issues—materials, kitting, work order release methodology, scheduling, staffing balance and flexibility, development and placement of metrics, and quality considerations. The installation of all drops was finalized; termination tables were modified, with wheels added to allow quick reconfiguration of work cell layouts; and all departmental equipment was relocated in accordance with the new layout.

We met with materials representatives to discuss our proposed kitting and marker layout and with IS reps to install additional scanning locations. We met with all planners and discussed scheduling requirements and the development of an integrated, time-sensitive schedule to support all programs. This was the first session in which all planners had met to discuss an overall master schedule, and it led to a discussion of systems, the accuracy of need dates, and the lack of a final assembly build schedule to drive component production. Daily planning meetings began immediately, with a rolling weekly production schedule being utilized. We pulled all active orders from the system and developed a prioritizing matrix for developing three internal schedules: a build schedule (daily manufacturing schedule), a planner schedule (work orders to be released), and a materials expedite schedule (orders with materials shorts), all driven by need date.

We met with Barry James, General Manager, and Jackson Poe, Director of Operations, to discuss organizational structure and the deficiency observed in the lack of a master scheduler and coordinator of overall planning activity. The organization was restructured, and an offer was made to and accepted by Jesse Bodine to fill the master scheduler slot. A daily production meeting is now held to establish current and next-day orders. No short kits are being released to the floor—if it can't be completed, it is not started. We met with the work package group and implemented a revised process to provide packages in the correct order, and we streamlined the package content to provide only the documents that are required. Document control was placed in the loop for document release.

Training sessions were held for floor operators, in which we explained the process and objectives of demand flow, teamwork, and a minimal work-in-process flow. We held a staffing planning session and scheduled the lines with flexible operators to provide a one-piece flow. This was fine-tuned as we progressed through the week. A training area was established to work off work-in-process, with third-shift personnel transferred to the first shift to do this.

Metrics were discussed, developed, and put in place to monitor on-time delivery, velocity, hours per unit, delays, and kit accuracy, utilizing a storyboard on the shop floor.

The transition was completed and the results monitored as of the end of the month (approximately two weeks into the new layout). The results shown were:

1. Units per day increased from a baseline average of 67 to a new average of 110 to 140.
2. Velocity (throughput) increased from a baseline average of 18 days to 3 days.
3. WIP units on the floor decreased from a baseline average of 1,900 to 300 and dropping.

The process is in place and showing excellent results, and it is receiving a high degree of enthusiasm from the personnel involved in the departmental operation.

Final Thoughts on Doing a Baseline

And so our baseline (or value-stream mapping event, if you prefer) is over. Whether your team has analyzed a business unit or a specific problematic portion of your business, the power of a cross-functional event provides the perfect starting point for lean implementation. The baseline is detailed at the task level, highly visual, and data driven. Your team leaves this week with a highly focused, collective vision and mission. The team members have defined the current state, they have developed the future state, and they now know what activities they must engage in to get there. They also have a common vocabulary with regard to waste and opportunity.

I find that in the majority of events I have been associated with, this is the first time that most, if not all, of the individuals involved have had the opportunity to view the entire business, from initial customer contact to delivery of finished product, as opposed to seeing only their specific areas or departments. This type of event changes perceptions dramatically.

Following a baseline event, the next week or two is typically spent translating the details of the identified projects into a task-level, executable project format. Justifications need to be finalized and approved, resources should be defined and allocated, and project steps and timelines should be detailed. This is a critical step in the process. It is usually fairly easy (there's lots of hard work, but the process is straightforward) to execute a very well detailed plan. However, it is usually quite difficult to take the time to develop a very well detailed, executable plan. Don't lose the momentum and energy levels created by an intensive event and allow your team to simply disperse and return to the activity traps of their respective positions.

Flesh out your projects. What are the steps? Who is accountable? When will each task be completed? Keep your team moving toward the future state, remove the obstacles, and begin the lean journey.

Enough said. Let's talk about some of the tools. On with the "how."

CHAPTER 16

Lean-Engineering Analysis

Know What You Do

Engineering analysis is one of the most interesting areas of activity as you begin your lean journey. It is also one of the most startling to members of the management team.

During the course of most baselines, it becomes obvious to everyone that the process that is widely believed to be in place in your manufacturing areas is not the process that is actually in place. Some companies insist that they know their process, while others readily admit that they don't; however, most operations fall into the former category. As the baseline team builds a task-level process map, it's the rule, not the exception, that the management types on the team will reach the point where they have no choice but to pull out their "standard data." As the process map expands and becomes more involved, and more people get the opportunity to provide input on the tasks, large discrepancies usually surface with regard to timelines, task content, and task sequence.

Case History: The First Step Toward Lean

I worked with a baseline team on a discrete segment of a product assembly that was targeted to be the initial lean model within the company. The process delivered a subassembly of the company's product to the main assembly line. It was a good segment choice in that it occupied its own facility bay and was a stand-alone assembly from start to finish, so it could be treated as a stand-alone business from a flow viewpoint. The company wanted to change this segment into a lean model and use the lessons learned to make a similar transition throughout the rest of its manufacturing areas. This is the Pac-man theory of transition, if you will, or, as the company put it, ''the first bite in eating the elephant.''

The process involved approximately 190 hours of ''actual data'' work and employed around 25 people. This operation had a timekeeper in the middle of the assembly bay, and the shop floor people would walk to this timekeeper in between each assembly bite and clock out on that bite and in on the next. The company felt that it had excellent data on actual assembly time, with a highly disciplined focus on documenting and compiling the time spent on each segment of the assembly. There were mountains of data. In contrast, I felt that the company had excellent data measuring its ability to make people walk to a timekeeper in between each assembly bite and spend some time clocking out and in, while chatting about the weekend, and fishing, and the weather with other folks who were also waiting to clock out and in. At any rate, there were lots of data; that was their story, and they were sticking to it.

This was a very clean process (not in the housekeeping sense)—highly repetitive, making the same product over and over, with a takt time of ten hours. (See Chapter 17 for a discussion of takt time.) Every ten hours, a finished unit would pop out the end of the process. The floor layout was designed so that every assembly person had a ten-hour segment of work, at which time the assembly would move to the next station. There were a dozen or so main assembly stations, with a large separate area that provided subassemblies to the main stations. The materials flow and location was a train wreck, with common bins for hardware and fasteners, and larger skids of materials dropped by material handlers wherever they could find a space—a different location every time.

As we built the process map, it looked like Figures 16-1 and 16-2.

Once the big boxes were up on the process wall, we started to bore down on the details.

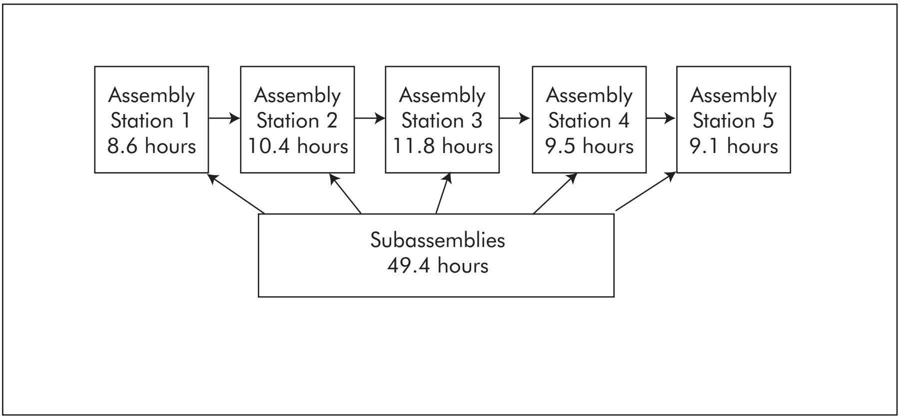

Figure 16-1

Me: What's inside of that 8.6 hours box at station 1?

Industrial Engineer: There are four large assemblies; they put the gizmo on, then they install the gazmo, then they install the what's it, and they finish by assembling the who's it.

Me: OK, let's break it down. What are the times for those pieces?

IE: Well, the gizmo is 1.8 hours, the gazmo is 4.3 hours . . .

(And so on, as IE looks at his standard data printout. When we started to question operators from the floor on the accuracy of the map, as constructed so far, the plot thickened.)

Me: OK, John *(John is the senior assembler on this line)*, walk me through these process steps that your supervisory team has constructed. What do you see?

John: Looks about right. The gizmo takes 1.8 hours to install. Let's see . . . hmm . . . yep, the gazmo takes 4.3 hours, except we don't put that on at station 2 anymore, we install it at station 6; it's easier to reach before you install the thingamajig. *(And so on.)*

I've been playing this game for a number of years, and when you ask an operator, "How long does this take?" it's common to get a couple of different types of answers. In some operations, everything—and I do mean everything—takes "about 15 minutes." In other operations, everything takes "exactly what the standard data

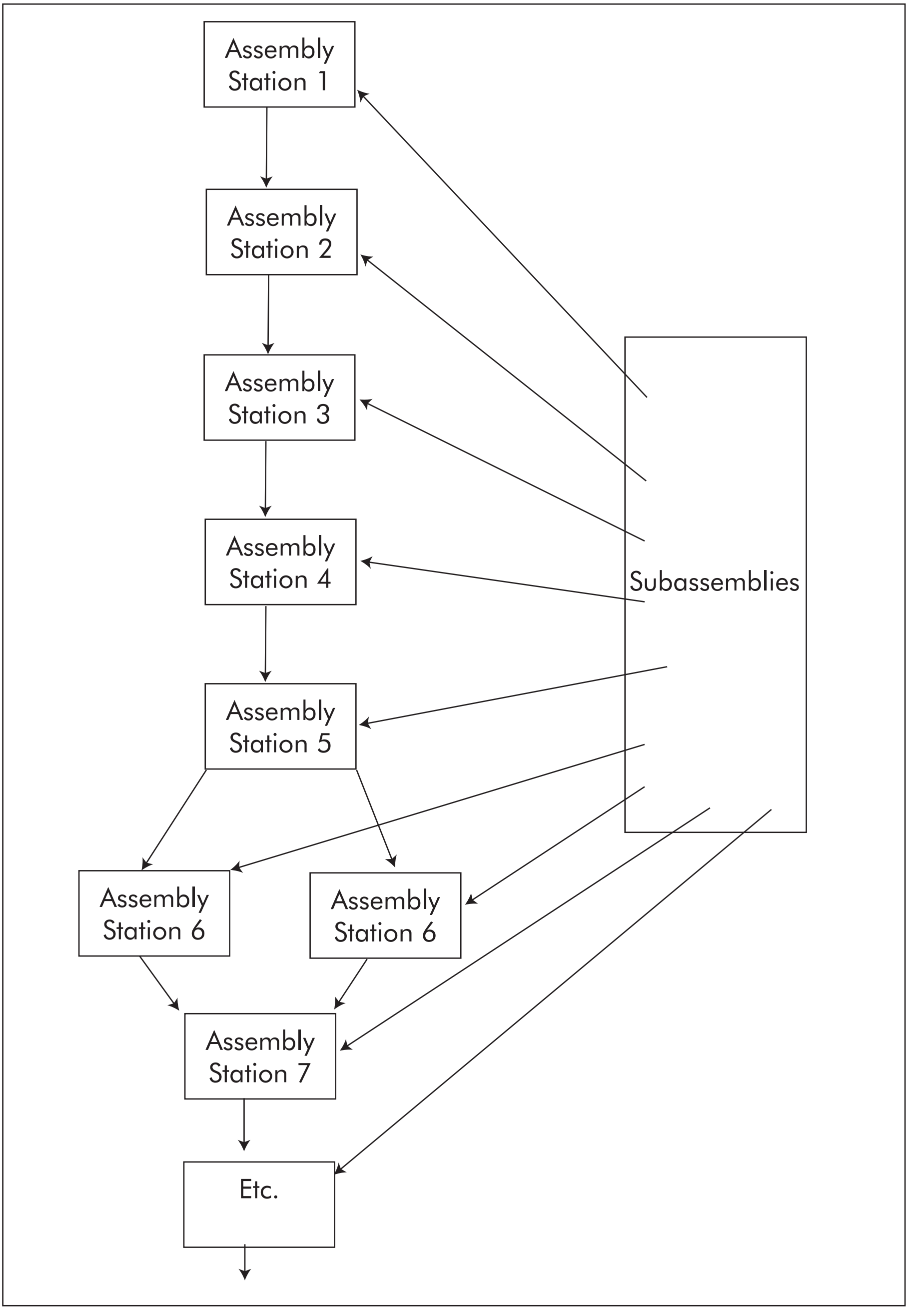
Assembly Station 1
Assembly Station 2
Assembly Station 3
Assembly Station 4
Assembly Station 5
Assembly Station 6
Assembly Station 6
Assembly Station 7
Etc.
Subassemblies

Figure 16-2

say it takes." I have yet to meet an assembler who will say, "Oh, yes, that takes 4.36 hours."

We were clearly in the second type of operation.

And so:

> **Me:** OK, Stan (Industrial Engineer 3), where are your studies on the activity in these operations?
>
> **Stan:** Well, our studies don't really show the pieces; we get those from the actual times that the guys clock. Our studies just show the overall station.
>
> **Me:** That's OK. What do they show you?
>
> **Stan:** We start the clock for the overall station, and we capture the total time.
>
> **Me:** No details?
>
> **Stan:** We take three studies of every station to make sure our data are accurate, but we use the studies only for costing purposes, so we've never gone to a low level of activity. We don't have the time to do that, and we've never used a study to change anything, so we don't need the detail, just the cost.
>
> **Me:** I see; thanks.

I assure you that an exchange like this one is not uncommon. This was an actual conversation in a company that is a leader in its industry. It has good engineering people, and it is very profitable, with an eye on becoming more profitable. It simply has not had a lean mindset. And so I'll jump ahead.

We have completed the baseline and the team members are developing project detail to allow them to rebalance all work tasks and create a flow-pull layout. One line item in the plan is to detail the process accurately so that they can recombine and rebalance the workstations. They have determined that it will require forty person-weeks to do a detailed industrial engineering study with three passes, as the conventional logic would require. I challenge their timeline and their logic, and suggest that they do a lean-engineering study, which I estimate will require about forty person-days (twenty linear days with two people on the study), as opposed to the conventional forty-person-week projection. The manufacturing manager asks me to accept the assignment, and away we go.

Action Plan

I sit down with the engineering manager and his staff to detail the approach and the format that I prefer. My recommendations are along these lines:

1. Develop a synchronous diagram of the ABC assembly:
   a. This step provides a linear assembly schematic of the process, showing the main assembly flow with feed-in of all components. This preliminary step defines all material and component relationships from raw material to finished product—in this case, an ABC ready-to-ship to main assembly.
2. Define element composition.
   a. Using the synchronous diagram, all major elements are defined. The definition of an element is a sequence of assembly activity that it would be inefficient to break into smaller increments.
3. Define the sequence of process data analysis.
   a. The sequence of element analysis and rough timelines are developed. This assures the timeliness and focus of the overall analysis.
4. Detail the sequence of activity.
   a. The element analysis will be performed, defining current station ID, element number, description of activity, activity time, part numbers consumed, part quantities, tooling, jigs or fixtures, and hand tools utilized.
   b. Element analysis will be detailed to define value-added, required non-value-added, and non-value-added activity times and percentages of total element content.
   c. Element analysis will contain comments on observed activity that provide opportunities for process improvement—e.g., inefficient or inadequate tooling or fixturing.
5. Elements will be sequenced to define a linear process flow.
   a. This format will provide the baseline team with the necessary data to develop a work sequence that will accommodate takt times at varying levels of demand, allowing for line balance accordingly, and develop a materials and tooling plan to provide a point-of-use layout.

Doing a One-Pass Analysis

I've got the engineering manager, Jack Felts; a senior manufacturing engineer, Kevin Willis; and the supervisor of industrial engineering, Kathleen Costa. Here's how the conversation goes.

Jack: Thanks for being available to support us on this accelerated timeline, Bill.

Me: My pleasure, Jack; our engineering posse is at your disposal.

Kathleen: I'm not sure about your suggestion that we do a one-pass study. As a professional engineer, I'm concerned that we'll lose integrity of data.

Me: I appreciate your concern, Kathleen. Please expand on your question of integrity of data.

Kathleen: You propose to take one snapshot of the process. I guess my first question would be, what if our people slow down during your study? Will that give you skewed times? And how do you rate operators?

Me: OK, good questions. As you know, or maybe you don't, I have blue card certification in MTM, Mini Most, and Maxi Most, and twenty-five years of manufacturing experience. Years ago, we used to rate people on their level of performance to accommodate slowdowns and, conversely, extremely fast performance. With a lean format, the speed at which people work doesn't really matter. If someone is painfully unqualified to be performing assembly work, I might make a note of it, but for the most part we'll be observing all the people across your process at various times and on different shifts, and with your experienced workforce, we should get a good balance.

Kathleen: But what if some of our operators intentionally slow down to pad the time?

Me: They can't slow down. Work is work, and it takes so much time. For example, when you pull the trigger on an air driver to drive a screw into place, it takes what it takes. There's not a lot of variation from one cycle to the next or from one person to the next in the value-added activity. Where the variation occurs is in the non-value-added activity, the go-gets, the wait-fors, and the downtime in between assembly cycles. *(I pull up a sample study on my laptop.)*

Let's look at a sample format, like this one (Figure 16-3).

Here's a sample study of a subassembly that took 2,700 seconds, or 45 minutes. As we follow the activity through any type of assembly, we break up the activity into the eight categories of waste and work that we use in lean theory. We get materials, we get tools, we assemble something, we inspect something, we rework some-

C	D	E	F	G	H	I	J
XYZ process study			Subassembly BCD			Operator-Robby Linch	
3/24/2002							
			Category				
Element	Element—Description	Element Time (sec)	Value-Added	Non-Value Added	Req. Non-VA	Part Numbers	Tools/Fixtures
1	**#234 ziqmo**						
	get can	184		184		127-R4S	
	unpack/aside box, banding,wrap, skid	440		440			
	get tools/inspection gages	34		34			25mm go/no-go
	get	103		103		pin 65-431	pF-122035-0100 thru gage
						roller 1227	Large C-clamp
						pin 122408	vice grips
						washer MS83-18	channel locks
	ass'y	208	208				
	get tools	31		31			needlenose
							127-R4S
	get parts	77		77		retainer 12286	3/8" box
						screw M206-261 (2)	
						washer M83-42 (2)	
						control 15082-3	
						screw M207-269 (2)	
						nut MS23N3 (2)	
	ass'y and tape to side	120	120				
	get					screw 13319	
		0				nut M691-17	
	ass'y	100	100				
	get tools	170		170			3/16" allen 5"
		0					5/16" allen
		0					3/16" box
	get parts	188		188		cover 1226-AR	
		0				screw MS997-99 (3)	
		0				forwarders 1778 (2)	
		0				screw MS167-60 (8)	
		0				loctite 271	
	ass'y	230	230				
	cont. . . .ass'y	83	83				
	cont. . . .ass'y	182	182				
	inspect/adjust height	83			83		
	get doors/ass'y	171	171			158-52	
						12317	
						123176	
						122	
	get cart & aside	176		176			
	TOTALS		Value added	Non-value added	Reg Non VA		
Totals/mins	45.0	2700	1034	1523	83	60	2700
Totals/hrs	0.75	Total/secs	**41%**	**56%**	**3%**	xx	100%
Totals/mins/V	18.23						

Figure 16-3

thing, and so on. If you look at this study, 41 percent of the activity is touch time, where parts are going together; 56 percent is non-value-added, go-gets and such; and 3 percent is required non-value-added, things you need to do, but not necessarily the way you're currently doing them. You'll also see what materials, tools, jigs, and fixtures are used and in what sequence. When people take more time to get things, or look for information, or rummage around in their toolbox for the correct tool, all of those activities are going to be discounted when you use the study. You're going to redesign this station with the materials and necessary tools at the point of use, and you're going to use a projected target time that's based on the reduction of non-value-added activity, as defined in the study. Most of the noise in the process is usually in the non-value-added tasks, not in the value-added. In addition, you'll have the opportunity to affect the touch time, what I'm putting in the value-added category. In this example, you'll notice that all the tools gathered and used to assemble fasteners, screws, and so on, are hand tools. This individual used no air or electric drivers of any sort for the variety of screws that are listed in the materials column. The definition of tools used allows you to methodize the touch activity to improve the value-added tasks. What do you think?

Kevin: We'll be able to follow these studies and develop our pictorial training documents in the exact sequence that people are working.

Me: Yes. A task-level study is very easy to follow and captures everything that's being done. It's also an excellent reference for correcting any discrepancies that exist in your bill of materials (BOM). I typically ask that you provide me with an engineering contact, and as we go through the process, we'll consume the BOM to assure total capture of activity and correct the BOM as we go. You'll end up with a nice, clean package to work with: tasks, tools, materials, sequence, elements for balance, and so on.

Jack: Will you be available to work with us as we break up the database and recombine our new process?

Me: I certainly will.

Preparing a Flowchart

Let's get to work. The first step in a study is to put together an overview of the process sequence—a flowchart with big boxes, if you will. Figures 16-4 to 16-7 show the piece we'll use for this example. Once again I'm jumbling the parts and process names to maintain confidentiality, but the process is real.

This goes on for several pages, with the existing process being defined as best as we can. This allows us to get a feel for the pieces

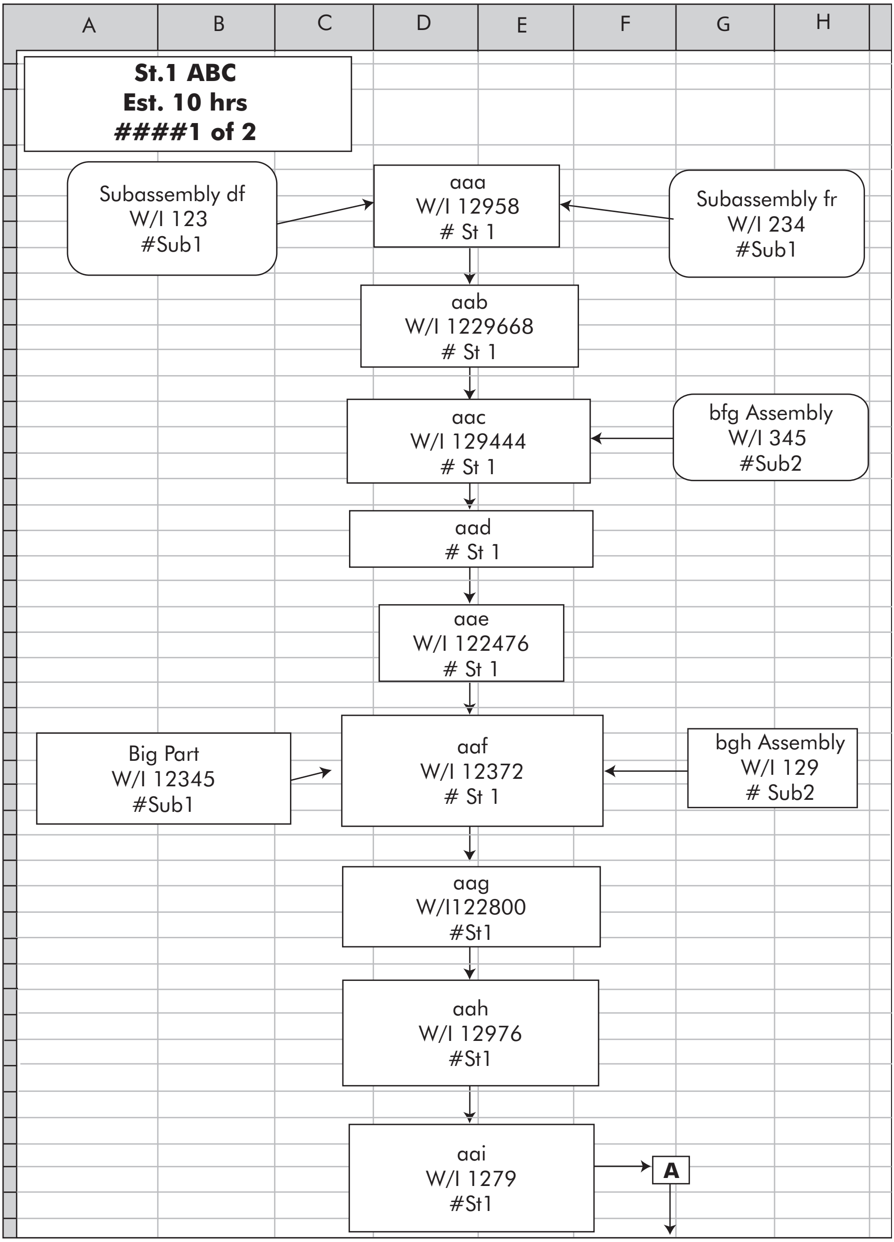
A
B
C
D
E
F
G
H
St.1 ABC
Est. 10 hrs
####1 of 2
Subassembly df
W/I 123
#Sub1
aaa
W/I 12958
St 1
Subassembly fr
W/I 234
#Sub1
aab
W/I 1229668
St 1
aac
W/I 129444
St 1
bfg Assembly
W/I 345
#Sub2
aad
St 1
aae
W/I 122476
St 1
Big Part
W/I 12345
#Sub1
aaf
W/I 12372
St 1
bgh Assembly
W/I 129
Sub2
aag
W/I122800
#St1
aah
W/I 12976
#St1
aai
W/I 1279
#St1
A

Figure 16-4

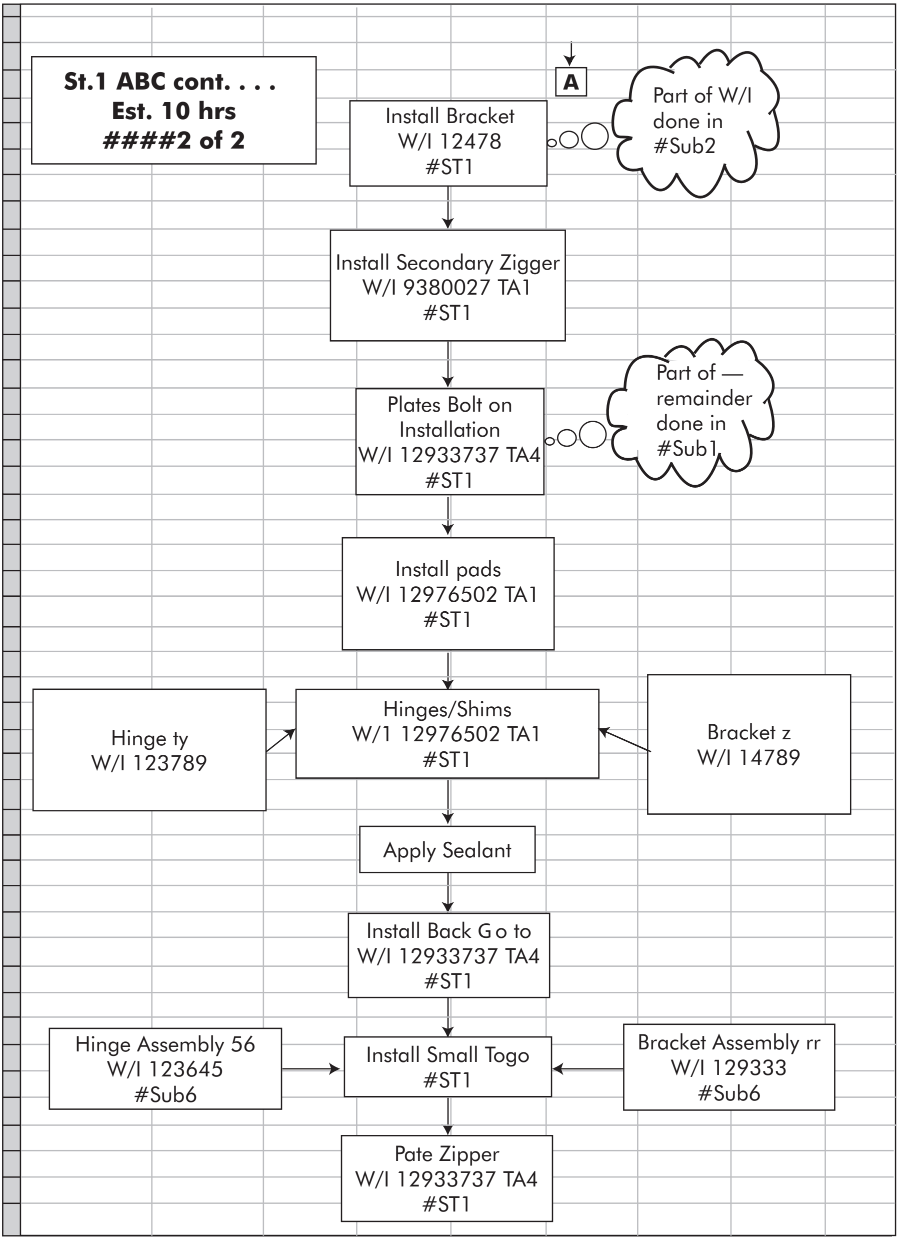
St.1 ABC cont. . . .
Est. 10 hrs
####2 of 2
A
Install Bracket
W/I 12478
#ST1
Part of W/I
done in
#Sub2
Install Secondary Zigger
W/I 9380027 TA1
#ST1
Plates Bolt on
Installation
W/I 12933737 TA4
#ST1
Part of —
remainder
done in
#Sub1
Install pads
W/I 12976502 TA1
#ST1
Hinge ty
W/I 123789
Hinges/Shims
W/1 12976502 TA1
#ST1
Bracket z
W/I 14789
Apply Sealant
Install Back Go to
W/I 12933737 TA4
#ST1
Hinge Assembly 56
W/I 123645
#Sub6
Install Small Togo
#ST1
Bracket Assembly rr
W/I 129333
#Sub6
Pate Zipper
W/I 12933737 TA4
#ST1

Figure 16-5

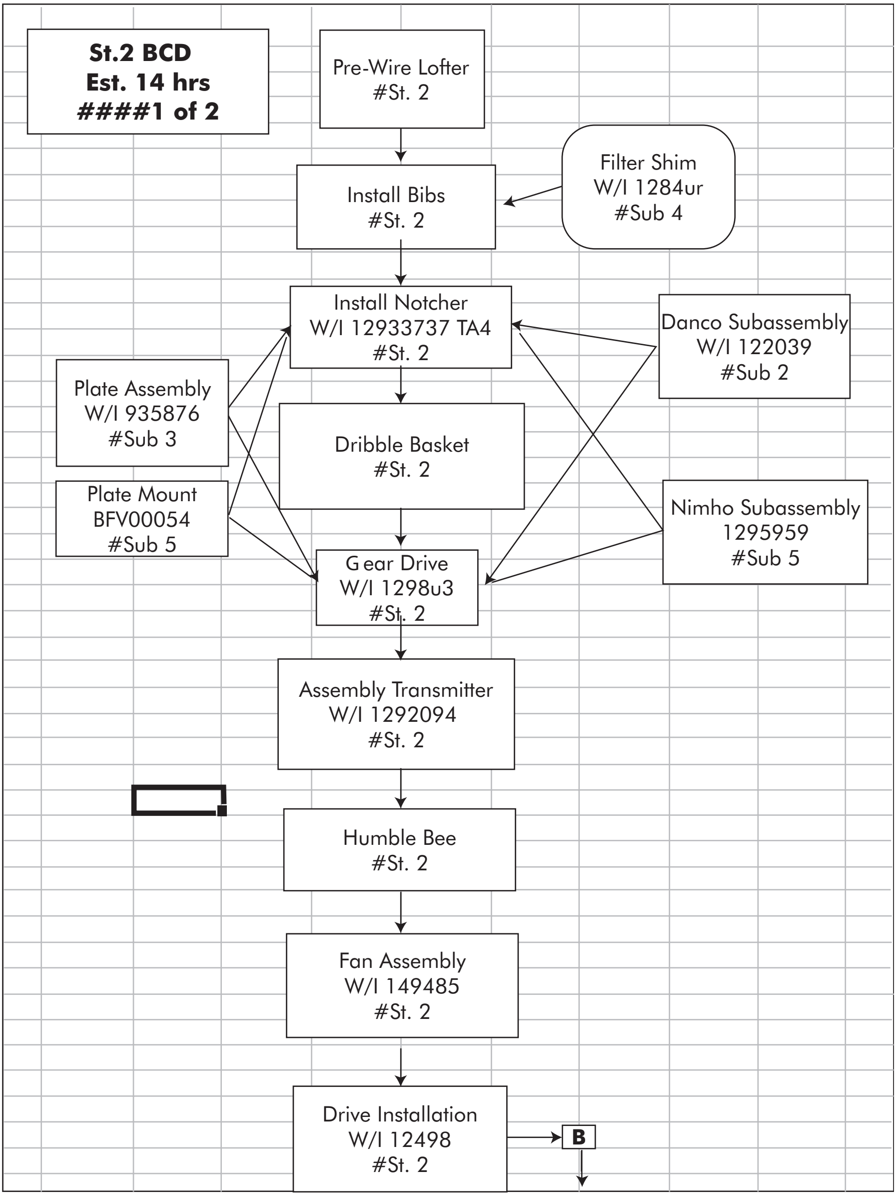
St.2 BCD
Est. 14 hrs
####1 of 2
Pre-Wire Lofter
#St. 2
Install Bibs
#St. 2
Filter Shim
W/I 1284ur
#Sub 4
Install Notcher
W/I 12933737 TA4
#St. 2
Danco Subassembly
W/I 122039
#Sub 2
Plate Assembly
W/I 935876
#Sub 3
Dribble Basket
#St. 2
Plate Mount
BFV00054
#Sub 5
Nimho Subassembly
1295959
#Sub 5
G ear Drive
W/I 1298u3
#St. 2
Assembly Transmitter
W/I 1292094
#St. 2
Humble Bee
#St. 2
Fan Assembly
W/I 149485
#St. 2
Drive Installation
W/I 12498
#St. 2
B

Figure 16-6

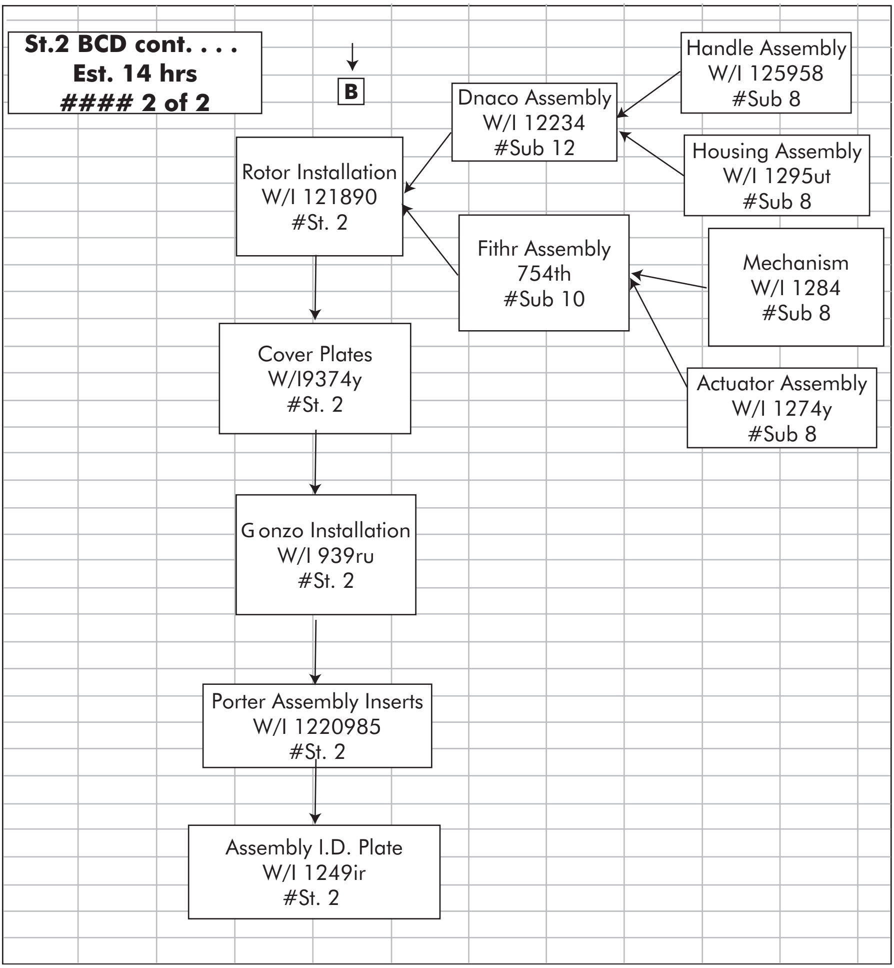

Figure 16-7

of the process: the names of the various assemblies and subassemblies and where they are performed in relationship to each other. Using this flow diagram, we'll begin to roll out the study.

So now we take our show to the floor to get an overview of the stations and areas and an introduction to the people who are making product. The most important element of a good study is to go back to the ''one man in the building'' theory. Make the study completely linear so that you can recombine and play with the pieces when you're finished. If one person were to build the entire product from start to finish, you would get a very clean view of the activity and the best sequence. This makes it very easy to recombine tasks and introduce simultaneous activity in a logical fashion. The second critical component is to ask a lot of questions.

I've been told about engineering teams that enter a facility and simply watch the assembly people do their jobs, with virtually no interaction. Usually I hear about these firms while I'm working on a project to redo the work that they did. They typically provide a huge database of numbers that are of no use whatever when it comes to actually changing something. The people on the floor are the product experts. Not only do they know the smallest nuances of the assembly process, they also know a hundred ways to improve the process. Listen carefully and pay attention.

Down on the Shop Floor

The first hurdle is the time-study syndrome. I'm beginning a study of the first station with Jake Trombley, assembler at large.

Me: OK, Jake, you're up. I apologize if this is going to make you nervous, but I need to capture the entire sequence of activity here at your station. I'm also going to slow you down a bit by asking you to give me all the part numbers of the materials you use and to talk to me about all the hand tools you use, socket sizes, air drive sizes, and so on. When I'm done, I need to know what you do, the materials you use, and all the tools required to do the job. I'd appreciate it if you'd give me your thoughts on any quality problems, shortages, better ways to do things, things that seem dumb to you, anything that you don't like about the way things happen or go together.

Jake: Hey, I get paid by the hour. If management says I gotta put up with ya, I will, but I gotta tell ya, I think it's BS to have you out here watching me.

Me: How so?

Jake: Well, every time a guy like you shows up, we end up losing jobs. I've been here twenty-seven years. We used to have 1,500 guys working here, and now we have 450 left on the floor. They just keep cutting times and cutting jobs.

Me: Where's the work going? Are you losing sales or what?

Jake: They keep sending it to other divisions, mostly down South where they can pay people less—no unions, inexperienced people, you name it.

Me: Well, I can't speak for your management, but I can tell you that I don't view my job as a means of sending you home to your family with an unemployment check. When a company hires a guy like me, it wants to improve its position, not weaken it.

Jake: Talk is cheap; you don't understand the way it is around here.

Me: Here's the game, Jake. When you get a new order for 500 of your gizmos, or six months' worth of new production, guess what happens?

Jake: What?

Me: Thirty-five people get laid off in Ohio or Alabama or wherever. Thirty-five people get to go home and tell their wife and kids, or their husband, that things are going to be tight; ''I just got laid off.'' Anybody who wants to buy one of your products can buy one, right now. There are a number of companies, you and your competitors, that produce the same exact product, and they're all competing for a limited number of customers. When you get an order, somebody else loses an order. It's a hard game, but that's how it works.

Jake: So? *(Jake is paying attention now.)*

Me: So, which company do you want to work for? The one that's taking business, or the one that can't compete because its cost is too high, or its quality doesn't make the cut, or its delivery time is too long—which also translates to cost, by the way.

Jake: What's your point?

Me: My point is, if your management team is just going to take the improvement opportunities that we show them and downsize, then you're going to be out of work either way. The company will just continue the way it has been, getting smaller and smaller, until it just dries up and blows away. If your management has decided that it's going to turn this ship around, then it'll use the improvement ideas we give them and get better, get faster, lower its costs, and take some business from the competition. The company will grow, not just keep on shrinking. And it can't do this without your support and help. You know the work; management doesn't.

Jake: I'll believe it when I see it.

Me: Fair enough.

I continue to work with Jake: What's this part? What's that assembly do? Why are those parts all the way across the bay? Once the initial discomfort with the situation is past, Jake starts to give me a good lesson. I find that the majority of the people I meet take a great deal of pride in what they do for a living, especially if they are very accomplished at their trade. When they get an audience that is genuinely interested in the details of how and why things work, most people become pretty good professors in a hurry.

And so I'm following Jake as he spends about four minutes going through a large bank of plastic bins located in the middle of his assembly bay, gathering screws and washers and bolts of various sizes for the next sequence of his assembly. His assembly sequence involves about ten hours' worth of work, a huge number of different parts, and a very complicated assembly. Jake is a machine; he just keeps on working—no wasted motion, no slack. I'm impressed with his work ethic and with his talent as a mechanical assembler.

Me: You've got a better memory than me, Jake. How do you remember all these part numbers?

Jake: I've been working this station for about four years now; it just gets to be habit.

Me: Why are the bins located where everyone has to walk to them? Why don't you have your materials at your station?

Jake: We used to have everything we use at our stations years ago, but every three years or so a new bunch of managers shows up and everything gets changed around. Talking to management is like talking to that wall over there.

Me: You're telling me that you tried? I thought you were hard-core antimanagement.

Jake: So if you're not interested in cutting time, what's that stop watch for?

Me: Ah, but I am interested in cutting time—just not your work time.

Jake: At last the truth comes out.

Me: Jake, I've been following you around for about two hours now. *(I wave the 10 pages of tasks and times I have on my pad.)* This study has nothing to do with your ability to work. This study is really a report card on how well your management is doing at providing you with what you need to get the job done. What do you think about that statement?

Jake: I'm listening. *(Fortunately, Jake can work and listen at the same time. He's not missing a beat.)*

Me: I need times in order to quantify the different boxes that your job is composed of. Work is work, and I'm not all that interested in that piece of the puzzle, although I do have some ideas about the tools that you're using. What I'm really interested in is the nonwork.

Jake: You're crazier than most of the engineers I've met. Nonwork?

Me: In the past couple of hours, you've spent about half your time putting product together and about half your time getting this and getting that. When I get done with this, we're going to go over the results, and I'm going to work out some ideas with you before I discuss this study with management. The ideas that I'm going to hit you with will be along the lines of, ''If you now spend fifteen minutes gathering parts from all over the department, walking hundreds of feet from your area, and we located those parts a few feet from your work area, so that you had to spend only a few seconds getting parts, are you going to stand idle during the time that we save, or will you just have more time to assemble product?'' Most of the nonwork that I'm seeing has to do with layout and distance traveled, not having the best tool for the job, quality glitches that cause you to retap a hole or fiddle around trying to get parts to fit together. None of that activity has anything to do with building product. That's what I mean by nonwork; we call it non-value-added where I come from.

Jake: You're preachin' to the choir, Bill.

Me: I know.

And on we go.

As we progress through the day, Jake becomes impatient with my questions on part numbers and decides to share his personal notebook with me. It contains all the part numbers for every component that he assembles. We start to save a lot of time. He fills me in on various techniques that he uses to overcome minor part fit issues; he tells me that several of the components that were thought to be being assembled at this station have been moved upstream, and several of the upstream components have been taken over by his station; he explains how he compensates for a cable that is about four feet longer than required by wrapping it and tucking it behind this compartment (the design changed a couple of years ago, but the old cable is still in use; yes, he's told engineering, but they can't seem to get it changed); he lets me know why he uses larger clamps than the bill of material calls for (the cost reduction from using the smaller clamps worked on paper, but you can't get the wire harness under the clamp that is called for); and on and on. And last but not least:

Jake: C'mon, Bill, you're going to love this one. *(Jake starts to walk out of the department, and I follow.)*

Me: You finally going to break for a coffee?

Jake: Nope. Follow me.

(Jake walks out of his bay and goes into the test bay next door. He goes to a rack of bins at the test station and gets two small washers.)

Jake: These are a special type of washer that we don't use anywhere except for test and in the assembly that I'm putting on next.

Me: You're kidding me. Why don't you keep a bin at your station?

Jake: It's their house, Bill. I just work here.

Getting the Real Picture

The true process starts to unfold. We work through twenty-five people and compile the demonstrated activity on a process that is recorded at 190 or so actual work hours. The station studies look like Figures 16-8 to 16-12.

This is an illustration of station 2: tasks, materials consumed, and all tools and fixtures used, broken into eighteen elements, with a station summary at the end of the station study. This is an example of a fairly large study of a complicated, technically sophisticated product. After working through all station and subassembly areas, we summarize the results to show opportunity compared to the actual data that this company has compiled for this process. The summary results for this study look like Figure 16-13.

As you will recall, the actual hours for this process were thought to be 190, as recorded by timekeeping and as stated by management. The target time given to the employees in this process corresponded to the 190 hours and was broken down by station into black box increments: "Station 2 has a target of 10 hours. We know that this is

C	D	E	F	G	H	I	J	K
ABC process study			Station 2			Operator-Benny Alberico		
5/21/2002								
			Category					
Element	Element—Description	Element Time (sec)	Value-Added	Non-Value-Added	Req. Non-VA	Part Numbers	Element	Tools/Fixtures
1	**Plates**							
1-1	get parts	87		87		plate (1) 4587		
1-2	ass'y hardware	35	35			screws (4) 345-67		3/16" allen
1-3	seal small plate	47	47			black RTV BML 43947		7/16" hand socket
1-4	seal large plate	44	44					
1-5	get tools	70		70		plate (1) 12599		
1-6	to unit	37		37		screws (6) MS13333		
1-7	ass'y small plate	81	81			washers (6) MS36666		
1-8	ass'y hardware	33	33					
1-9	ass'y large plate	66	66					
1-10	dropped bolt get another	36		36				
1-11	ass'y	55	55					
2	**Gull Port**							
2-1	get parts	235		235		sub-ass'y (1) 127888	2-1	
2-2	ass'y bolts	42	42			spacer (1) 12999	2-1	3/8" drive Impact
2-3	get hardware	27		27		handle (1) 12333	2-1	9/16" x 2" socket
2-4	loctite bolts	23	23			bolts (2) B182123456	2-1	9/16" x 1.5" swivel socket
2-5	get crane/cover/to unit	197		197		springs (10) 1237809	2-1	
2-6	ass'y cover/spacer/rotate cover up/check lock open	368	368			bolts (4) MS9999L	2-1	
						bolts (4) MS4444	2-1	
2-7	crane aside	15		15		washers (10) 1044-99	2-1	
2-8	ass'y springs/cap	57	57			end cap (1) 12987659-1S	2-1	
2-9	ass'y 2nd cap	36	36			end cap (1) 123456	2-1	
2-10	get tools	102		102				
2-11	drive	37	37					
2-12	torque	46			46			Torque wrench/ 9/16" socket
2-13	mark white	35			35			
2-14	get inside unit/test shut and lock	80			80			
2-15	torque aside	27		37				
2-16	paperwork	53		53				
Element	Element—Description	Element Time (sec)	Value-added	Non-value-added	Reg Non-VA			Tools/Fixtures

Figure 16-8

Element	Element—Description	Element Time (sec)	Value-Added	Non-Value-Added	Req. Non-VA	Part Numbers	Element	Tools/Fixtures
3	**Covers/Brackets—frontside**							
3-1	put locator screws	54			54			3/8" drive Impact
3-2	get cover #4	40		40		cover (1) 2456	3-2	3/4" swivel socket
3-3	get hardware	48		48		bolts (5) BH6788	3-2	pry bars
3-4	ass'y hardware	57	57			washers (5) 8900	3-2	impact/bit/ explosive bolts
3-5	bolts to cover-finger tight	30	30					3/8" drive Impact
3-6	get hardware/bracket	47		47				3/4" swivel socket #12-123
3-7	ass'y bracket hardware	27	27					3/4" box wrench
3-8	get brkt #3 (jig #xyz)	131		131		brkt (1) 5432	3-8	jig #xyz
3-9	ass'y hardware	92	92			bolts (3) 5559-9	3-8	
3-10	drive	17	17			washers (3) 555-55	3-8	
3-12	ass'y bracket to platen	59	59					
3-13	crane & jig aside	38		38				
3-14	get cover #2 (with clamp #dft555) to unit	102		102		cover (1) 2350	3-14	clamp #dft555
3-15	get pry bars (2)	18		18		bolts (2) 5559-9	3-14	
3-16	position/ass'y/pry bars in/ clamp off	76			76	washers (2) 555-55	3-14	
3-17	ass'y #2/orient/bolts in/ drive (2 bolts)	64	64			H-bolts (6) 2444	3-14	
3-18	drive	17	17			washers (6) 8900	3-14	
						washers/black (6) 6780	3-14	
3-19	get cover #1	13		13		cover (1) 55521	3-19	
3-20	ass'y hardware/drive	37	37			bolts (3) 5559-9	3-19	
3-21	get hardware #2/ unwrap bolts	67		67		washers (3) 555-55	3-19	
3-22	get hardware/bracket (on #3)	76		76				
3-23	ass'y hardware	20	20			bracket (1) 12345	3-22	
3-24	bolts to platen-finger tight	35	35			connector (1) 34567	3-22	
3-25	get gun	12		12		screws (4) 778-9	3-22	
3-26	drive #2	43	43			washers (4) 555-55	3-22	
3-27	bolts to bracket (on#3) -finger tight	43	43			nuts (4) 6767-67	3-22	
3-28	drive	27	27			bolts (4) 5559-9	3-22	
						washers (4) 8900	3-22	
3-29	bolts to bracket (on weldment) drive	48	48			bolts (6) 8989-98	3-29	
3-30	gun aside	12		12		washers (6) 555-55	3-29	
3-31	get crane/aside clamp	22		22		nuts (6) 2223-2	3-29	
3-32	to office/return	78		78				

Figure 16-9

Element	Element—Description	Element Time (sec)	Value-Added	Non-Value-Added	Req. Non-VA	Part Numbers	Element	Tools/Fixtures
4	Platen Slides—side							
4-1	get platen #5	32		32		platen (1) 12678	4-1	3/8″ drive Impact
4-2	bolts to platen -finger tight	66	66			bolts (5) 5559-9	4-1	3/4″ swivel socket
4-3	ass'y hardward (#7)	41	41			washers (5) 111-1	4-1	pry bars
4-4	get platen #7	23		23		platen (1) 16789	4-4	impact/bit/ explosive bolts
4-5	bolts to platen (#7) -finger tight	56	56			bolts (4) 444-4	4-4	3/8″ drive Impact
4-6	get gun	17		17		washers (4) 333-3	4-4	3/4″ swivel socket #12-123
4-7	drive	9	9					3/4″ box wrench
4-8	temp bolts to #6	30			30			
4-10	search for work packet-cannot find	385		385				
4-11	get platen #6	55		55		platen (1) 12789	4-11	
4-12	bolts (#6)-finger tight/pry bar/orient	80	80			bolts (4) 5559-9	4-11	
4-13	orient #5/drive	20	20			washers (4) 111-1	4-11	
4-14	orient #6/drive	45	45					
4-15	orient#7/drive	50	50					
4-16	drive #5	15	15					
4-17	interrupt/matl's	132		132				
4-18	get cover bases #8, #9	28		28		cover bases (1) 66789 (#8)	4-18	
						bolts (3) 5559-9	4-18	
						washers (3) 174-5	4-18	
						cover bases (1) 8889 (#9)	4-18	
						bolts (1) 444-4	4-18	
						bolts (1) 666-6	4-18	
						washers (2) 174-5	4-18	
4-20	interrupt/matl's	73		73				
4-21	search for work packet-cannot find	170		170				
4-22	get hardware #8, #9	47		47				
4-23	ass'y #9/drive	46	46					
4-24	ass'y #8 to #9/drive	39	39					
4-25	interrupt-instruct station #3 on chain use	209	209					

Figure 16-10

a fair time based on historical averages. We're just not sure what is inside the ten hours."

The demonstrated study hours in this example ended up at 105.3. The value-added hours totaled 54.6. I believe we have uncovered some opportunity for improvement.

Element	Element—Description	Element Time (sec)	Value-Added	Non-Value-Added	Req Non-VA	Part Numbers	Element	Tools/Fixtures
18	**Flange Mounts**							
18-1	get parts plates	151		151		Flange 1234		
						screws (2) 111-1		Impact
						washers (2) 222-2		3/4″ socket
18-2	get hdwr	125		125				9/16″ socket
18-3	ass'y Flange/plate and hinge ass'y over/under cover/insert hold pins/plates left, right	397	397			Flange 2345		needlenose pliers 67-223
						screws (2) 111-1		
18-4	get hdwr	22		22		washers (2) 222-2		1/2″ impact model/AH123
18-5	assy'y side Flange bolts/loctite	192	192			screws (1) 333-3		3/4″ socket
						washers (1) 444-4		9/16″ box wrench
18-6	get parts/box	180		180		washers (1)555-5		
18-7	ass'y box/ cover/Flange	404	404			nut (1) 666-6		ball peen hammer 3 oz.
18-8	get hdwr	59		59		screws (3) 111-1		
18-9	ass'y hrdw/ bracket/Flange	310	310			washers (3) 222-2		
18-10	get hdwr	13		13		washers (3) 444-4		
18-11	ass'y cover/ bracket/Flange	561	561					
18-12	rework hand tap one hole	55		55				
18-13	tighten all bolts	115	115			Flange 6789		
18-14	tools aside	35		35		cover 67890		
						screws (2) 111-1		
18-15	get parts data plate	114		114		washers (2) 222-2		
18-16	stamp/wire to unit	131	131					
						cover 1362		
						washers 222-2		
	TOTALS		Value Added	Non Value Added	Req. Non VA			
Totals/ min's	578.4	34706	17131	15681	1996	60		100%
Totals/hrs	9.64	Total/ sec's	**49%**	**45%**	**6%**	— xx		34808
Totals/ hrs/V	4.76					—		

Figure 16-11

My Briefing to Management

Me: I'll summarize. I'm impressed with the expertise and attention to quality displayed by your ABC crew. They are a highly experienced and talented group of assembly and test personnel. On a cultural note, your people are convinced that any improvement effort will

C	D	E	F	G	H	I	J	K
Element Summary								
Element	Element—Description	Element Time (min)	Value-Added	Non-Value-Added	Req. Non-VA			
1	**Plates**	9.85	6.02	3.83	0.00			
2	**Gull port**	23.00	9.38	10.93	2.68			
3	**Covers/brackets-front/sid**e	24.17	10.27	11.73	2.17			
4	**Platen slides-side**	27.80	7.78	19.52	0.50			
5	**ST 5**	30.27	17.33	10.63	2.30			
6	**ST 6**	18.47	10.43	7.13	0.90			
7	**ST 7**	30.08	18.27	11.82	0.00			
8	**ST 8**	19.65	12.58	7.07	0.00			
9	**ST 9**	31.57	10.72	18.13	4.42			
10	**ST 10**	43.38	20.52	22.12	0.75			
11	**ST 11**	35.20	24.23	7.88	3.08			
12	**ST 12**	66.83	24.30	33.38	9.15			
13	**ST 13**	43.53	14.12	28.47	0.95			
14	**ST 14**	33.17	17.35	11.53	4.28			
15	**ST 15**	35.73	23.68	11.80	0.25			
16	**ST 16**	19.33	5.35	13.73	0.25			
17	**ST 17**	38.67	18.02	19.07	1.58			
18	**Flange mounts**	47.73	35.17	12.57	0.00			
	Totals	**578**	**286**	**261**	**33**			
Element	Element—Description	Element Cost	Value Added	Non Value Added	Req. Non Va			
1	**Plates**	$3.41	$2.08	$1.33	$0.00	**Note:** Cost estimated at $16.00/hr direct with 30% fringes		
2	**Gull port**	$7.95	$3.24	$3.78	$0.93			
3	**Covers/brackets-front/side**	$8.36	$3.55	$4.06	$0.75			
4	**Platen slides-side**	$9.61	$2.69	$6.75	$0.17			
5	**ST 5**	$10.47	$5.99	$3.68	$0.80			
6	**ST6**	$6.39	$3.61	$2.47	$0.31			
7	**ST7**	$10.40	$6.32	$4.09	$0.00			
8	**ST8**	$6.79	$4.35	$2.44	$0.00			
9	**ST9**	$10.92	$3.71	$6.27	$1.53			
10	**ST10**	$15.00	$7.09	$7.65	$0.26			
11	**ST11**	$12.17	$8.38	$2.73	$1.07			
12	**ST12**	$23.11	$8.40	$11.54	$3.16			
13	**ST13**	$15.05	$4.88	$9.84	$0.33			
14	**ST14**	$11.47	$6.00	$3.99	$1.48			
15	**ST15**	$12.36	$8.19	$4.08	$0.09			
16	**ST16**	$6.68	$1.85	$4.75	$0.09			
17	**ST 17**	$13.37	$6.23	$6.59	$0.55			
18	**Flange mounts**	$16.51	$12.16	$4.35	$0.00			
	Totals	**$200.02**	**$98.73**	**$90.37**	**$11.50**			

Figure 16-12

Study Results:					
STATION	Total Time	VA	NVA	RNVA	
St 1	138,744	82,353	40,317	13,956	
St 2	63,020	30,526	23,570	8,924	
St 3	41,739	22,719	14,661	3,956	
St 4	34,706	17,131	15,681	1,996	
St 5	35,321	12,758	17,433	5,135	
St 6	22,639	9,219	7,934	5,486	
SUBS					
Subassembly 1	4,947	3,674	1,082	191	
Subassembly 2	5,016	3,128	1,098	790	
Subassembly 3	4,116	2,428	1,060	628	
Subassembly 4	3,927	2,396	1,301	230	
Subassembly 5	3,018	2,233	291	494	
Subassembly 6	2,700	1,094	1,523	83	
Subassembly 7	1,437	852	426	159	
Subassembly 8	1,629	768	282	579	
Subassembly 9	2,599	764	142	1,693	
Subassembly 10	1,804	708	766	330	
Subassembly 11	769	538	231	0	
Subassembly 12	1,629	438	650	541	
Subassembly 13	675	398	277	0	
Subassembly 14	757	290	467	0	
Subassembly 15	757	290	467	0	
Subassembly 16	772	204	490	78	
Subassembly 17	557	193	91	273	
Subassembly 18	557	193	91	273	
Subassembly 19	517	193	0	324	
Subassembly 20	732	192	427	113	
Subassembly 21	771	187	389	195	
Subassembly 22	810	135	673	2	
Subassembly 23	353	121	232	0	
Subassembly 24	313	103	0	210	
Subassembly 25	251	72	135	44	
Subassembly 26	251	72	135	44	
Subassembly 27	316	56	260	0	
Subassembly 28	0	0	0	0	
Subassembly 29	0	0	0	0	
Subassembly 30	940	0	940	0	
Seconds	**379,089**	**196,426**	**133,522**	**46,727**	
	Total Time	**VA**	**NVA**	**RNVA**	
Demonstrated Process Hours	**105.3**	**51.8%**	**35.2%**	**12.3%**	99.36%
Total Value-Added Hours	**54.6**				

Figure 16-13

result in the loss of jobs—a difficult environment in which to foster a continuous-improvement mindset. As we discussed, I would suggest a concerted effort to improve relationships in this area.

With regard to perceived efficiency, your people are extremely good time managers. They have been given expected outputs for the various areas that total approximately 190 hours, and they are performing at the levels requested of them. This study provides you with some interesting data to improve this area. The departure from conventional engineering studies is that our approach addresses value-added activity and provides a level of detail that will let you make improvements in a nonconfrontational mode. The example we discussed is ''If you are currently walking three hundred feet to gather hardware, with a time consumed of three minutes, and we change the layout to place the hardware at a distance of four feet, with gather time reduced to thirty seconds, you have a choice: stand idle for two and a half minutes or use this found time to perform value-added work.'' You're not working harder, you're simply working on different things.

Since our study captured demonstrated activity and discounted activity that did not relate to the ABC manufacturing process, you have a total demonstrated process time that reflects the true process time. The level of detail (task level) also provides your people with the specifics they need to change the process and identifies the corresponding savings potential. If you remove a task, you remove the time. An interesting observation from this process is that the majority of the non-value-added activity is a result of layout—go-gets. This identifies huge potential in a short-term time frame. Questions?

Jack: I find it hard to believe that the difference is so great. What are these people doing with the difference between 190 hours and 105 hours?

Me: I can't give you the specifics on that. We documented each task needed to complete an ABC unit. If an individual left the area or stopped working to engage in any non-process-related activity, our clock stopped. We're engineers, not police officers.

Jack: Fair enough. I'm just surprised at the magnitude.

Me: I spend about half my year engaged in engineering studies, Jack, It's always the same. Most companies never take the time to go to the level of detail it takes to really change the process. You chose to do the work, and now you'll reap massive improvements when you rebalance the process and change the layout of your production floor.

Kathleen: The guys are going to have a hard time with these times.

Me: No, they won't. I've discussed each study with the people in each area. I didn't go over the summary results, but I reviewed the detail of each station study with each individual involved, and ended with the question, ''Here's what you did. If you disagree with any of these demonstrated steps, now's the time to take exception.'' When you follow this format, it's simply a record of what was done. There's no rating, no manipulation of the data; it is what it is. It's very difficult for a person to disagree with this approach, or the results, simply because it is what it is. It's their tasks and times, not mine.

Kevin: What did you see on the materials side?

Me: We consumed the entire bill of materials. There were quite a few part numbers that were being used that never got changed in the bills as your design changed slightly over time, but they have all been corrected as we went by your engineers. You have a clean package to begin your lean implementation.

And so we end this example. I will jump ahead a bit and tell you that this particular company took this study and, working closely with the people on the production floor, rebalanced its assembly bites at takt time, implemented a flow layout with materials at point of use, improved the tools and fixtures in use, trained and put a 5S mindset in place, and implemented kanban systems for replenishment. Inside of two months following the implementation, it was experiencing actual assembly times in the high-80-hour range, down from 190 hours plus. Those are real numbers and real money.

I will restate my beginning message:

Know what you do.

Take the time to investigate the details of your process as you go down the lean path. You cannot change a process; however, you can add, subtract, and change tasks.

CHAPTER 17

SEEKING BALANCE

You've completed your baseline, you've done a lean-engineering analysis, and now you're ready to balance your activity and create your line or cell model. How do you start? There are different ways to accomplish this task. I've seen and worked with various techniques, and they will all take you where you want to go. Will you have a perfect system? No. Will you be on the path to dramatic improvements in your business performance? Absolutely. Let's noodle it around.

When I look at the ways in which different operations structure their processes, I see a common thread in technique. People, for whatever reason, have a tendency to optimize locally, as opposed to across the system. If I were to hazard a guess as to why this is, I would probably point to the most common metric in use today in most companies, the standard costing system. This accounting method focuses on the efficient use of resources as opposed to value-creating activity, and it leads people to focus on the pieces, not the system. When you look at activity across the typical process, you will see balance from one station to the next that looks something like Figure 17-1.

Doing a Task-Level Study

The reason I use the words *hidden imbalance* in Figure 17-1 is that when you observe people working in a batch-and-queue operation,

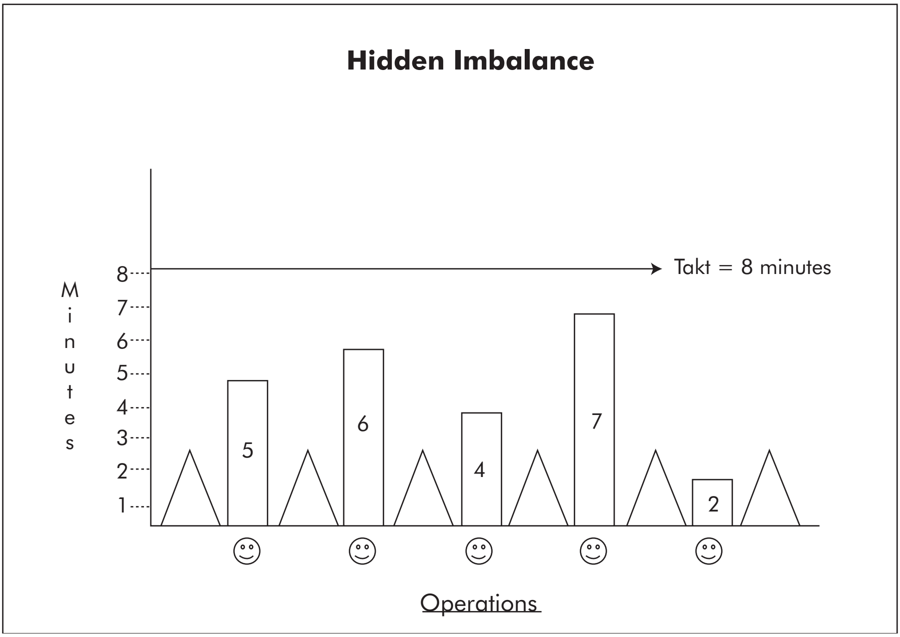

Figure 17-1

you will not observe any idle time. People are surrounded by work in process and are working as fast as they can in their disconnected departments. Only by following a unit through the process with a task-level study can you identify the required work in each area, lay out the sequence, and make the imbalance visible. The classic approach to the situation in Figure 17-1 is to begin at the first operation and fill up that station to slightly below the takt time, then proceed to the next station and do the same. Essentially, you are taking work from the upstream operators and transferring the work downstream.

When you have done a lean-engineering analysis, you have the entire process defined at the task level, and you have further broken down the tasks into elements and determined the time for each activity and each element. You have identified and quantified non-value-added activity. You have identified all materials and tooling usage in the assembly sequence, and you know where all items should be in the process.

The approach I prefer for developing your future-state layout is, as usual, very visual and team-based. Buy a large magnetic wallboard and the thin magnetic cut-up strips that go with this type of board. Write each element on a small magnetic square, along with the demonstrated time to do it. As you work through this step, you should be looking at the non-value-added steps in your engineering analysis and reducing these times in accordance with the goals you have established for improvement. For example, if there are large amounts of time spent on go-gets and your future-state layout is going to place components and tooling at the point of use, by how much will these go-gets be reduced? By 25 percent? By 50 percent? Whatever the figure, put the adjusted, projected time on your element magnet squares. Arrange the entire process on your board, in a linear flow, in this fashion. You will probably have a couple of hundred elements. Establish your takt time and people requirements, and place this at the top of your board.

Takt Logic

Let's digress a bit and discuss takt logic, as we want to all be using the same words. *Takt time* is a term you'll hear frequently in connection with lean balancing theory. (I've heard several differing opinions on the origin of the word *takt,* with the most common being that it is a Swedish word that translates to *time, measure,* or *cycle* in English.) It simply means "the frequency with which your customer consumes a unit of product." Some people define this term as "the amount of time you have to produce a unit of product to meet your customer demand." This is really the same definition turned inside out; use whichever you prefer. The equation to calculate takt time is:

$$\text{Takt Time} = \frac{\text{Available Work Hours}}{\text{Salable Quantity of Products}}$$

It's important to note the term *salable*. If you're producing product that is going to stock, under the definitions used in lean manufacturing, there is no demand, and therefore no product would be produced. The denominator in your equation would be zero.

Designing a process using takt time is the next step. To do this, you must know your customer demand, the actual time required to produce a given unit of product, and your available work hours as used in the takt equation. Let's say that the actual time to produce a unit of your product is 11.5 minutes and your customer demand is 500 units per day. Let's start with available work hours. Your workday is a one-shift operation (8 hours, 480 minutes). You have two 15-minute breaks per shift (30 minutes), a start-up meeting in the morning (10 minutes), and a clean-up period at shift end (10 minutes). Do the subtraction, and you have 430 available work minutes per shift. Your demand, the product you must ship per day, is 500 units.

$$\text{Takt} = 430/500 = 0.86 \text{ minute, or } 51.6 \text{ seconds}$$

Every 0.86 minute you must put a unit into finished goods to satisfy customer demand. So, your takt time is 0.86 minute or 51.6 seconds. The next step is plugging your actual build time into the formula. Your actual build time is 11.5 minutes, or 690 seconds.

$$690 \text{ seconds actual} \div 51.6 \text{ seconds takt} = 13.37$$

You need 13.4 people in this process to produce a unit of product every 51.6 seconds. You can't have 0.4 people, so let's round up to 14. You can have 14 people each building an entire unit in 11.5 minutes, or you can have 14 sequential stations with a 51-second workload; the result is the same. It's your particular product, equipment constraints, and so on that determine how you decide to design the detail.

Streamlining the Process

OK, we're past takt; now it's time to involve your production people. With their close involvement, your lean team is ready to develop the appropriate number of stations, group the task and time content of each, and establish the best sequence of production. I always find elements and tasks that the production people tell me should be done either earlier or later in the process, for ease of manufacturing; now is the time to clean these areas up. With the completion of this exercise, you will have a very well defined process with clearly defined time expectations, one that has resulted from everyone involved in the area having thought out the details and contributed to the design. Better yet, you are basing this process design on observed tasks and times. This is a definite "can do"; there is no subjectivity or estimated data.

If you have a good enough imagination to see a giant magnetic board with 234 element squares arranged in a simulated balanced flow production process, your result will be something like Figure 17-2. You will have a fairly equal work distribution across the required stations and no work in process, and the unnecessary upstream stations will be eliminated.

Let's go back to takt logic for a bit. I see this tool used extensively in the automotive industry, to the point where many people think of it as a Toyota Production System term. Whenever I hear or read about takt time logic, as used by the automotive people, I always hear the term *production smoothing* or *level loading* described as a prerequisite for the successful use of takt theory. It is also pointed out that takt is calculated and maintained for appreciable amounts of time; these people do not recalculate takt every day, or even every week. If your product mix consists of four or five models, run over and over for a long period of time, takt is a good tool. But what if you have hundreds or thousands of models running through a process with an appreciable variation in actual build time? And let's complicate the equation even further by giving you a short-lead-time target and volatile demand patterns. As you can see, the impact of these variables on the

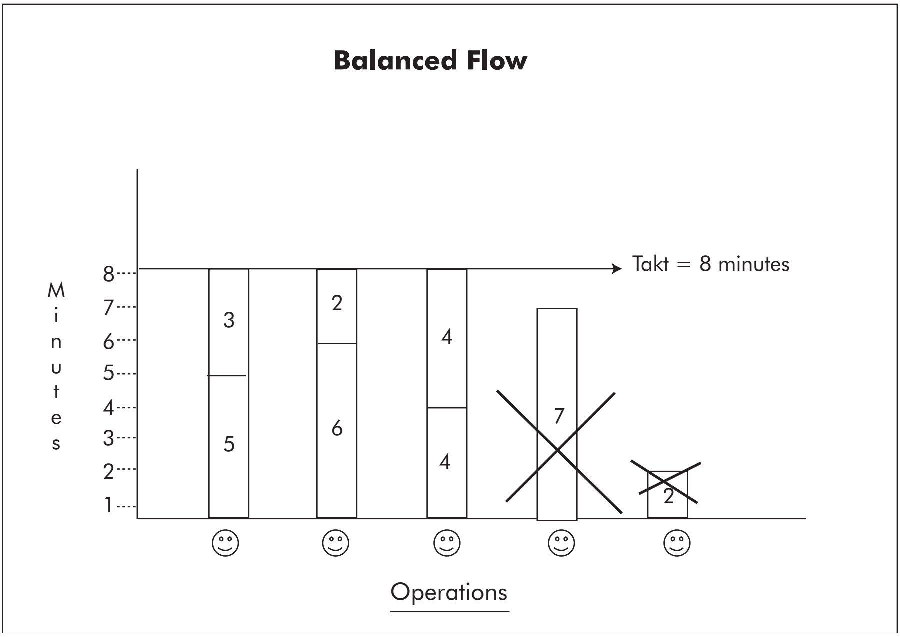

Figure 17-2

formulas used for takt time will lead to massive difficulty in developing an efficient process. As a result, some companies develop a weighted actual for use in designing their process. It's not an exact model, but it's an effective technique.

Using Weighted Actuals

Let's look at a sample routing (see Figure 17-3). This routing shows actual time at the various stations in the current-state process and the resulting total labor hours required, 7.9 hours. You'll notice that some stations are not required on this particular model.

Let's look at a second routing (Figure 17-4) in the same format with a total time required of 11.3 hours.

This process is used for 456 different models with a wide variety of characteristics. We have done an engineering analysis on all the models to define the current actuals. We have used 365 models, which represent 92 percent of the annual volume across this process, to develop the distribution shown in Figure 17-5.

These data are summarized in Figure 17-6.

By multiplying the annual quantities of each model by the station actuals, we get the weighted, current-state, demonstrated actual time across the process to satisfy the annualized mix. This distribution has taken the annual unit requirements and model mix and defined the required time at each station. The current-state distribution looks something like Figure 17-7.

Achieving Balance

Now go on to the next steps. Define your takt by determining target units per day, go to the station studies from your lean-engineering analysis, break down the linear activity into elements, and begin recombining those elements to flatten the distribution. This will give you a line that is balanced against the weighted requirements. This is not an exact science, since your mix can change from day to day and require some variation at the station level, but it will get you on the right path. The best suggestion for handling this potential variation is to provide cross-training to your operators so that they will be able to move to adjacent stations and to plan for a bit of occasional overtime if you get a heavy mix swing for a short period.

Carreira Sim, Inc.					Model #ABC	
LAYOUT ANALYSIS/Routing						
			Std Data	#Ops.	Hourly	
			Demonstrated		Expected	Totals
Element	Activity		(Minutes)		Output	per Shift
10	Station 1		18.5	1	3.2	23
20	Station 2		28.7	1	2.1	15
30	Station 3		19.1	1	3.1	23
40	Station 4		46.8	2	2.6	18
50	Station 5		23.3	1	2.6	18
60	Station 6					
70	Station 7		5.3			
80	Station 8		19.1	1	3.1	23
90	Station 9					
100	Station 10		14.1	1	4.3	30
110	Station 11		15.3	1	3.9	28
120	Station 12		9.3	1	6.5	46
130	Station 13		3.96		0.0	0
140	Station 14		0.9	1	66.7	478
150	Station 15		1.8		0.0	0
160	Station 16		3.98	1	15.1	108
170	Station 17		25.6	1	2.3	17
180	Station 18		30.6	2	3.9	28
190	Station 19		22.6	1	2.7	19
200	Station 20		10.5	1	5.7	41
210	Station 21		5.4		0.0	0
220	Station 22		26.5	2	4.5	32
230	Station 23		31.4	2	3.8	27
240	Station 24		45.46	3.5	4.6	33
250	Station 25		10.9	2	11.0	79
260	Station 26		1.3		0.0	0
270	Station 27		28.3	1	2.1	15
280	Station 28		11.7	1	5.1	37
290	Station 29		13	1	4.6	33
60	473.4	Demonstrated Hours	7.89			
					29.5	Total Direct
					7.167	Hours
7.167					211.4265	Total Hours/1st Shift
Mins/shift	430					
Std Labor Rate	$12.15					
Fringes @ 1.3	$15.80					
					$124.62	**Unit Cost**

Figure 17-3

Carreira Sim, Inc.					**Model #4**	
LAYOUT ANALYSIS/Routing						
			Std Data	#Ops.	Hourly	
			Demonstrated		Expected	Totals
Element	Activity		(Minutes)		Output	Per Shift
10	Station 1		21.7	1	2.8	20
20	Station 2		30.6	1	2.0	14
30	Station 3		19.4	1	3.1	22
40	Station 4		51.5	2	2.3	17
50	Station 5		23.3	1	2.6	18
60	Station 6					
70	Station 7		26.5			
80	Station 8		37.6	1	1.6	11
90	Station 9					
100	Station 10		28.7	1	2.1	15
110	Station 11		15.3	1	3.9	28
120	Station 12		5.6	1	10.7	77
130	Station 13		3.96		0.0	0
140	Station 14		0.9	1	66.7	478
150	Station 15		1.8		0.0	0
160	Station 16		3.98	1	15.1	108
170	Station 17		25.6	1	2.3	17
180	Station 18		30.6	2	3.9	28
190	Station 19		22.6	1	2.7	19
200	Station 20		10.5	1	5.7	41
210	Station 21		5.8		0.0	0
220	Station 22		26.5	2	4.5	32
230	Station 23		44	2	2.7	20
240	Station 24		136.38	3.5	1.5	11
250	Station 25		48.4	2	2.5	18
260	Station 26		1.3		0.0	0
270	Station 27		32.2	1	1.9	13
280	Station 28		11.7	1	5.1	37
290	Station 29		13	1	4.6	33
60	679.42	Demonstrated Hours	11.32			
					29.5	Total Direct
					7.167	Hours
7.167					211.4265	Total Hours/1st Shift
Mins/shift	430					
Std Labor Rate	$12.15					
Fringes @ 1.3	$15.80					
					$178.86	**Unit Cost**

Figure 17-4

A	B	C	D	E	F	G	H	I	J	K	L
Carreira Sim, Inc.											
Distribution Analysis-Gizmo Line											
		Model 1		**Model 2**		**Model 3**		**Model 4**		**Model 5**	
annual qty	3719	Std Data	qty	Std Data	qty	Std Data	qty	Std Data	qty	Std Data	qty
		Demon-strated	24	Demon-strated	24	Demon-strated	35	Demon-strated	24	Demon-strated	26
Element	Activity	(Minutes)		(Minutes)		(Minutes)		(Minutes)		(Minutes)	
10	Station 1	18.5	444	18.5	444	12.1	424	12.1	290	12.1	315
20	Station 2	26.8	643	26.8	643	26.8	938	28.7	689	26.8	697
30	Station 3	18.8	451	18.8	451	20.7	725	21	504	20.7	538
40	Station 4	41.8	1003	41.8	1003	64.4	2254	64.4	1546	64.4	1674
50	Station 5	23.3	559	23.3	559	23.3	816	23.3	559	23.3	606
60	Station 6	9.5	228	9.5	228		0		0		0
70	Station 7	33.8	812	9.5	228	27.3	957	27.7	666	27.3	711
80	Station 8		0	9.5	228		0	31.8	763		0
90	Station 9	14.8	355	9.5	228	14.8	518	39.3	943	14.8	385
100	Station 10	3.3	79	3.3	79		0		0		0
110	Station 11	12.4	298	10.6	254	14.8	518	51.6	1238	14.8	385
120	Station 12	15.3	367	15.3	367	15.3	536	15.3	367	15.3	398
130	Station 13	5.6	134	5.6	134	5.6	196	5.6	134	5.6	146
140	Station 14	4	96	4	96	3.96	139	3.96	95	3.96	103
150	Station 15	3.96	95	3.96	95	0.9	32	0.9	22	0.9	23
160	Station 16	1.8	43	1.8	43	1.8	63	1.8	43	1.8	47
170	Station 17	3.98	96	3.98	96	3.98	139	3.98	96	3.98	103
180	Station 18	25.6	614	25.6	614	25.6	896	25.6	614		0
190	Station 19	30.6	734	30.6	734	30.6	1071	30.6	734		0
200	Station 20	22.6	542	22.6	542	22.6	791	22.6	542	63.2	1643
210	Station 21	10.5	252	10.5	252	10.5	368	10.5	252	3	78
220	Station 22	5	120	5	120	11.1	389	11.5	276	11.1	289
230	Station 23	26.5	636	26.5	636	26.5	928	26.5	636	26.5	689
240	Station 24	25.4	610	25.4	610	29.3	1026	64.4	1546	51.6	1342
250	Station 25		0		0	45.5	1591	181.8	4363	45.5	1182
260	Station 26	6.7	161	6	144	12.0	420	66.2	1589	12.0	312
270	Station 27	1.3	31	1.3	31	1.3	46	1.3	31	1.3	34
280	Station 28	24.6	590	24.6	590	24.6	861	28.3	679	24.6	640
290	Station 29	11.7	281	11.7	281	11.7	410	11.7	281	11.7	304
300	Station 30	13	312	13	312	13.0	455	13.0	312	13.0	338
Demonstrated Hours		6.79		6.71		7.88		13.30		7.87	
Annual Qty		24		24		35.0		24.0		26.0	
Annual Hours		162.96		161.04		275.8		319.2		204.62	

Figure 17-5

	Model 365							
qty	Std Data	qty						
208	Demonstrated	269		Annual Mins Req		Min/Dist		
	(Minutes)							
848	18.5	4977	Station1	54768	Station 1	20.9	1	20.9
970	26.8	7209	Station 2	73288	Station 2	27.9	1	27.9
973	18.8	5057	Station 3	48580	Station 3	18.5	1	18.5
734	41.8	11244	Station 4	125608	Station 4	47.9	3	47.9
846	23.3	6268	Station 5	61139	Station 5	23.3	1	23.3
846		0	Station 6	6412	Station 6			2.4
846	24.3	6547	Station 7	62969	Station 7	24.0		24.0
102		0	Station 8	12095	Station 8			4.6
950	12.5	3363	Station 9	47998	Station 9	18.3		18.3
0		0	Station 10	356	Station 10			0.1
744	10.6	2851	Station 11	42585	Station 11	16.2		16.2
182	15.3	4116	Station 12	40147	Station 12	15.3		15.3
165	5.6	1506	Station 13	14694	Station 13			5.6
24	4	1076	Station 14	10427	Station 14			4.0
87	3.96	1065	Station 15	5091	Station 15			1.9
74	1.8	484	Station 16	4723	Station 16			1.8
28	3.98	1071	Station 17	10444	Station 17			4.0
325	25.6	6886	Station 18	61696	Station 18	23.5		23.5
365	30.6	8231	Station 19	73746	Station 19	28.1		28.1
701	22.6	6079	Station 20	68836	Station 20	26.2		26.2
184	10.5	2825	Station 21	25947	Station 21	9.9	1	9.9
123	5	1345	Station 22	16263	Station 22			6.2
512	26.5	7129	Station 23	69536	Station 23	26.5	2	26.5
531	25.4	6833	Station 24	96954	Station 24	36.9	2	36.9
682	22.74	6117	Station 25	135931	Station 25	51.8	4	51.8
496	5.8	1560	Station 26	34841	Station 26	14.6	1	13.3
270	1.3	350	Station 27	3411	Station 27			1.3
886	24.6	6617	Station 28	69064	Station 28	26.3	1	26.3
434	11.7	3147	Station 29	30701	Station 29	11.7	1	11.7
704	13	3497	Station 30	34112	Station 30	13.0	1	13.0
								511.6

Figure 17-6

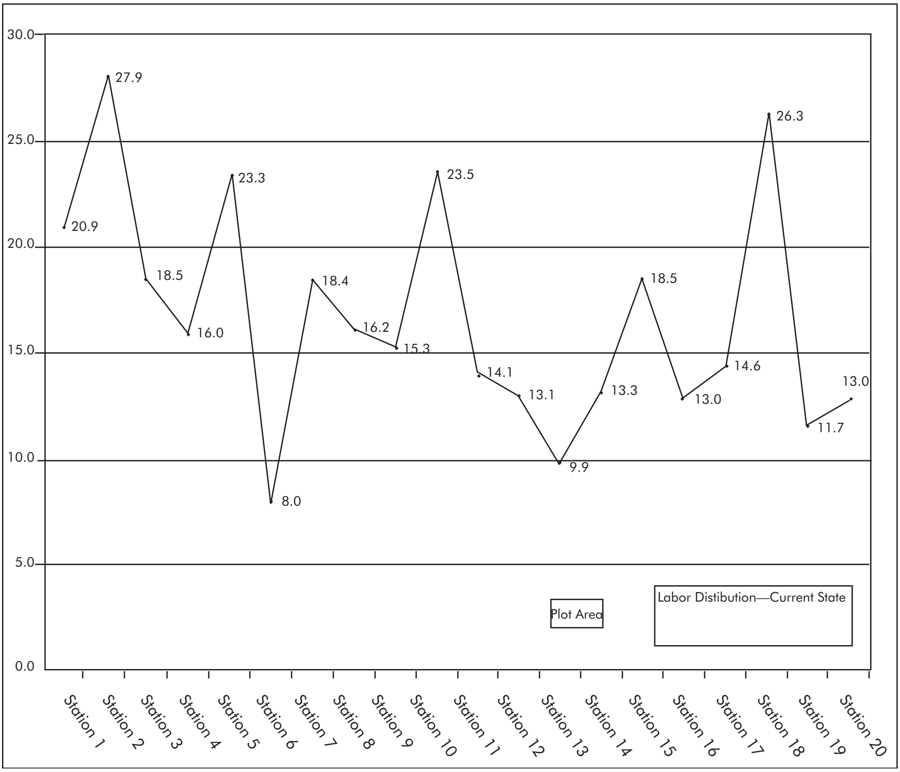

Figure 17-7

Let's look at another scenario. You run thousands of different machined parts, and your facility is composed of forty or fifty islands—various types of machining, balancing, broaching, gear cutting, painting, and so on. You have no industrial engineers on staff who spend time on process definition or distribution analysis; your focus has always been on machine utilization, not people utilization. Your people (machinists and assemblers) know what the cycle times are for various parts and what it takes to do the work, but you have no database and no inclination to spend the time and money to develop one. You have the best equipment, the most highly skilled machinists, and the most technically competent toolmakers that money can buy, but you have never had much use for all those fancy systems, computers, and such.

You have baselined a product family that makes up a large percentage of your volume, and you have identified huge opportunities with regard to lead-time compression, inventory reduction, and people utilization. You're interested in going lean, but you want to put that pilot cell in place and see that it works before you commit to the entire project. You simply can't seem to develop a clear definition of what your takt time is, but you have a large amount of available capacity on the off shifts, and you are satisfying all of your current customers with your as-is business. You are clearly from Missouri.

Let's build you a cell. Here's the concept: We get a team of process experts together and sketch out the concept pilot cell, with the required equipment. Our experts balance machine cycle times to give us good machining balance as we build a unit, start to finish. This also gives us the target throughput time of a middle-of-the-road, plain-vanilla unit (the 80/20 rule) based on optimized machine cycle times. Let's call our target time 2½ minutes, based on our highest machine cycle. We then introduce our first associate and walk him through the preliminary activity as defined by our experts. Get the first part, load the first machine, walk to here, inspect this characteristic, and so on. When the first associate has been assigned 2½ minutes of activity, we add a second associate. In this fashion, we balance our equipment against the high station and balance our cell people inside of the time window. We top this off with defined materials entry and exit from the cell and with specific locations and sequence logic for parts as they flow through the cell.

This cell is locked, loaded, and pretty well balanced. If your current people utilization sampling puts you at 38 percent touch time and this proposed cell takes you to 85 percent touch, you've reduced your labor requirements to get the same amount of parts that you're currently getting by almost 50 percent. If your current plant throughput is four weeks, you might see how to get an average order through the shop in six hours. You haven't used the classic tools recommended in the lean handbook, but you've put a high-velocity, worker-balanced cell in place.

I've seen this approach used many times with the first experimental cell, with great results. Lean is a continuous-improvement mindset, so don't feel bad about starting out with a less than textbook implementation if you are resource-poor. The important thing is to think it out to the best of your team's ability and get going now. I call this approach an "MBR" event, which stands for *Missouri Boat Ride*. It brings to mind an old Zen saying: "Leap, and the net will appear."

CHAPTER 18

THE 5S SYSTEM

Much to-do has been made about the 5S system. There are those who think that 5S is just a fancy housekeeping program. On the other end of the spectrum, there are those who think that 5S is lean. I was sitting in an airport one Friday evening and the guy next to me struck up a conversation. He was questioning me on what I did, and I told him I worked with manufacturing operations.

"I help manufacturing companies become more profitable. We specialize in lean/JIT manufacturing philosophy and systems."

"Oh, yeah, I've read about lean; some of our divisions are going to lean. You do that 5S thing, right?"

"That's right, I do the 5S thing."

"What time's your flight?"

I enjoy the opportunity to visit and walk through many different companies. As I walk through various facilities in various stages of disorganization, when the topic of 5S comes up, the standard response from management is usually something like, "Yes, we are well into 5S; we've been undergoing events for about eight months now." As I look around at inventory filling every available space, with half the people I observe being in motion, going somewhere to find something, I usually just answer with a polite "I see; that's good." If I end up becoming more involved with a company like this, and I reach the point where I am working with the people on the manufacturing floor, I always ask the question again.

Me: So, Jimmy, you guys have been implementing 5S for about eight months now? Where are the areas that you've 5S'd?

I'm usually led to a corner of the shop or an out-of-the-way assembly area where a couple of benches or racks have been set up with components or tooling. The items have been somewhat arranged, and a numbering or identification system has been started.

Jimmy: We started arranging the tooling and dies for cell 5. We have a guy on second shift in the experimental machine shop who is a pretty good welder, and he started putting together some custom racks for us.

Me: This is it, huh? What started the 5S project here in your shop?

Jimmy: Our vice president of operations, Harry Smith, had an efficiency consultant come in to show us where we could improve the operation. He looked around for a couple of weeks, and his conclusion was that if we did 5S, we would be more efficient.

Me: As easy as that?

Jimmy: Yep.

Me: Where'd you begin? How'd you know where to start?

Jimmy: The consultant spent three weeks putting everyone in the shop through training. He showed us some videos and talked about the program—you know, sort, shine, all that stuff. Everyone went through a two-hour session in the main conference room.

Me: Sounds like an OK start. What happened then?

Jimmy: Then Harry got all his staff guys together and told them to roll it out across the shop, make it happen.

Me: And?

Jimmy: Rolie Franks, our production manager, put together a Gantt chart of all the departments and gave it to me. He said, ''Here's the timeline; make it happen.''

Me: You're in charge of maintenance, right?

Jimmy: Yes. I've got eight guys on the first shift, four guys on the second shift, and two guys on the third shift. We cover maintenance for the facility, and we have to keep all the machines in production going. I really could use a couple more people, but they're always crunching the budgets, and my people always seem to be on the top of the cut list. Indirects get hit before direct people.

Me: Yeah, I know the game. So what do you think about this 5S project?

Jimmy: It's just another project on my list. I do a little when I can, but it's usually the day before my boss has to write his monthly report. The heat gets turned up then because he needs to include a 5S update in his monthly. We throw some stuff together, and he's got something to write about. Then I go back to trying to keep production going until the next report is due. It's been fizzling out the last couple of months, so maybe they'll come to their senses and stop the busywork and let us get on with our real jobs. Those guys up front seem to have too much free time. There's always a program of the month going through here: TQM, SPC, you name it. Usually it's a big whoop-de-do: Throw up some charts and graphs, write a bunch of reports to corporate, then after a couple of months it dies down and we go to the next program of the month. Some of the folks on the floor think it's funny, but they don't get stuck in the middle with doing it like I usually do.

And there you have it: Another 1S in the works.

Unfortunately, I see this a lot: a well-intended vision from the tower, an ill-defined communication plan, lots of delegation to make it happen, with inadequate resources, no budget, an unrealistic implementation plan, and little follow-up, with the exception of lots of reports written in the front office. If we wait patiently, it will go away.

It seems that everyone is talking about 5S, but very few companies are actually implementing the total system successfully. In viewing the common approach, I am convinced that there is a fundamental disconnect in understanding what the essence of this system is really about.

So what is 5S, and, more important, why should we take the time to do it?

The 5S system is a tool, or system, that supports a philosophy of operating. The philosophy that this system supports is one of discipline, efficiency, and attention to detail.

Promoting the Right Work Environment

When I walk through a facility, what I see tells me everything I need to know about the company: the attitudes of the people who are running the company and who are employed by it, the levels of product and partnership quality I can expect to see, the timeliness of the company's deliveries, the competitive position of its pricing, and, in general, what type of a business associate it will be. If the environment is cluttered, disorganized, dirty, and unsafe; machines are oil-covered and have drip pans under them with pig rolls of sawdust stacked against the pans; air lines are on the floor, running across walkways; stuff is in disarray everywhere; workbenches are piled high with parts and tools; assemblers are rummaging through toolboxes looking for a needed socket or hand tool; there are no discernible identifiers for location or description; and lots of people are in motion looking for items and there is no clear flow to their process; I generally form the immediate opinion that this is a "close enough" environment. The company does not consider attention to detail to be important, which will result in unsafe working conditions; poor, inconsistent quality; unacceptable on-time delivery performance; and excessive cost in the system, which the company will inevitably pass on to me. In addition to its pricing, the company will face much disruption and additional cost dealing with quality and delivery issues, which may have a serious impact on its relationships with its customers. The attitude that this type of environment fosters in its people is one of "close enough is good enough." This is not a professional organization; these guys are just fooling around. They are telling me who they are and what they are about. I don't care what their words say, the environment that they create is who they really are. Do I want to partner with these guys? I don't think so; give me a call when you get your act together.

When I walk through a company that is at the top of its game, I see a spotless, well-lit, extremely organized workplace. All equipment, machines, and workbenches are clean and painted; all lines and cables are dropped from the ceiling to points of use; there are no trip points, no liquid spills, no flood pans, no oil leaks dripping on the floor. All materials on the floor are clearly labeled. There are floor shadow boxes painted showing the exact locations where things are to be put and descriptions of what goes where. All tooling is at the point of use, with shadow boards showing what and where. At workstations, all materials, fasteners, and hand tools are within the strike zone and within easy reach. Visual "best practice" instruction sheets are hung at an easily visible level, where needed, describing safety, quality, and assembly "need to knows." I can see the flow of product through the facility. Whiteboards are in place at each cell, and up to date, showing metrics, production targets, on-time information, quality metrics, and improvement projects that are underway—who, what, and when. I see cross-training whiteboards listing operations and individual levels of attainment throughout the shop. Everything does indeed have a place, and that place has been very clearly identified—to the level of detail that if I need to set aside my broom, there is a shadow board and hanging clip for it.

As a stranger to the operation, I can walk through and understand what is being done and where things belong, and, more specifically, I can immediately spot an out-of-standard condition. A tool is missing; I can see the shadow, but there is nothing hanging there. A skid of materials is sitting in a location that has no corresponding floor box painted and labeled. To some people, this level of detail seems unnecessary and a bit overmuch. To me, it tells me who these people are and what they are about. These people are professionals, they are extremely good at what they do, and they are paying very close attention to everything. There is no level of activity so minor that they consider it to be unimportant. Nothing, and I really mean *nothing*, is left to chance or assumption. All facets of their business are well thought out and very visual. The variation in their processes and in the techniques of their people will be extremely minimal. Their employee safety record and product quality will be superb, based on a task-up mentality, and they probably won't know what a final inspector is. Their on-time delivery will be exact, they will never make a promise that they can't keep, and their cost will be extremely competitive. Do I want to partner with these people as I compete in a global marketplace? You bet. Partnering with a company like this will make me stronger. Close enough is not good enough.

I may be overstressing this message, but this is the message you are delivering to your vendors, your customers, and your employees and work associates. In the very best companies, there is no compromise, and 5S is one system that is utilized to promote this type of work environment.

Setting Effective Standards

Manufacturing is a game played in seconds. At the end of the day, if you've experienced a problem that has caused rejects and wasted materials, you can see it. You'll see a container full of rejects; you can count them and touch them. At the end of the same day, all issues that have caused you to waste time are in the past; you cannot see a container full of wasted time. Wasted time is invisible, untraceable, gone forever, and most likely to be repeated the next day. The hidden enemy in a manufacturing process is variation, and the shortest path to controlling variation is to establish standards. This takes us to the question, what's a standard, and how do we implement standards? In simplest terms, a standard is something that tells us how to do something. Here's the way to do it, every time. From a pragmatic point of view, the most effective standards are easy to use, simple and concise, and very visual. In an environment without standards, everything is undefined and subject to interpretation. When you do something, you have the opportunity to first spend some time figuring out the way you're going to do it today; maybe you talk to some other folks about the way they might do it, and then you actually do it. Lots of effort, lots of time spent, lots of room for infinite variation.

A stoplight is a good example of an effective standard: It's very visual, everyone knows exactly what it means, and it's the same every time. No interpretation is needed; just do it. Green means go; red means stop; orange means prepare to stop (or go really fast, if you're in Cleveland). Try driving through Manhattan at rush hour on a Wednesday afternoon when all the stoplights are out. It's a chaos environment, out-of-control variation. You'll probably get home eventually, but your car will be dented and it will take you five hours longer than normal. When you pull into the market parking lot, there are standards that tell you specifically where and in what orientation to place your car, and let's not forget the spaces with the wheelchair symbol for people who need the location closest to the building. When you get inside the market, the aisles are labeled with large hanging signs (standards) to show the location of products; the check-out counter has a standard for ten items or less, or no checks, cash only, and on and on. It's very visual and very clear: Do it the same way every time. So why is it so tough to do this at work? There's no time; we're too busy; gotta make the numbers.

And so, on to the five Ss. They stand for:

1. Sort
2. Set in order
3. Shine
4. Standardize
5. Sustain

Prior to implementing this process, it is essential that top management be on board and firmly in the driver's seat. I've seen management teams that were in the process of implementing this type of philosophy, but that had key individuals who thought that they weren't really involved: "It's a shop floor thing." Not so; it's a company mindset. When you see an office with three years' worth of reports and memos strewn across the top of someone's desk, this is an unacceptably cluttered and dirty condition; 5S it. I've heard executives ask questions like, "If we invest in this program, exactly what can we expect as a return? Will efficiency improve by 5 percent? by 12 percent? We need to know the numbers before we proceed." The top guy in the company needs to sort these people out, or forget it; don't waste your time. Keep doing things the way you're currently doing them. You must have a totally committed team. You can do it or not, but you can't kinda do it. The message has to be clear and uncompromising to every employee in the company. Here's what we believe in; here's what we're going to do; we will be successful. Period.

Implementing the Model

That being said, OK, management is driving the process, you've communicated to everyone where you're going; where do you start to "do it"? If you're working through this book with the intent of putting your first cell in place, that's an excellent place to start. If not, pick a small department or area. Either way, I like to implement a model.

When you begin a new way of doing things, people have no idea what you really mean. They understand your words, and they get the concept, but they don't really know what it's going to look like. It's like describing what an orange tastes like to someone who has never tasted an orange. "It's kinda like a lemon combined with a pineapple." A person can envision what having a slice of lemon and a slice of pineapple in her mouth would taste like, but she still doesn't know what an actual orange tastes like. The only way to "really" describe it to her is to hand her a slice of orange and say, "Here, taste this." When she does that, she'll understand what an orange tastes like, but not until then.

Back to the model approach. When you do your first area, you should implement the entire package, all five Ss, and you should complete it to the smallest detail in that area before you even think about going to a second area. The logic is, you want a completely organized and visually immaculate area (new mindset) in the middle of your old, dingy, disorganized plant (old mindset). You want an oasis of clarity and order, if you will. This will have the same impact on your organization as turning on one bright light in the middle of a large, dark cavern. It will get lots of attention, lots of sizzle, lots of people approaching the team and asking if their area can be next. Once you have implemented the complete process on a small scale, just do the same thing over again, twenty-three more times. Your entire company can see the end results that are expected, everyone's interest and energy levels will be quite high, and you'll have a core team trained to assist the remaining areas of your company.

The 5S System in Action

S1

The first step is the *sort*. Gather the people who work in your pilot area and have them remove everything from the area that is not required in order to do the work in that area. The identification tool here is the "red tag" (see Figure 18-1).

Designate a red-tag area and rope it off. Complete the information and attach a red tag to all items that are not needed to meet production requirements in that area. Remove those items to the red-tag area. This is a quarantine zone. Name a team composed of the appropriate people to deal with all items in the red-tag zone, the appropriate people being those individuals who know what this stuff is, whether it is needed anywhere else in the company, and whether it will *really* ever be used again. If you're dealing with capital assets, don't forget to include a member of your accounting staff to ensure that the correct procedure is followed. The timing of the disposition

Cell/Area	**RED TAG**	Tag Number
Category (circle one) 1 Raw Mat'l 2 WIP 3 Finish Mat'l 4 Tools 5 Supplies	6 Equipment 7 Furniture 8 Office Mat'l 9 Books/Mags 10 Other	
Tag Date		
Item Name		
Quantity		
Reason Tagged		
Disposition Required (circle one) 1 Discard 2 In Cell Storage	3 Long Term Storage 4 Reduce Inventory 5 Sell/Transfer 6 Other	
ACTION TAKEN	**DATE**	
Cell/Area	**RED TAG LOCATOR**	Tag Number
Location		
Description		

Figure 18-1

is up to you, but don't sit on this stuff forever. You should measure what has been removed so that you can define the improvement impact—how much floor space was made available for additional production, and so on. Before-and-after photos on a 5S board are a great communication tool for the rest of the operation. Jazz it up a little; you know the game. You will most likely have an impressive pile of stuff. Over time, in most undisciplined workplaces, people tend to collect everything, just in case they might need it someday. Nothing is ever thrown away.

When you've completed the first S, you should have a work area that contains only those items that are required to do the job. No clutter, no noise.

S2, Set in Order

The next question is, "We've got all these items remaining that are needed to do the required work; where does everything belong? What is the best location for this stuff?" And on we go. I have a decided preference for flexibility and things that you can touch and move when I play with layouts. There are many ways to accomplish this task; go with what you like, but I like paper dolls. Maybe it's because I have so many daughters, who knows? Recruit the assistance of one of your computer kids, someone who is quick with AutoCAD, and have him join the team. If you don't have anyone in your company, hire a temp for a few days; it's worth it. Have a scale drawing made of the area and it's perimeters. The drawing needs to include the details of things you can't move, like beam locations, and if you have any monuments, include those. A monument is a piece of equipment that it is impractical to consider moving: a monster stamping die, a furnace in a foundry (200,000 pounds of liquid metal, 2000 degrees, etc.). If you're dealing with machines, make sure you have the seams in the floor identified so that you can footprint equipment without straddling a seam. And have your CAD person put a grid over the empty area (1/8 inch to a foot gives you a nice large working paper) so that you can visually count the boxes and see distance, as in Figure 18-2.

Next, have your CAD person draw everything in the area, right down to the trash cans, to the same scale, as in Figure 18-3. Glue this paper onto some construction paper to give it some weight, and cut out every item with scissors. Glue the scale layout of the empty area to a big piece of cardboard to give it enough depth to put a stick pin in. You now have a scale layout of your area with a visual grid showing your distance, and you have every item in the area as a separate paper doll, also to scale. You can put the pieces down, slide them around, play with the layout, and pin items to the grid when you want to hold them. So you now have the area, empty, with a visual grid, and all the items that go in the area as separate templates. What's left?

Now we come to the materials piece. This piece is worth some

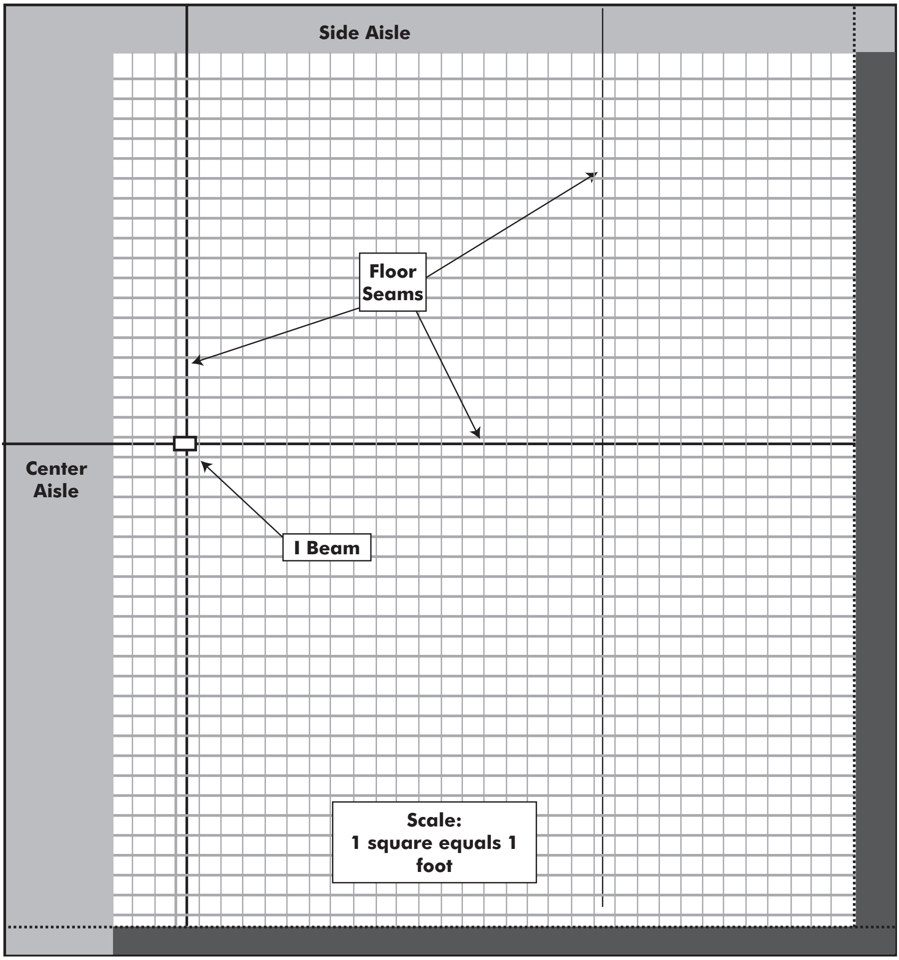

Figure 18-2

thought. I suggest that you look at the materials required at each step in the process, determining how many parts you want at the point of use and designing some custom racks. Again, it doesn't need to be elaborate; an angle iron frame with plywood shelf construction works just fine. To do this, you'll need to look at the size of your components, define how frequently you want to replenish this area, and cube up the required space for each part number. This activity fits in nicely with kanban sizes if that's where you're going. At any rate, Figure 18-4 gives you the idea.

This rack was cubed for one shift of production parts. It takes about 24 square feet, and it replaced rolling flat racks that used a

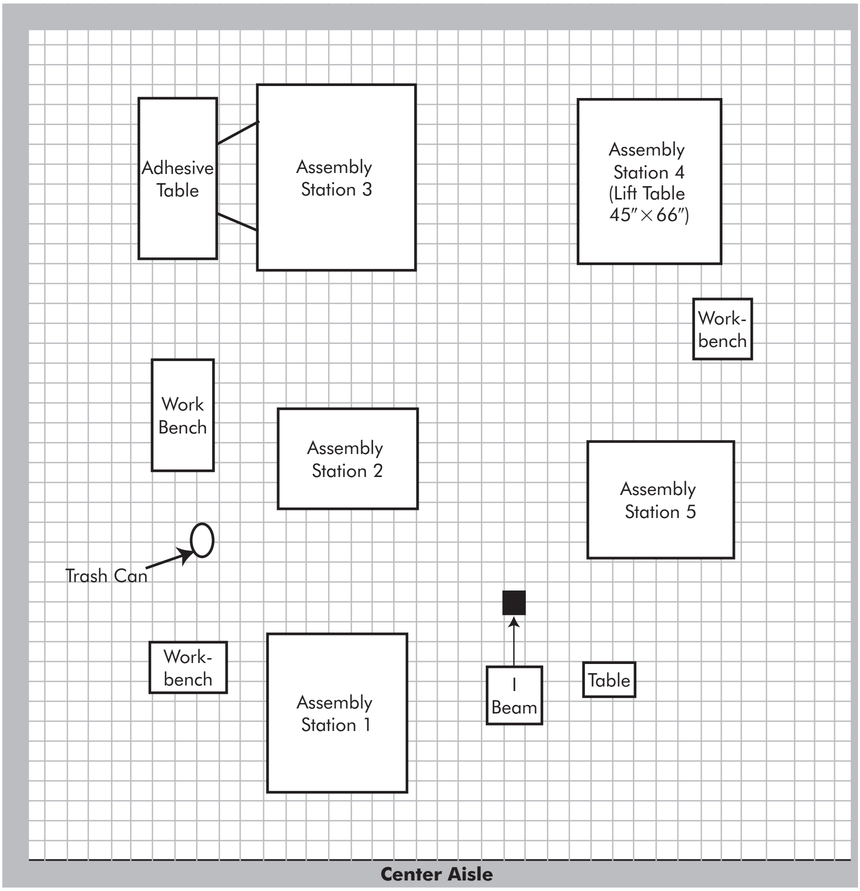

Figure 18-3

space of approximately 40 feet by 20 feet (800 square feet). It's located directly beside the operator's station, so that getting all components needed for this particular assembly takes only a few seconds.

Figure 18-5 gives another example of the same idea. In the original layout, parts were at floor level with no cubing logic. Storage was reduced from 300 square feet of parts to about 16 square feet, with a reach of a couple of feet for the operator, as opposed to walking through twenty-five or thirty floor carts to gather components. I'll remind you that most people spend about half of their day building product and the other half of their day getting things. A couple of minutes here, a few seconds there. When you design the area, you lock in the amount of waste that will exist, permanently, or until you redesign it again.

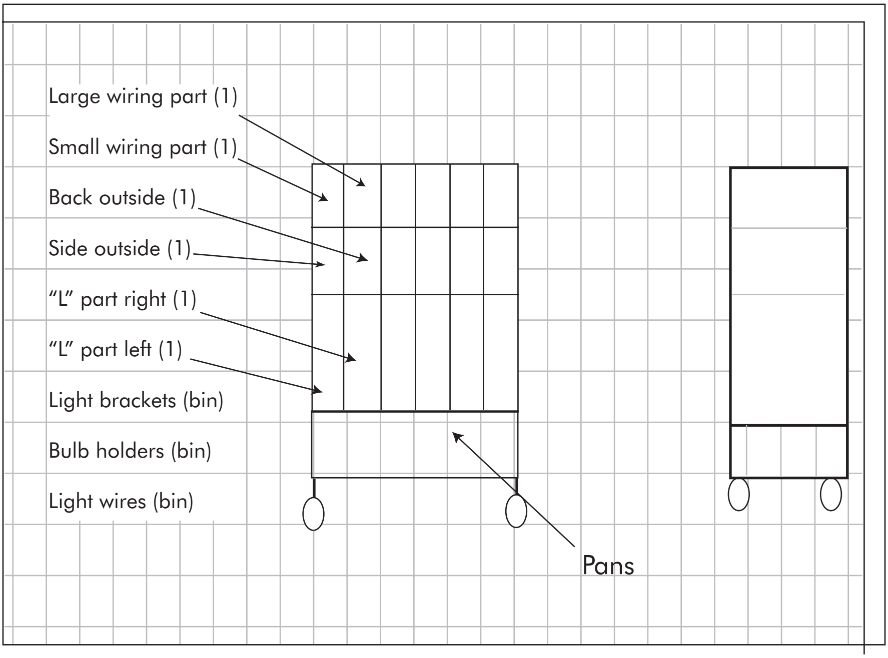

Figure 18-4

Take a look around your facility at all those big slogan posters hanging everywhere that say "do it right the first time!" This is the place to practice what you preach. Enough said. So you have cubed your defined quantity of materials and designed custom racks at point of use. Draw them to scale, cut out the templates, and add them to your layout paper dolls. Now have your area team put everything into the area and arrange the sequence of activity (see Figure 18-6).

When a team has these kinds of visual templates to work with, there's usually not a lot to disagree about; the shortest path wins. The shortest distance means the shortest amount of time spent. When your team has the layout the way it wants it, take the view down to the level of tooling. How do you orient your parts on the various stations? Mark up the tables. Where do you need an air driver? Show the location on the layout and make a note for maintenance to add a holster for your driver to that table at that location. What fasteners do you use and where? Make a note for maintenance to attach small bins for these fasteners. You don't want to bump into these bins every time you walk by, but you do want them under or over your work area, at the point of use. If you need to reach more

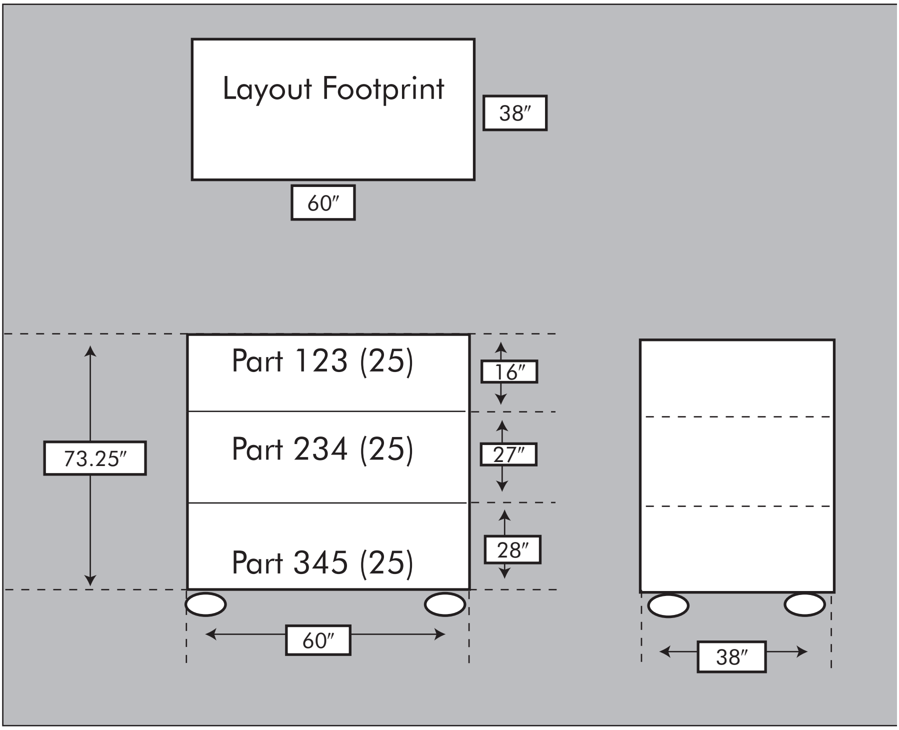

Figure 18-5

than a few inches for a tool or a fastener, you haven't thought out the details. Seconds count. Where do you need power or special lighting? Where do you want your cleaning shadow boards for brooms and cleaning supplies, trash cans, coat rack? Include everything you need to the smallest detail. Mark the drawing.

If you're going to your first cell and you're following my lead, you'll have done a lean-engineering analysis and you'll know the exact sequence of activity and everything that is required to do the work: tools and materials. If not, back to the one step at a time method. This step requires ruthless definition of what is really required and what is not. If someone insists that he needs an item, have him show the team exactly where and how it is used in the process. You'll bring in workbenches as required; you'll bring in the parts to make one assembly; you'll simulate the work being done and bring in those tools and fixtures that are needed to complete the sample assembly, one tool at a time. If the first step in the process is to assemble three components with eight screws, you'll bring in those

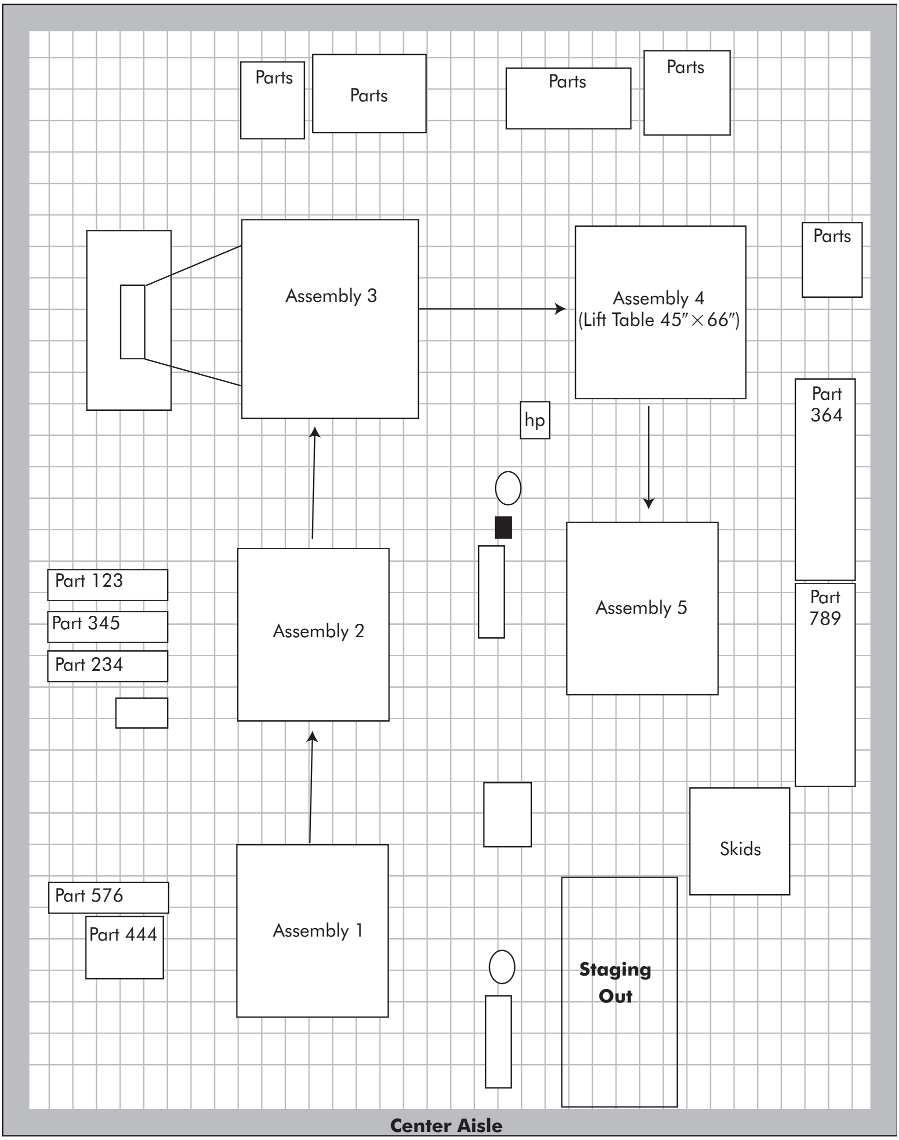

Figure 18-6

three components, eight screws, an air driver and the specific screw bit that drives those eight screws. You will not bring in a toolbox filled with eighty-six different tools, twenty-seven wrenches, thirty-three sockets, twenty-seven different size bits, and the special hammer that you got from your grandfather.

When you get through this exercise, you are approaching the end of the set in order step. The last thing you have to do is give your marked-up working templates back to your CAD person and have her lock everything in—all the items required; locations for air, power, lights, and so on—to that you have a completed drawing of the area. Now you're ready to pull the trigger. Move everything to the designated location, fine-tune as necessary, and tape and label the floor to locate every item in the area. Empty the area back out, give your updated drawing to maintenance, and have it run the drops.

S3

While this step is being done, I like to go to the third S, "shine." Paint the floor, paint and label all locator boxes, clean and paint all items being brought into this area, bring all machines and equipment to like new condition (this is the inspect piece), and apply a fresh coat of paint (see Figure 18-7).

Now we'll jump back to finish the second S, "set in order." Put

Figure 18-7

everything in the designated locations, and you've set things in order. You've also created what looks like a brand new business in the middle of your old business. It'll be a startling contrast and receive a lot of attention.

S4

The fourth S, "standardize," is already well under way, as you can see. What's left to do in this step is the fine tuning. I won't dwell on this one; we've already discussed standards. The mission is, everything should be labeled and identified. You should have a color-coding system that will be universal across your entire operation; use one of the conventional systems or make up your own. Your visual standards should tell you what goes where, who does what, when, and how, to the smallest detail. Where do I put my mop? See Figure 18-8.

Where do I put my tools? Here (Figure 18-9)? No, no.

How about here (Figure 18-10)? That's a yes.

Here's another yes (Figure 18-11).

Figure 18-8

Figure 18-9

Who is responsible for cleaning what areas? Refer to the cleaning matrix and layout drawing on the area information board. What materials go where? Refer to the floor boxes, or hanging locators, or cubicle part number tags on your custom racks. Is the way it is done in Figure 18-12 okay?

No.

How about Figure 18-13?

Another no.

You want it more like Figure 18-14.

Or like Figure 18-15.

Figure 18-16 shows a good one, a subassembly fastener area arranged in sequence of use, by unit.

How do you do the work? Refer to the pictorial work instructions hanging at each station. Safety and quality instructions? Refer to the same pictorials. You get the picture. A "perfect" 5S will allow you to bring an individual who has never been in your facility into the area, and that person will understand what is required and will be able to complete an assembly using your standards. And I do realize that perfection is difficult to achieve in real life.

Figure 18-10

S5

So, now it's on to the fifth S, "sustain." This is a tough one. Some people like slogans, contests, walk-arounds with gifts or tokens of appreciation. Whatever your personal flavor is, go with it. But the fundamental driver is communication and training. You can't overtrain or overcommunicate. Communicate and communicate, and when you're done communicating, communicate some more.

You're only going to get one first chance to deliver your message; make the most of it. Close enough is not good enough. If you're going to do something, do it with some passion. Sail into port with all sails up! If your passion is genuine, you'll find that it's infectious. People will sign up, and you'll succeed.

Figure 18-11

Figure 18-12

Figure 18-13

Figure 18-14

Figure 18-15

Figure 18-16

CHAPTER 19

Setup Reduction

Setup reduction is a game best played with an empty mind.

As you prepare to implement your first flow cell, there are a few speed bumps that come to the surface immediately. In a disconnected batch operation, when you have a quality problem, you simply go work on something else until it is resolved. When you change over a machine or station, everyone around you can continue to stay busy; when you have a breakdown, you just move the work and the people to another area until you get the equipment running again. There are lots of places to hide all of your problems; they almost become invisible. When you link together a series of machines or assembly stations, it's a whole new game. Any issue that consumes time or delays the flow will shut down the entire sequence. Everybody is out of work, there is no production going on, and the visibility is excruciating.

The bad thing about lean flow is, there's nowhere to hide. The good thing about lean flow is, there's nowhere to hide.

Setup reduction is at the heart of batch sizes and velocity. If your setups are long and difficult, you'll want to amortize them over the largest run size you can afford. Most companies make a great deal of effort to figure out a way to batch like orders together over the course of a week or a month, or to build to stock or forecast to increase runs. This effort is misdirected, in that we are focused on the effect and not on the cause. We discussed EOQ logic earlier, with setup times being the primary driver in determining size of runs. And so, as your setup times go, so goes your ability to approach the theoretical one-piece flow model.

I've often read the statement that any setup in a nonlean facility can be reduced by 50 percent without a great expenditure of capital; all it takes is some attention to detail and some creative analysis. I am involved in a great many setup events, and I can say that this is definitely the case. I can also say that in working with some very good people, I am constantly surprised by how difficult it is for most teams to perform an effective setup analysis. With that being said, let's walk through an actual setup scenario and see where it takes us. The example I'll use is based on real events or a combination of events, with names and details changed to protect the innocent, as Jack Webb would say

Let's look at a machine tool changeover; it could be in any company, for any product. As always, I prefer an event format, with heavy involvement from the people who actually work in the process and their support counterparts in technical roles: programmers, manufacturing engineering types, and so on. I generally schedule a three-day event with the following agenda.

ABC SET UP REDUCTION EVENT
OCTOBER 10–12, 2001

The following is a list of participants and a schedule for the setup reduction event at the ABC machining cell. Let me know if there are any conflicts with the chosen dates.

Thanks,
Bill Carreira

Participants:

Jim Atson	Machinist, first shift
Mike Kelly	Machinist, second shift
Scotty Thomes	Quality engineer
Dave Garlock	Machinist, third shift
Linda Cook	Programmer
Bill Markum	Manufacturing engineer
Billy Crisco	Tooling engineer
Jackson Sykes	Maintenance
Mel Hubert	Supervisor, Machining first shift

Day 1, October 10

1. Setup reduction theory discussed.
2. CNC changeover theory discussed and training video viewed.
3. Changeover filmed.
4. Process analyzed for internal/external and non-value-added activity.

Day 2, October 11

1. Process analyzed for internal/external and non-value-added activity.
2. Quick 5S simulated; area cleaned out and unnecessary clutter eliminated.
3. Quick corrections implemented and simulated.

Day 3, October 12

1. Simulated changeover filmed and analyzed for time.
2. Corrective actions identified, with cost, timeline, and accountability.

Day 1

"Good morning, I'm Bill Carreira. We'll be spending the next three days analyzing the setup process on your ABC machining cell. Today we're going to start out by discussing a few areas of setup theory and watch a quick video on CNC setup ideas, then we're going to take an actual setup, video it, and break it up into pieces to see where the time is. Tomorrow we'll put some quick changes into place, based on what we see today, and if time allows, we'll begin a simulated setup. On Wednesday, we'll complete the simulated improvements, evaluate them for time and money saved, and put together a go-forward plan to complete and implement those items we have targeted for the future-state setup. That's a lightning overview. Let's take a minute to make some introductions, since I don't know all of you, and then we'll get to it."

Getting Started

Introductions are made, and we spend a few minutes chatting about who does what, about our backgrounds, and a little about where we've been in our careers.

Me: OK, let's start with some words. Have any of you folks been involved in a formal setup reduction event or exercise before?

Scotty: I have when I worked for Deloner Industries. We did a lot of kaizens and setup events.

Linda: I've never been involved in a kaizen, but we did have setup teams that would focus on different areas of our shop when I was with Norstar.

Me: Good. As we work through the next three days, feel free to jump in and add anything that you've done in the past that you think will improve our session. So let's begin. The three big boxes we're going to put all activities into are, internal, external, and we'll throw a buzzword in just to jazz up the event, let's call the third non-value-added. Any guesses as to what external means?

Bill Markum jumps in: Those are the things you can do before the change-over starts.

Me: Good; such as?

Bill: Well, getting your tooling together and making sure the parts for the next order up are available.

Linda: Prints, any inspection gages or tools, and specs.

Me: Yep, all those things. Does anything else come to mind? Do you use any special containers or parts labels on the floor?

Mel: Our parts stay in the same production containers through the process. Any tags or labels are issued with the work packet; they're with the parts.

Me: OK, so let's rephrase this a bit. When we talk about external activity, we're really saying things you can do while the machines are still running—more specifically, things you want to have done before you've completed the order you're working on. Which brings us to a couple of questions that will back us up. What is a setup, and why is it so important to reduce it?

Jim: A setup is when you change over from one order to the next.

Me: OK, I agree, but give us a more precise definition. When does a setup start? When does it end?

Mike Kelly: I think I know what you're looking for. A setup begins when you shut down your machine after your last part, and it ends when you start running the next order.

Me: That's exactly what I was after. You could say it's the time between the last good part of one order, with *good* being the important word, and the first good part from the next order. And let's talk about why it's so important to reduce setups. Who wants to take a spin on that one?

Dave Garlock is ready: The less time you spend changing over, the more time you spend on making parts.

Me: Good logic, Dave, and that's what we're after: faster lead times and less money tied up in inventory. The longer your setup times are, the bigger the batches your scheduling people are going to schedule. Inventory is a big expense—there's money invested in buying it, money for space to store it, and more money for people to move it around. When we talk lead time, what does the customer care about?

Jackson: Getting the orders.

Me: You bet, but let's get a little more technical. When you look at the pieces of lead time, what are they?

Billy: It's the time it takes to get an order through the shop.

Me: Yes, but the customer's only paying for part of that time. What is the customer willing to pay for? That's the real question. Whatever that is, we want to do more of it, and less of the stuff that the customer is not willing to pay for. Let's break it into the pieces. *(I get up, go to the whiteboard on the wall, and start sketching.)*

Breaking Out the Steps

Me: When you look at an order, or the steps that an order goes through, here's the first step. *(I draw a triangle on the board. A triangle is the symbol for work in process, as in Figure 19-1.)*

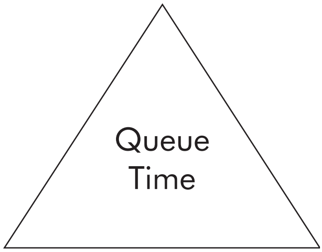

Figure 19-1

So the order is sitting in queue with four or five or however many other orders are in front of your machine. Good so far? *(All heads are nodding.)* OK, what happens next?

Mike: We start the setup.

Me: OK. *(I draw the next box, as in Figure 19-2.)*

Me: And?

Mike: We're done with the set up, we run the order. *(I draw the third box, as in Figure 19-3.)*

Me: You're on it, Mike; how come you're doing all the work? Next?

Scotty: The order's complete, so you take it to the next station.

Me: Does it leave immediately after it's complete? What would we see if we walked out in the shop right now?

Dave: Well, not immediately; we call materials handling and they come and get it when they get to it.

Me: OK, let's call that wait time after run. *(I draw another box, as in Figure 19-4.)*

And, one more step to take us back to the beginning?

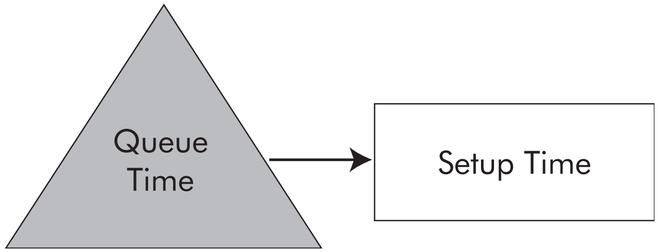

Figure 19-2

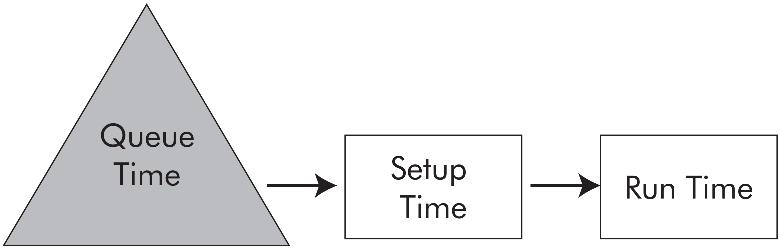

Figure 19-3

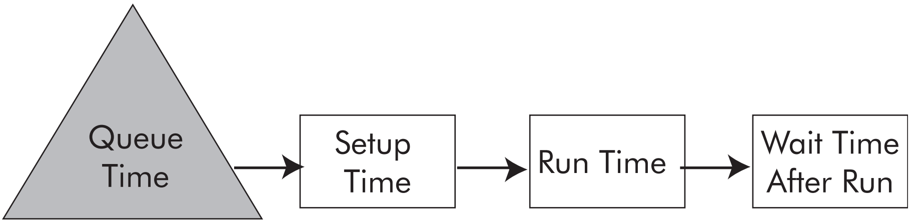

Figure 19-4

Billy: Move time to the next station?

Me: You got it. Move time takes you back to queue time again, in front of the next operation. The parts go through this same sequence, over and over, as they work through the shop. *(I draw another box, as in Figure 19-5.)*

Value to the Customer

Me: And so, where's the money? What's the customer willing to pay for; where does he, or she, see value?

Mel: The customer cares about the run time; that's when the part is being made.

Me: Everybody good with that?

Bill Markum: The customer expects to pay for setup time; he knows it's costed in.

Me: Maybe. Your engineers told me that it currently takes about ninety minutes to change over a center. With the sequence of centers and stations that you guys run through, your total setup time for this type of part is currently about 3½ hours. What happens if you're competing with a company that reduces its systemwide setup time to thirty minutes? Run times are the same; everybody's got the same equipment, feeds and speeds, tooling, and so on, so same cost; but

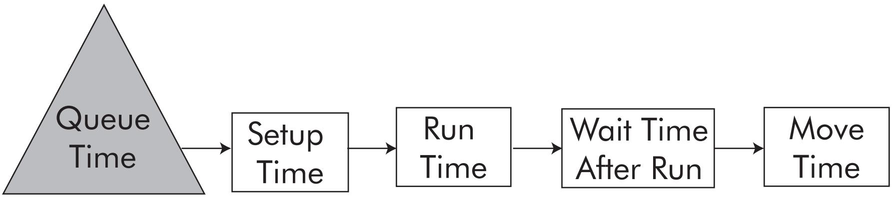

Figure 19-5

you have three more hours tied up in setup. Where's your quote going to be compared to your competition?

Bill: OK, point taken; we'd be more expensive.

Me: Right. The value-added is only in the run time (Figure 19-6). Your company has baselined this process; that's why we're looking at setup reduction. There are some plans for layout changes and cellular flow. Those projects will take care of the queues, the wait time, and the move time. The piece this team has to get is the set up time to round out the process. That's why this is so important.

Evaluating the Internals

Me: So let's get back to it. We've talked about lead times, value-added, and a bit of external. That takes us to internal. Who's up?

Jackson: Well if external are things you can do while the machines are still running, I'll take a wild guess and say that internal are things you can do only with the machines shut off.

Me: An impressive show of deduction, Dr. Watson. Internals are the toughest piece of setup reduction, and usually cost some money. Things like quick-change tooling and fastener improvements are a couple, although there are some areas that can be improved without big expense. We'll see what comes up when we look at your setup.

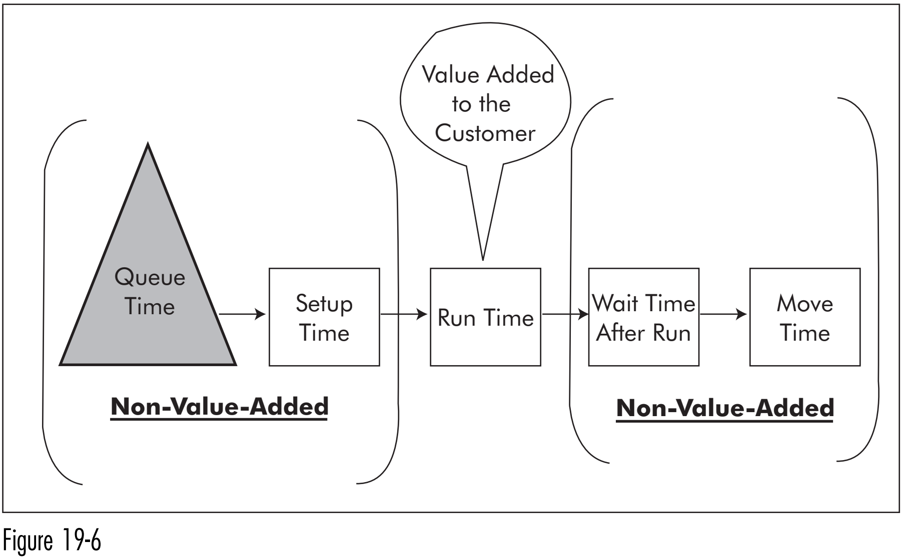

Figure 19-6

> Which brings us to the last big box, non-value-added, and I'll cut to the chase on this one. These are the completely unnecessary things that you see when you look at a setup. I can't find the right wrench, so I walk over to Joe's area to borrow one. I have to search around to find the next order of parts because the materials handler puts them in a different place every time she drops an order. The stuff that you can just make go away with a little planning and organization. So those are the areas of definition. I've got a short video that is aimed at CNC changeover techniques, data, programming techniques, and ways to cut time from one setup to the next. It's pretty technical, so you machine and programming people will probably enjoy it more than some of the rest of us, but it's a good one. It lasts about thirty minutes, and then we'll hit the floor and begin our adventure. Mike, hit the lights there if you would. Thanks. *(And the video begins.)*

There are some excellent videos on the market for CNC changeovers. I would suggest that any company involved in the lean transition add a few of them to its training library.

Analyzing a Current Setup

Following the video, we discuss a few of the points that were made and reconvene at the target cell to begin our analysis. Since the changeover times are relatively quick in this cell, an estimated ninety minutes per machine, we have chosen to videotape two of the most common types of units that run through this cell. The process consists of two turning centers, a vertical and a horizontal; a Haas drill and tap; a deburr station; and a stamping machine. The first part we will analyze requires only turning; no secondary drill and tap is required. We have a video camera and a tripod, and we begin the shoot with Jim Atson, our first-shift machinist, on deck. The setup is relatively smooth, with the exception of a touch of pressure due to the audience involved. Ninety minutes later we have reconvened in the conference room with our first setup on tape.

> **Me:** OK, folks, we're ready to begin. The process we want to follow is to view the tape and record the tasks and corresponding times as we go. We want to group activity in discrete elements, so you guys need to talk to the tape as we go and describe what it is we are

watching. The beauty of a video is that we can stop to discuss and rewind if we need to, and we'll all be looking at and talking about the same things. Let's fire this one off. I'll do the element writing and times so you all can get the hang of the format, and you'll take over on the next one. I've got my format of choice on my laptop, so we'll freehand the analysis and transfer to a computer format later to have a clean record for your management and the rest of your associates when you present the results of this session. Questions? OK, let's go. *(We start the tape. The setup begins with Jim removing the jaws from the first center chuck.)*

Me: OK, guys, the clock's running. Talk to me.

Jim is translating: I'm removing the bolts from the jaws. Jaws to the bench, taking off the Ts. I'm clocking, writing the activities being described, writing the seconds down next to each task, and watching the video.

Me: What's up with the Ts? Don't you have spare jaws and Ts? That should be external, not internal.

Scotty, laughing: I told you guys Bill would go nuts over that. We don't have spares; they told us they're too expensive.

The guys are laughing as they watch Jim spend almost two minutes swapping out jaw Ts.

And on we go. Load tools, look for the program, single block and touch off, run, inspect, correct the work shift, and on through the first part on the first center. We're done with that one, and it's on to the second center. The guys are calling out the details of the activity as we go, and the study unfolds. Loosen the rough bore tool, 202 seconds; remove tool, put tool, tighten tool, error and retouch, 217 seconds; search for a gage, 123 seconds (excellent detail breakout); set up the stamper; inspection paperwork; reinspection by QC; adjust; and begin run. The clock's off, and the study is a lock. I have the study details, about seventy or eighty steps, on a yellow legal pad in pencil. We run off copies for all members of the team and pass them out.

Me: All right, let's walk through these steps and box them: internal, external, or non-value-added. We don't want to solve any problems or burn up a lot of time discussing alternatives yet, we just want to box the activity. Be fast. We'll get to solutions when we get the summary sheets with some numbers to go with the tasks. *(The group collectively discusses each task and decides on which category it falls into. There is some lively conversation and some digression to solutions, but we manage to stay on track fairly well and run through the task categorization in about twenty minutes.)*

OK folks, take a break and grab a sandwich. I need about twenty minutes to clean this up and tally up some categories, then we'll discuss what we saw.

The group breaks for a few minutes and I power up my computer. About twenty minutes later I have the study loaded and broken into categories with percentages. The study looks like Figures 19-7 and 19-8.

The categories and the percentages are shown in Figures 19-9 and 19-10.

Brainstorming Ideas for Improvement

We have a video, a detailed breakout of tasks from the video, the time to perform each task, the tasks grouped into categories, and the percentage of time consumed by each category. Now our first analysis begins. The group is back, and the running lights are on. The members have been on the floor, discussing what they saw, while I was doing the dog work, crunching the data. They've leaped ahead of me, and they're going to all kinds of solutions and better ideas for orchestrating a running changeover. This is an extremely competent, technical group of people, and they are seeing with a collective eye, maybe for the first time. Hot stuff, indeed!

Me: OK, guys, and Linda. By the way, Linda, where I come from ''you guys'' means girls and guys, so I'm really not ignoring you, as the only girl on the team, when that phrase slips out.

Linda: I understand, but I should point out that since you're our guest, the correct term for you to be using is ''y'all.'' *(The group is having fun with this one, they get off on a few tangents of language usage, depending on the part of the country you happen to be in.)*

Me: I'll try—well, maybe later. And so, here are the numbers. Let's tear this study down and get creative. Before I showed up this week,

A	B	C	D	E	F	G
Setup 1		ABC			Jim Atson	
Oct-01						
				Category		
Setup step #	Element	Element Time	Internal	External	Non-Value-Added	Comments/Ideas
Machine 1	unbolt jaws	52	52			
	remove t's	15		15		
	t's on	94		94		
	jaws on	183	183			
	unfasten drill	36	36			
	remove drill	12	12			
	insert drill	18	18			
	tighten drill	25	25			
	look for program	30			30	
	load program	75			75	
	input variables	128	128			
	single block/touch off drill	154			154	
	load 1st piece	6	6			
	single block	32			32	
	variable correction	45			45	
	single block	67			67	
	touchoff correction drill	318			318	
	single block drill/face turn	194			194	
	inspect	129	129			
	workshift correction	65			65	
	inspect bore	20			20	
	rerun part	176			176	
	inspect	29			29	
	part aside	5	5			
	cleanup	13	13			
	load 2nd piece	5	5			
	loosen insert fasteners	20	20			
	get insert (box)	21	21			
	put insert	3	3			
	tighten insert	13	13			
	run 2nd piece					
Machine 2	unbolt jaws	21	21			
	jaws off	4	4			
	remove t's	55		55		
	cleanup	21	21			
	t's on	51		51		
	get scale	11	11			
	jaws on	40	40			
	loosen rough bore fastens	202	202			

Figure 19-7

	get scale	11	11			
	jaws on	40	40			
	loosen rough bore fastens	202	202			
	change tool	6	6			Different bolts from rest of head—12mm vs.10mm—manual remove —have gun —no driver
	tighten fasteners	68	68			
	loosen finish tool-gun	34	34			
	remove tool	7	7			
	put tool	13	13			
	tighten	24	24			
	put part	13	13			Only one screw—2nd hole doesn't line up
	arrange tools bench	12			12	
	load program	64		64		
	input variables	96	96			
	set work shift	48	48			
	touch off rough	102		102		
	touch off 2nd bar	130	130			
	single block	41			41	
	error? retouch? help Linda	217			217	
	program correction	100			100	
	single block	147			147	
	look for gauge/get	123			123	
	inspect	38	38			
	adjust bore/rerun	63	63			
	inspect	17	17			
	part aside	9	9			
	adjust bore	10	10			
	stamp setup	114		114		
	stamp 1st piece	26	26			
	inspection paperwork operator	355			355	
	move to QC-reinspect	312		312		
	discuss bad dimension/adjust/ start run	75	75			
	Totals		**Internal**	**External**	**Non-Value-Added**	
77.5	**60**	**4652**	**1645**	**807**	**2200**	**100%**
			35%	**17%**	**47%**	**4652**

Figure 19-8

H	I	J	K	L	M
Single Block/Touch Off		Change Jaws		Rework/Error	
single block/touch off drill	154	unbolt jaws	52	arrange tools bench	12
single block	32	remove t's	15	error? retouch? help Linda	217
single block	67	t's on	94	program correction	100
touch off correction drill	318	jaws on	183	look for gauge/get	123
single block drill/face turn	194	unbolt jaws	21	discuss bad dimension/adjust/start run	75
inspect	129	jaws off	4		
workshift correction	65	remove t's	55		**Rework/Error**
inspect bore	20	cleanup	21		**527**
rerun part	176	t's on	51		**11%**
touch off rough	102	get scale	11		
touch off 2nd bar	130	jaws on	40		
single block	41				
single block	27				
inspect	38	**Change Jaws**			
adjust bore/rerun	63		**547**		
inspect	17		**12%**		
Single Block/Touch Off					
	1573				
	34%				
Change Tools		Inspect Op		Inspect QC	
unfasten drill	36	inspect	29	move to QC-reinspect	312
remove drill	12	inspection paperwork operator	355		
insert drill	18				**Inspect QC**
tighten drill	25		**Inspect Op**		**312**
loosen insert fasteners	20		**384**		**7%**
get insert (box)	21		**8%**		
put insert	3				
tighten insert	13				
loosen rough bore fastens	202				
change tool	6				
tighten fasteners	68				
loosen finish tool gun	34				
remove tool	7				
put tool	13				
tighten	24				
	Change Tools				
	502				
	11%				

Figure 19-9

Load Variables		Load/Run		Load Program	
input variables	128	load first piece	6	look for program	30
variable correction	45	part aside	5	load program	75
input variables	96	cleanup	13	load program	64
		load 2nd piece	5		
		put part	13		**Load Program**
	Load Variables	part aside	9		**169**
	269	adjust bore	10		**4%**
	6%				
		stamp 1st piece	26		
		single block	120		
			Load/Run		
			207		
			4%		
Set Stamper		Set Work Shift			
stamp setup	114	set work shift	48		
	Set Stamper		**Set Work Shift**		
	114		**48**		
	2%		**1%**		

Figure 19-10

your engineering people told me that this setup had been worked on and fine-tuned to the nth degree, and there wasn't much that could be done to improve it. The real issue, they said, was the need for quick-change chucks. That was the only item needed; these magic chucks would solve all your problems. Let's look at this study and see if they were right.

(We begin to discuss the categories.)

Me: The biggest number is 34 percent for single block. I'm a little confused about this one. I thought these were production parts: mature design, repetitive runs, over and over. You guys spent a third of your total setup single blocking; what's up with that?

Billy: These are production runs. We don't want a crash, so we single block.

Me: I'm still not with you. Are the programs debugged?

Billy: Of course. We've been running these parts for years.

Me: So why can't you just touch off to locate once and hit go?

Billy: We can, in theory, but our tooling is not repeatable, or, to be more precise, our tooling and tool holders are not repeatable.

And away we go. The team gets into a detailed discussion of the shortcomings of their tooling, holders, techniques to shim where required, and all of the detail and nuances of the particular machines that these people live with every day. They've used insert tooling with quick-change holders and have a few around the shop. They discuss "Wild Bob," a machinist in one of their cells who has taken the time to detail locations and mark his tooling, which he keeps locked up in his toolbox. Apparently he can set up and run without single blocking, but he is a pretty crazy guy, and he is reputed to have a very large brain. He has taken it upon himself to work out the details that allow him to run this way, but it's not common practice throughout the rest of the shop. If the majority of the population was allowed to operate this way, with the existing tooling configurations, half the centers in the shop would crash every day.

Billy: We know what we need, and the tooling that we've sampled is repeatable to extremely tight tolerances. We just always thought this area would generate too much expense.

Me: Can we simulate what the setup would look like if we had repeatable tools and holders?

Billy: Sure. We'll just locate the tools and preset them to illustrate the condition if they could repeat off a predetermined datum.

Me: OK, there's one for our simulate list. What's next? Jaws at 12 percent. There are no spare jaws and no spare Ts, you're using a hand Allen when you could be using an air driver, you fool around for 3½ minutes trying to locate the jaws to your chuck when you could be using a center bump to simply slide up to them and lock them down—man oh man, you name it, and it's going on here. Most of this piece should be external, with the internal jump started with better hand tools and bump fixtures. Yes? No?

The team kicks this one around and comes up with a list of items to put together. The team members don't like my idea for a center bump, but they replace it with a quick, temporary, spot-welded locator to the outside of the jaws to locate visually. That's better yet. The last remnants of my ego disappeared years ago; go with it. In the course of this logic flow, the team members work through every block of the setup detail and brainstorms: internal, external, better, easier, stop doing this, do this before that, and so on. They have a new, improved setup flow thought out and choreographed, with a list of things to do to simulate a future-state setup.

Me: You guys have a great plan for this first setup simulation. Anybody here a racing fan?

(*This gets some sideways head tips, with a "where's he going now?" look. The team thinks I'm going off on a disconnected racing story of some sort.*)

Me: When you see a changeover in the Indy 500, a car pulls into the pit for the tire changes and all the other stuff that is needed, do you see one guy come walking out and begin to pull off the first tire? Cup of coffee in one hand, Allen wrench in his back pocket?

Mel jumps in: We run each cell with one person; we don't have a setup crew. They'll never let us add people for that.

Me: Who's they?

Mel: Management.

Me: The same management that's paying me and this entire team to spend three days figuring out the fastest possible setup scenario for this pilot cell?

Mel: C'mon, Bill, I've worked for these guys for a long time; take my word for it.

Me: The same management that wakes up in the middle of the night and jots down notes about machine utilization, but let us shut down one of your primary cells for nine shifts to do this session?

(*Mel is laughing now.*)

Me: OK, let's talk people. As you follow the flow you have envisioned for this simulation, look at adding whatever resources you need to give you the fastest running setup you can get. This is a best-case presentation. Do you have any available people in house?

Dave jumps in: We have a setup person on each shift.

Me: What does he do? How does it work?

(I'm getting the look-arounds that say that I've hit a hot spot. Let's see where this takes us.)

Mike Kelly speaks up: They mostly help the guys that they're friends with, when they're around. *(The grenade has been rolled.)*

Me: Do these guys work for you, Mel?

Mel: No, they report to Mike Olson, our plant manager.

Me: Why would setup guys report to the plant manager?

Mel: Well, they're not in any one area, they're all over the plant and across three shifts.

Me: Do they have a setup schedule?

Mel: What do you mean?

Me: You schedule all production runs through the shop, don't you?

Mel: Of course.

Me: And you know the cycle times of the products, and you know what orders to load to each cell on each shift. That tells me that you can establish a projected window, plus or minus, when setups should happen in each cell. Yes? No?

Mel: Yeah, I guess we could, but we don't.

Me: I'll drop it for now, but give it some thought: If production is important enough to schedule, why wouldn't setup also be important enough to schedule? Put up a traffic light in each cell, and hit orange when you are approaching a setup. Green is running, orange is approaching setup, and red is doing a setup. Something along those lines. At any rate, we'll worry about resources later; our objective this week is to show management what's possible.

Mel: What if you had four or five cells setting up at the same time?

Me: What ifs? That's a question we don't have an answer for. Here, I'll ask you one: How long is a piece of string?

(The group's laughing again. We're going down a hole controlled by current management philosophy; it's time to pull out of this topic.)

Me: My only point is, if you can figure out how to schedule production runs, you can also figure out how to schedule the setups in between the production runs. You, and I don't mean "you Mel," I mean "you, your company,'' doesn't do it now because it's never been important.

(And so the team takes another look at its simulated setup and lays out the sequence of a two-man running setup: Who does what, when and how. We're ready to get some quick items fabricated, set the area up, and simulate setup 1.)

Me: OK, folks, setup 1 is lined up and ready to go; let's go to setup 2. You wanted to look at this part because it's also a very big percentage of your mix, but it requires that you go through all the machines in the cell, including the Haas. Let's hit the floor again, same game.

The team has decided that Mike Kelly, our second-shift machinist, will perform this setup. He is the junior guy in the cell as far as seniority, but he's acknowledged as the most experienced machinist of the three we have on the team. His style is different, and his setup and run ability is superior to that of his associates, or so they claim. And so we return to the floor and go through the same procedure: video, break the film down into tasks, categorize, brainstorm solutions, and develop a detailed plan for simulating the second changeover. It's been a long day, and we're through when we finish detailing the second session. Tomorrow we'll fabricate our simulation tools and put things in place to begin the simulation by day's end if things work out as planned. Day 1 is a wrap.

Day 2

''Good morning, everybody. Looking at the amount of donuts y'all have brought this morning, I feel like I'm involved in a session with the South Boston Police Force. It's OK; I have friends in South Boston; I'm allowed to poke fun. Today we need to get all of your simulation aids done; get your toolroom going on chuck bumps; steal some inspection equipment and hand tools, a run-out stand, spare Ts and jaws, whatever we need at the point of use. We need maintenance to jury-rig some air and power drops so you can have your tools in the right place, do a quick 5S cleanup, and then walk through the planned setup. When the camera starts running, you guys are going to forget where you are and go into a movie star freeze-up mode, so we want to do dry runs until we're comfortable, then we'll pull the trigger on the simulation. Questions? If you're all ready, let's get moving on our list of items.''

There is a rehash discussion on what's needed and who is getting what done, and the morning is consumed in gathering everything we need. While everyone is hustling around the shop, setting the stage, I took the opportunity to sneak away and have one of the guys introduce me to Wild Bob. His reputation was well founded; he was a bit of a madman—he reminded me of Doc in the movie *Back to the Future*. He starts what turns out to be pretty much a monologue by stating his observation that ''these engineering kids aren't very good at listening,'' then he proceeds to give me a twenty-minute dissertation on tool and machine design, coupled with programming ladder logic, that contains roughly the equivalent information of a two-semester course in tooling engineering at MIT. I knew I was in the presence of intellectual excellence. A little scary, but truly impressive.

We regroup at mid-afternoon. Everything is ready, the cell has been emptied out and repopulated with only those items needed to get the job done (a lightning 5S, if you will), and we're ready to go. Mike and Dave are going to perform, with Dave in the role of external set-up man there for the assist. The guys choreograph the sequence of the running setup, with the external guy coming in as the in-cell operator takes the last run piece to the second machine. Away we go. We shoot the simulation of the first setup, and follow that up with some discussion on how it went. The guys got off track in their sequence a couple of times and express a desire to do a retake. The group agrees, and feel we have enough time if we agree to stay with it tomorrow until we are done, regardless of how late it gets. Today was a very busy day of preparation with barely enough time left to videotape the first simulation. Tomorrow we'll do a retake on setup 1, simulate setup 2, and dissect both videos to break out content, comparisons, and results.

Day 2 is a wrap.

Day 3

''Good morning, all. You all agreed to a retake on setup 1, so let's get to it; times a-wasting.''

We group at the cell, and following a few minutes of discussion and last-minute verification of the planned sequence, we reshoot setup 1. It goes off well; all hands are surprised at the speed of the running setup and are pleased with the results, although we haven't formally crunched the numbers. We regroup and go right into the second simulated setup. We've simulated the setup of two different parts representing the majority of types of product produced in this cell.

We go back to the conference room, where we dissect the simulated videos with the same format, time, and tasks.

The summary looks like Figure 19-11.

Here's an overview of the results. We calculated times for setup, current and simulated, and calculated worker time paid as a labor impact spent on the process. We left the calculations for impact on inventory dollars as a result of EOQ recalculations to the baseline team to get back to us with.

In the first setup, turning only, the setup velocity went from eighty-two minutes currently to nineteen minutes simulated, a reduction of sixty-three minutes, or roughly 77 percent. The person-minutes paid went from eighty-two person-minutes with one person to thirty-eight person-minutes, with two people for nineteen minutes, or roughly a 53 percent reduction in people dollars spent. Very big numbers.

Setup 2 showed these results: Velocity went from a touch over ninety minutes currently to a little over twenty-two minutes simulated, a reduction of sixty-eight minutes, or 78 percent. Person-minutes paid went from ninety minutes to thirty-three minutes, a reduction of 57 minutes, or 63 percent. The guys were really paying attention to the time and money, so they made the setup person leave the cell and continue to the next setup on simulation 2, which gave them a higher labor reduction percentage on this 2nd simulation. The summary also contains the cost to implement, the people responsible for the various tasks, and the timeline to complete. Following this event, those action items addressed were approved and implemented, and the first setup event was rolled out in this facility.

I did suggest to management that they consider naming Wild Bob their setup team lead going forward. They patted me on the shoulder, thanked me for my assistance as their setup event mentor, and quickly changed the subject.

A	B	C	D	E
ABC Changeover Event			**Oct-01**	
ABC Changeover Team:	Jim Atson, Machinist 1st, Mike Kelly, Machinist 2nd, Scotty Thomes, Quality Engineer, Dave Garlock, Machinist 3rd, Linda Cook, Programmer, Bill Markum, Manufacturing Engineer, Billy Crisco, Tooling Engineer, Jackson Sykes, Maintenance, Mel Hubert, Machining Supervisor, Bill Carreira-Navigator			
Summary of Events				
1. CNC changeover theory discussed—training video viewed				
2. 2 changeovers video'd—2 lathe w/tool swap. 2 lathes & Haas				
3. Process analyzed for internal/external and non-value-added activity				
4. Quick corrections implemented to chuck change activity—visual bumps. Ts, proper hand tools, etc.				
5. Quick 5S simulated—area cleaned out—unnecessary clutter				
6. Programming improvements, sufficient memory, and quick-change tooling (repeatable) simulated				
7. Proposed changeover video'd and analyzed for time				
8. Corrective actions identified w/cost timeline, and accountability				
Results				
	Current C/O Time	Simulated C/O Time	Delta/Reduction	% Reduction
ABC1 15/16″	8 min 39 sec	19 min 4 sec	62 min 35 sec	77%
Labor Cost	$20.41@ 81.65 person-minutes	$9.53 @ 38 person-minutes	$10.88	53%
$15 avg. rate				
	Current C/O Time	Simulated C/O Time	Delta/Reduction	% Reduction
ABC #2 3 5/8″	90 min 15 sec	22 min 28 sec	68 min 33 sec	76%
Labor cost	$22.56 @ 90.25 person-minutes	$8.35 @ 33.4 person-minutes	$14.21	63%
$15 avg. rate		(Setup person left when that portion was complete)		
Corrective Adds				
Item	Cost (Estimated)	Time to Completion	Who	Date Complete
1. Chuck bumps	$ 1,000.00	immediate—1 month	Bill M.	11/10/2001
2. Ts	$ 1,200.00	1 week	Bill M.	10/20/2001
3. Hand tools/gauges	$ 2,500.00	1 week	Bill M.	10/20/2001
4. Runout stand	—	1 week	Scotty	10/20/2001
5. Setup resources scheduled	—	1 week	Scotty	10/20/2001
6. Inspection procedure defined	—	1 week	Jim/Mike/Dave	10/20/2001
7. Setup sheet procedure defined	—	1 week	Scotty	10/20/2001
8. Memory	$ 3,000.00	2 weeks	Linda	10/30/2001
9. Presetter (for Haas)	$ 5,000.00	4 weeks	Mel	11/10/2001
10. Quick-change tooling	$ 25,000.00	4 weeks	Bill M./Mel	11/10/2001
11. 5S	$ 1,000.00	4 weeks	Scotty	11/10/2001
Totals $$'s	**$38,700.00**			
Note: Cost reduction potential for EOQ/inventory reduction to be quantified @ ABC baseline team.				

Figure 19-11

CHAPTER 20

Total Productive Maintenance (TPM)

Total productive maintenance, preventative maintenance, and just plain old *Maintenance*: These words represent a massive transition in definition and application. This shift is truly from a "flat world" theory to a "round." The maintenance mindset is one of, "The operators run the machines; the maintenance people fix them when they break." A preventative maintenance mindset is: "The operators run the machines; the maintenance people will change the oil every now and then, and fix the machines when they break." A total productive maintenance mindset is one of, "Everyone in the organization is responsible for and involved in our success. We will all work together, as our individual skill sets dictate, and we'll keep our mechanical resources in outstanding condition, to promote an environment of superb total quality and minimal variation during our production day." It's as simple as that.

There are lots of programs and philosophies about maintenance floating around. TPM is the one associated with the lean model. But it does cause you to ask a few fundamental questions concerning the meaning of the words. What is *maintenance*? My personal interpretation of this word is, "Activity performed on a piece of equipment, or a machine, to keep it in excellent working condition." The implication is that you do the work in order to keep the machine in good operating condition, and using the words *to keep* further implies that this activity takes place before a malfunction occurs. I change the oil on my car every 2,500 miles whether the oil is dirty or not. That is simply my timeline on oil changes. I sold a little Acura a couple of years ago that had 227,000 miles on it, and the guy I sold it to is still driving it back and forth to work. With that thought in mind, when someone says to me, "preventative maintenance," I hear the same word twice. It's redundant. Maintenance by its nature occurs before something breaks down. After a machine has burst into flames and ground to a halt, you are not performing maintenance, you are performing a repair. You are fixing something that is broken; it no longer works.

So the real question for any given company is, "Do you have a maintenance department or a repair department?" That being said, the real message of TPM is to develop a maintenance focus, not limited to those individuals whose job title happens to contain the word *maintenance*, but extending across all functions in the operation.

We've discussed process variation in several areas of this book, and the role of maintenance falls into this critical category. So, let's ramble around this category a bit and go back to my favorite topic, where's the money?

There are some companies that choose to run their equipment flat out, across three shifts, month after month, until their machines just seize up and come to a screeching, fire-breathing halt. Everybody then grabs a coffee and waits for the maintenance guys to show up. These companies no doubt feel that they are getting every last minute out of their machines with the least expenditure. The breakdowns are completely contained, a one-time expense in time and money; we'll move our operators somewhere else and let our maintenance guys, or gals, fix the machine and get it ready for the next marathon sprint. There are other companies that perform very thorough preventative maintenance on their machines, spending time and money at frequent intervals and at different levels of complexity, to ensure that their equipment never breaks down during planned hours of production. You'll hear the terms *proactive* and *reactive, planned expenditure* and *unplanned event*. You could ask, which way is better? Of course, the term *better* has no meaning; the real question is, which way promotes a more profitable operating model? In business, all activity, or absence of activity, translates into money.

Model 1: ''Run It Until It Catches Fire''

Let's start at the point where the equipment has failed. You're in the middle of a production run that's due to ship this afternoon, and you experience a showstopper of a machine crash. You quickly move the remainder of the order to another area; shut that run down; change over the newly assigned machine cell; reassign some people to areas where you may not necessarily need them, but you've got to find something to keep them busy; and you're back in business. You need to get the machine that went down, up and running as quickly as possible.

Your maintenance people evaluate the problem, complaining about management's short-sighted philosophy of not carrying the required replacement parts, and define the needed replacement parts; you hustle around and have them FedExed overnight. The replacement parts cost several thousand dollars because when your machine reached meltdown condition, many additional parts were damaged or destroyed that would not have been had the contributing condition been treated at an earlier stage.

The next day your people spend the day, and half the night, on overtime, getting this piece of equipment running again. All costs considered, this was a very expensive occurrence. Let's back up in time. This machine began exhibiting symptoms of this problem several weeks ago. At that point, your operators began having difficulty holding the tolerances on the parts they were producing. Their setup time increased by 8 percent, and they began experiencing a 12 percent higher reject rate on product being run because of variation in tolerances. Their run times increased because of the additional adjustments and tweaking that were required to keep the parts within specification.

You don't know it yet, but you will experience some large financial hits for rework and remakes when your customers return five large orders that contain an unacceptable percentage of parts that are out of date. I could go on, but I think I've made my point. If you actually took the time to build a cost model for these areas of lost time, inefficiencies, rejected product, and the associated administrative costs of explaining and disposing of these rejects, warranty and rework expense, and so on, you would be looking at a huge iceberg of hidden expense. The tip of the iceberg is the expense incurred on the day of the breakdown. However, all is not lost. This company has taken bold corrective action to address the problems its customers are seeing. It has added four final inspectors to its process, and when they find a suspect lot of product, it is promptly routed to a sorting area, where five very qualified technical individuals inspect them 100 percent. Way to go, guys!

Model 2: The TPM Way

This company has decided that everyone is responsible for product quality, customer satisfaction, and the corresponding future success of the company, and their livelihood. It has developed a schedule of maintenance requirements for all equipment, at several levels of complexity, with the appropriate checklists to document activity and results. The people who operate the equipment have been trained in and are responsible for daily and weekly maintenance activity. Tasks such as daily lubrication, inspection of hoses and cables, and weekly checks on the tightness and adjustment of various components are the responsibility of production associates.

More complex preventive and predictive activity is addressed by the maintenance staff. The company has implemented a TPM database program that contains information and history on all equipment, replacement parts, vendor information, timing and cost of maintenance work performed, and performance expectations on critical components, allowing those components to be taken down and replaced before the historically defined point of problem occurrence. If history tells you that you are very likely to experience a bearing failure at 1,500 run hours in a particular machine, the predictive schedule takes the machine down at 1,400 hours for a scheduled bearing replacement. This history and cost database allows the company to plan and budget for required work and parts, and to stock the appropriate components needed for planned replacement. It rarely, if ever, experiences an unplanned breakdown, with the associated production crisis event costs. It does not have the telephone number of FedEx committed to memory, although Jack Hammond, in shipping, did use their services last month when he almost forgot his mother's birthday and had to overnight some flowers at the last minute. Their customers receive on-time deliveries as promised, and are delighted with the consistency of the excellent product quality. There's no warranty expense, no rework, no customers lost to the competition, no noise. These are the two models that come to mind.

The Advantages of TPM

By involving all members of your production team in the TPM process, you will also realize a huge advantage in reduced cost through the active participation of the people who are most familiar with the equipment in question, your front-line operators. These are the individuals who run these machines all day, every day. They will notice the slightest change or variation in their characteristics—vibration or even intermittent sounds that are undetectable by the casual observer. If these folks are actively involved and responsible, as opposed to the old ''I just run it; maintenance fixes it'' mentality, your preventative effort will be superb.

When you delve into the technical areas of overall equipment effectiveness, measures of uptime, and machine loss theory, there are some excellent books on these topics, so I won't waste our time expanding on a subject that has already been addressed in a much more thorough manner than I would care to. But I will make the point that accurate historical data on stoppages, downtime, rejects related to machine variation, and setup detail are essential. Continuous improvement activity stands on this type of database.

There are some excellent database packages available to establish a good TPM program in your facility. There's no need to reinvent the wheel. These packages are inexpensive, Windows-based, and very user-friendly, and they contain all the modules, checklists, and documentation formats necessary for a thorough implementation. They are so easy to use that even I have implemented a couple. Buy one, load the data, begin developing a historical database, eliminate your variation, eliminate your waste, and improve your profitability.

At the heart of a lean system of operation is balance, flow, and minimal variation; some would call it predictability. If you adopt a cellular-flow philosophy of operation, you cannot tolerate unplanned equipment downtime. As I've said before, there's nowhere to hide; your entire process shuts down, and you're playing without a safety net. A TPM system and overall mindset is an essential ingredient in your lean recipe; don't underestimate the necessity for this tool.

And last but not least, go back to the foundation mechanism to establish a thorough TPM system: train, train, communicate, communicate, and then communicate some more.

CONCLUSION

The Why: The Psychology of Lean

So, what's this lean stuff all about? I sometimes think we are a wasteful and self-indulgent society. If something breaks, we throw it away and buy another one. Our grandfathers might have taken great pains to fix that old vacuum cleaner and try to make it last another year, but our children just toss it and go to the mall for another. It's the American dream: big houses, big cars and lots of them, a television in every room, a DVD player in the kids' room. We are also a "home run" society.

"Hey, what do you think about Jimmy McPhearson? He batted .350 last season; he got 200 singles with no strike-outs."

"Jimmy who? Forget him. Bobby Righter is the man; he got forty home runs last season."

"But he batted .220."

"So what? He's a slugger."

Big-picture thought processes are prevalent. Put together the home run business plan; you can ignore those little inconsequential tasks. They're not important. Forget about hitting a single; I'm going for the home run. But here's the good news: It's never too late to change.

Lean is a philosophy of no waste. It is also a philosophy of "a hundred small improvements every day" rather than "a home run once a year." It is a focus on excellence at the lowest, and highest, level of detail. It is also a concept based on a systemwide vision. The concept of value-stream analysis is critical foundation logic. If you change a piece in area 3, what is the ripple effect across the entire process? In addition, it is a concept in which the customer defines the metrics. It is a mindset of really *being* where you are. We Americans are not instinctively good at this; we must consciously work at it.

With that being said, let's have some fun. Here's the last conversation, between myself and Mr. Big, a business owner.

Mr. B: So, tell me, Bill, is lean a concept that will make my company more profitable?

Me: Yes.

Mr. B: Is lean a concept that will make my people more efficient?

Me: No. Your people will not be more efficient; they will be exactly as efficient as they are today. However, by analyzing the details of the activity across your value stream, you will eliminate a lot of non-value-added activity, which will allow your people to spend a greater portion of their day working on value-added tasks. The net result will be more product shipped and invoiced, and more money received from customers, with the same level of resource expense that you have currently. I wouldn't call this an increase in people efficiency, I would call it an increase in process efficiency, resulting in greatly improved company profitability.

Mr. B: Is lean a tool that will get my people working faster?

Me: No. As you eliminate waste and non-value-added activity, your people may, in some cases, actually be working more slowly. The net result is that their activity will include a much higher percentage of value-added work, things will be done correctly the first time, and the elimination of quality expense, rework, warranty returns, and all of the associated costs will further add to your improved profitability.

Mr. B: Is lean a tool that will allow me to eliminate jobs?

Me: Yes.

Mr. B: How many people do you feel I'll be able to cut from my direct workforce?

Me: Sorry, I don't understand.

Mr. B: How much can I cut my headcount?

Me: If your mission is simply headcount reduction, I suggest you think about the larger issue. As you embrace a lean philosophy throughout your organization, you will reduce inventories, greatly increase your sales generated per employee, eliminate your quality issues and expense, and improve customer satisfaction levels to unprecedented highs. This will allow you to reduce your pricing, if necessary, and take a much larger percentage of market share. As you know, anyone who currently wants to purchase the product you and your competitors make can readily do so. The question is, from whom? The only way for you to grow and obtain more sales is to take them away from your competition.

If you are content to simply downsize your headcount, the morale of your remaining workforce will be poor, your performance will ultimately suffer, and your company will become weaker. Granted, you may experience the short-term illusion of being more profitable, but this is not an acceptable endgame strategy. To become stronger and healthier as a company, you must have a strategy of growth. As you take orders away from your competition, you will grow, become stronger and healthier as a company, and ultimately increase your headcount. You may double your headcount while you quadruple your profitability. When I said that you would eliminate jobs, I didn't mean within your company, I meant in the workplaces of your competition. That's the game. As my Uncle Francis, who was a philosopher of note within my family, used to say, ''The big dog usually gets the bone.'' He was quite an acute thinker.

Mr. B: This approach will have a big impact on my manufacturing people. Do you also get involved in the training and oversee the implementation on my production floor?

Me: Lean is not just a manufacturing floor system. It is a total process tool. You need to forget the boxes of direct, indirect, salaried, and so on. You have 450 people who show up for work every day, across all job functions in your company. They all spend their days performing tasks. One is no more important then the next. The real focus as you analyze all tasks across the value stream is, ''Is this task value-added, and does it contribute to product being shipped out the door, with a very short time bite focus?''

Mr. B: All right, Bill, you talk a good story. Where do we start?

Me: Mr. B., that's an interesting question. And so it begins.

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