Apple, Foxconn & Manufacturing Strategy

A Study In Manufacturing & Strategy

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Steve Jobs and Apple Computer once built a "factory of the future" in Fremont, California. They spent $20,000,000 and then closed it after just two years. Today, Apple's net worth is more than Poland. So, what went wrong in 1984? And, what is going right today?

What went wrong was *not* cheap overseas labor. It was their failure to **integrate Marketing Strategy with Manufacturing Strategy.** Or, more likely, Apple failed to **even consider the issues** of Manufacturing Strategy. Later, when Apple partnered with Foxconn, Apple and Foxconn did not repeat the earlier mistakes.

What follows is a review of what is publicly known about Apple and Foxconn in the context of Manufacturing Strategy.

Manufacturing & Marketing Strategy

Manufacturing Strategy addresses the question "How to go about fulfilling our manufacturing tasks?" The answer is at a policy level and addresses a range of issues such as equipment characteristics, plant layout,

Apple, Inc. has been in the news a lot lately. Partly because of their profitability and stock value; partly because of labor controversy. At Strategos we take no position on the labor controversy or stock price.

Steve Jobs
"Those jobs aren't coming back."

We *can* comment on what little is known publicly about Apple's manufacturing operations—both current operations in China and past operations in the United States. When Steve Jobs

Apple's Key Manufacturing Task

Apple, from the very beginning has had a marketing and business strategy based on these characteristics:

- **Highly Innovative Products**
- **Fast Product Life-cycles**
- **Spectacular Promotions & Introductions**
- **High Quality**
- **Premium Pricing**

They have, generally, executed this strategy well over many years—but, that is another story. Our concern here is with the **demands this marketing and business strategy place on a manufacturing** system. The most important one or two of these demands become the **"Key Manufacturing Tasks."**

So what are Apple's key manufacturing tasks and what are their relative priorities?" This question leads back to marketing and product design.

Flexibility
More than anything else, Apple's marketing strategy requires flexibility in manufacturing. This flexibility comes in several forms

- **New Product Flexibility**
- **Volume Flexibility**
- **Product Mix Flexibility**

Apple's factories must be able to reconfigure for new products very quickly because of the fast life cycles (New Product Flexibility). The factories must be able to increase production from pilot to maximum demand quickly because of the initial promotions and short life-cycles (volume flexibility). If the factory cannot produce it probably has lost sales. Since sales forecasts are notoriously inaccurate and new product forecasts even more so, the factory must be prepared for a landslide, a fizzle and anything in between. Then, as the product life cycle nears its end, the factory must be able to decrease production and prepare for the next new product.

told Obama "Those jobs aren't coming back" he was probably correct. But, maybe, they didn't have to leave in the first place.

workflow and people.

As the design of a factory progresses, thousands of decisions are made by engineers, managers, contractors and suppliers. **A Manufacturing Strategy guides them** as they make decisions such as:

- Machine A costs more than machine B but it may be more adaptable to future products. Which to choose?
- Should we design the floor slab in this area for the light assembly operations originally planned? Or should we design it for machining and warehouse operations that might be in this area several years from now?
- Equipment in this area will be sensitive to vibration. The manufacturer says we can set it on a six-inch slab but should we make the slab thicker to absolutely guarantee the machine will be capable?
- Should we use conduit wiring (cheaper) or bus duct (more flexible)?
- How much space should we allow for purchased parts storage?

Such issues may seem technical, low-level and almost trivial—hardly the domain of top management. But the wrong decisions can have far-reaching effects. And, an accumulation of wrong decisions can saddle a company with a factory or multiple factories that does not meet current market needs yet is too expensive to replace. It affects long-term competitiveness and, eventually, stock price. **These are top management's domain.**

PDF

Quality
Apple has a reputation for good quality but quality is not their most important selling point. Good quality is important to Apple's customers because they perceive a risk in purchasing new, innovative unproven products. Once individuals decide that quality is good enough, they buy the products for their innovative features.

Consumers do not want to be stuck with an orphan or a lemon. Because of Apple's spectacular initial promotions, quality must be right in the beginning or Apple's reputation would be severely damaged.

For Apple, quality is what Terry Hill calls a qualifier. Apple does not need the highest quality in the market, just acceptable quality. A reputation for poor quality, however, would damage Apple's reputation with disastrous effects on the next new product. Hill calls such qualifiers "Sensitive Order-Losers." In other words, quality only becomes critically important if it falls below acceptable levels.

Cost
Apple charges a premium price and enjoys high profit margins. This means that, within limits manufacturing cost is not the most important consideration when designing or operating an Apple factory. Flexibility is far more important.

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Apple, Foxconn & Manufacturing Strategy

The Macintosh Factory

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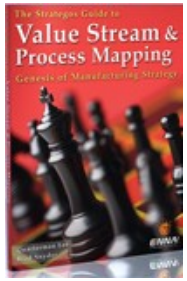

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The Macintosh Factory Video Tour

In about 1984 Apple Computer launched the first Macintosh and built a new factory in Fremont, California, designed specifically to build it. When that facility was **closed about two years later, the production did not move overseas.** It was shifted to other Apple facilities in California.

> Some of our conclusions in this article are informed speculation rather than proven fact. The scenes are often suggestive of issues that, in ordinary consulting work, would be confirmed or dismissed with additional data.

Apple is notoriously secretive. But they produced a **video tour** of their new facility that gives unintentional hints about various shortcomings and the probable reasons for its closure. The accompanying frames from this video illustrate and readers may watch the entire video on YouTube, below.

Scenes From The Video Tour


Conveyors are everywhere. This is a symptom of poor layout, excessive handling and functional operations. These conditions, in turn, contribute to quality and communication problems. The automated conveying systems Apple employed are very difficult to change.


MRP schedulers. This kind of overhead cost along with maintenance and engineering does not scale down easily when demand drops.


This gigantic ASRS system indicates high inventory and very poor supply chain performance. Combined with the MRP system it encourages large, unpredictable orders and probable shortages. Note also the wasted floor space.


Automated Guided Vehicles are rarely suited for high-volume, low variety production. they are symptomatic of poor layout and poor material flow.

In theory, they provide flexibility but there are usually more cost-effective methods.


The purpose of all this mechanical, pneumatic, electrical and logic circuitry and equipment is to flip a circuit board 180 degrees.


This automatic conveyor turns a circuit board 90 degrees. The operator pictured could have easily oriented the board as she set it on the conveyor if the workspace had been properly arranged.

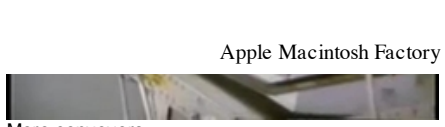
The facility was designed for high production of the original Macintosh. It appears that some other models may have been made there but it is doubtful that the facility was well suited to them.

After Apple's spectacular introduction of the Macintosh at the Superbowl, there was a surge of orders. But the **orders then fell and never really recovered.** It seems that the Mac had too little ROM, too little RAM, no hard drive, no software and no provisions for upgrade. This is when the real trouble started.

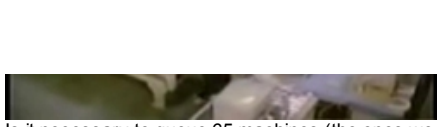
The Effects of Automation

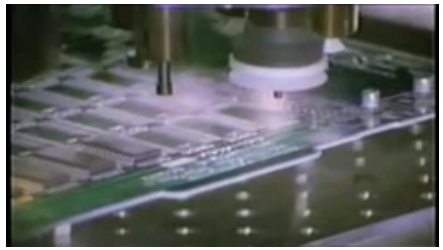
The facility was highly automated and designed for high production. It appears that much of this automation was unnecessary and not justified by cost savings. Moreover, the automation had negative effects on teamwork and quality. For an illustration of the problems created by separation combined with conveyors, see this I Love Lucy episode on YouTube.

This level of automation may (in theory) save some direct labor. But it **vastly increases indirect and support labor such as maintenance, engineering and scheduling.** It also increases other forms of overhead such as interest on the investment, cost of space, utilities and insurance. **If production slows, the overhead cash flow keeps going.**


More conveyors.


Automated shrink wrap conveyor.


Is it necessary to queue 65 machines (the ones we can see) in order to put one Mac in one box? This requires a lot of space and even more conveyors. It isolates the worker from the upstream operation. See I Love Lucy episode.


Automated pick & place for Surface Mount Technology.


Manual clipping of leads on through-hole components. Appears to be done in a separate dedicated area. This mandates a lot of material movement, hence the elaborate conveyors.


This appears to be a large area dedicated to automatic insertion. Could this be incorporated in a board fabrication cell along with manual insertion and other operations?


Manual insertion of large components in a dedicated functional area.


Dedicated visual inspection station. In a cell, this might be combined with some other operation.


More testing.


Transferring circuit boards from one location on the site to another using carts and an OTR tractor-trailer. Large Batching results.


Final assembly. No grounding straps, ESD smocks or leads.


Testing.

The ASRS, conveyors and WIP **wasted vast amounts of space** as seen in some of the scenes. This space was not usable for other production because it was intertwined with the automation which cannot be easily rearranged.

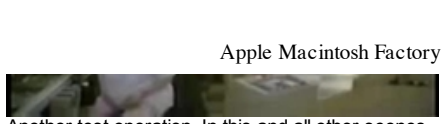
The Supply Chain

Judging from the size of the ASRS system the supply chain had significant problems. There may have been quality or delivery problems with the vendors. Or, the **MRP system may have created demand volatility** that the suppliers found difficult to deal with. This is very common with MRP systems and is one reason why they are inappropriate for repetitive, constant-rate production.

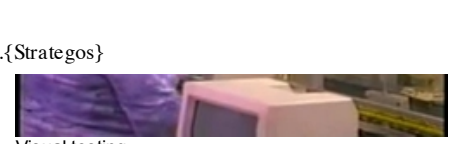
Quality

Apple depended almost entirely on inspect-reject for quality assurance with little effort devoted to preventing defects. Several facts make this clear:

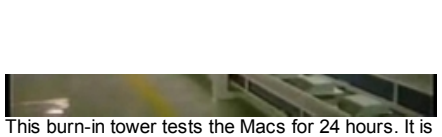
- There is not a single visible control chart or any reference to SPC, defect prevention or process improvement.
- There is great emphasis on the rework areas. Rework gets more "air time" than any other single operation.
- In this entire video there is not a single ESD smock, grounding strap or other sign of ESD control



Another test operation. In this and all other scenes workers are isolated from each other and have little opportunity to help each other or share tasks.

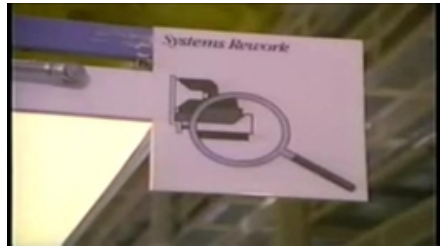


Visual testing.



This burn-in tower tests the Macs for 24 hours. It is HUGE. It may have been necessary because of a lack of ESD prevention.

Apple seemed quite proud of the rework areas.



More scenes of rework areas.

Finally on the truck.

Macintosh Factory Video Tour

control.

- The long 24 hour burn-in was probably necessitated by quality problems in general but ESD problems in particular. ESD is insidious and the damage may not appear for considerable lengths of time. this necessitated the large burn-in towers. These burn-in towers were huge, used a lot of space and must have required significant staffing; not to mention the electrical bill.

The Workers

The video talks about teamwork but the teamwork was limited to the basketball court. **Workers are separated and scattered by distance and equipment to such an extent that effective work teams would have been impossible.** To the extent that workers were aggregated, they were aggregated by function. "Team members" would not have had contact with the upstream or downstream operations but only others who were doing the same operation. They could not possibly have shared tasks or assisted one another in a significant way. This would have unbalanced operations and probably negated any direct labor savings from the automation.

PDF

Executing the Key Manufacturing Tasks

We previously identified the Key Manufacturing Tasks

and priorities for Apple as:

1. Flexibility (New Product, Volume & Product Mix)

2. Quality

3. Cost

So, how would Fremont have addressed these tasks? In a nutshell, pretty badly.

Flexibility

Clearly, the production system was very inflexible. New products might have been accommodated to some degree if they were similar in size and function. But **this factory could not have built the iPhone, the iPad or even one of the iMacs.** In its day, it could not have built the Lisa which was another of Apples products.

The big problem came with **volume flexibility.** When the Mac's sales dropped off the overhead stayed. Since the facility had substituted capital and overhead costs for direct labor, there would have been little opportunity to cut costs in line with volume.

Adding other products would have been impractical because every product would have gone through every department and the workers and equipment would have had to know all the products and

be able to switch back and forth quickly. The changeover costs and the additional quality problems changeovers create would have been horrendous. Not to mention the increased inventory.

Quality
There is no reason to believe that the products *shipped* from Fremont were deficient in quality. In fact, Apple has a reputation for good quality. However, that **end-product quality was paid for with a lot of testing and rework and was, surely, very costly.**

Cost
Cost should have been the lowest priority of the three "Key Manufacturing Tasks. However, there are limits. With such a large overhead and the inability to build other products, Fremont would have become unprofitable as volume declined. It is possible that the factory was never profitable given the inevitable startup and debugging costs of all that automation. **Apple certainly did not abandon their $20,000,000 factory because it made money.**

What Went Wrong

As was the case with Babcox & Wilcox, it appears that the **Apple planners failed to identify their Key Manufacturing Tasks** and then hold these tasks in mind as the project progressed and decisions made. This is a common error in facility planning and an easy error to make given the complexity and timeframe of such projects.

It is likely that the principle players in this project held opinions, desires and prejudices that influenced decisions unduly. **Without a strategy and without well-thought-out Key Manufacturing Tasks,**

such inputs can easily steer a project, imperceptively, in the wrong direction. Some examples of these attitudes might be:

- A fascination with technology and automation for its own sake.
- Undue focus on eliminating direct labor and material handling labor with insufficient appreciation for support and overhead labor.
- Overconfidence that the product will be successful for many years.
- Under appreciation for the role of people, teamwork and coordination in a factory.

Over the next few weeks, we will examine how Apple and Foxconn have successfully addressed these issues with their factories in China. And, Finally, how Apple **might have addressed them with U.S. factories.**

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Foxconn Delivers for Apple

The Foxconn Factory Video Tour

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The Foxconn Factory Video Tour

About The Video

This video is not the ideal factory tour. It was primarily used as background for a narrative on Foxconn's labor situation. As such, it emphasizes those areas with many employees such as final assembly and packaging. It shows few scenes from board fab and other areas. The editing jumps quickly from scene to scene for dramatic effect and makes it difficult to discern operational details.

Some of our conclusions come from frame-by-frame analysis which reveals more than a simple observation of the video.

Alternate Video Report

This short video shows some additional scenes at Foxconn. It is a much more impartial report about labor conditions and people than the Nightline report.

Key Features

Lines

One of the most striking features is the use of **long assembly lines with little automation and very short work times.** This is very similar to Henry Ford's approach of 90 years ago and for many of the same reasons (See Photo).

Foxconn, like Ford, uses unskilled labor and the migrant nature of this labor makes for considerable turnover. Short cycle times and repetitive tasks mean that individuals can learn a particular task quickly and are interchangeable.

Scenes From The Video Tour

Lots of people, short-cycles, repetitive operations and simple conveyors are the most striking features at Foxconn.

Packaging & Labeling workers using simple belt conveyor.

Assembly line at River Rouge complex. This is similar to Foxconn for the same reason--plentiful, unskilled and cheap labor.

Job applicants line up at Foxconn.

Job Applicants at Ford's Highland Park factory (1914).

Newspaper headline the day after Henry Ford's announcement of the $5 Day.

China's Manufacturing Environment

Capital for investment in sophisticated manufacturing equipment has been in very short supply in the past. On my first trip to China in the 1980's a Chinese official offered to barter our training for rugs, tools or weapons. That situation has changed but capital remains expensive compared to labor.

Chairman Mao was a schoolteacher before he was a revolutionary. While in power he emphasized universal education and that emphasis continues to this day. China now has a literacy rate of 92% overall and 99% in the younger population.

This has provided a huge pool of young, unskilled, inexperienced but teachable labor. In addition, China is growing a large cadre of technical graduates from trade schools and junior colleges.

Most line workers are young people from China's western provinces. They sign contracts to work for a year or so, travel to the Eastern cities and live in company dormitories. They may or may not return when their contract is over. The situation in the Western provinces is changing rapidly but for now, these provinces are agricultural and primitive. Educational policies give every Chinese child an equivalent high school education and this promotes a desire for a more rewarding life. A more rewarding life is unavailable at home, so they travel to the Eastern provinces and work for companies like Foxconn.

The work at Foxconn may include long and hard days but it is certainly better than walking behind a water buffalo from sunup to sundown.

Ford had a communications problem because most of his labor force came from dozens of different countries. Few spoke English and many could not speak their neighbor's language. China has about 130 languages and many more dialects. The line arrangement and short cycles reduces the need for communication and training.

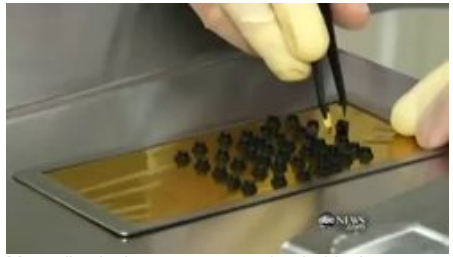
There appears to be about one supervisor for every four workers on this line. This ratio is also found in several other scenes.

NC machining of cases. Foxconn uses automation and technology when manual skills are insufficient.

Bill Weir of ABC Nightline takes an air shower to eliminate dust particles.

iPads move along a simple belt conveyor. Full bunny suits are required. Probably because the workers are touching unprotected circuit boards.

Weir displays a camera module and is apparently in a board fab area.



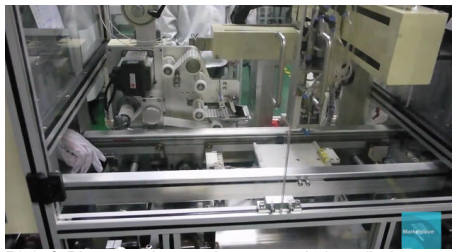
Manually placing components (probably the camera module) on circuit boards. Note gloves, tweezers and bunny suit.

Full bunny suits and ESD grounding straps indicate an effective ESD program and a concern for quality.

High level contamination control.

Bunny suits, gloves, ESD work surface and air ionizers for ESD protection.

iPad motherboard assembly. Note blue grounding strap on left wrist.



Pick & Place equipment just recently installed.

Final testing. No extended burn-in is required, probably because of the extensive ESD control and other quality control.

Motivation on a line is always problematic since there is little inherent job satisfaction and little opportunity for teamwork. Motivation is enforced through work standards and line speed in these situations.

Automation
since their labor is inexpensive and capital is probably in short supply (see below), automation at Foxconn is limited. Foxconn uses automation to compensate for unskilled and/or inexperienced workers. Automation is not used to eliminate work that can be done manually. In the video it is seen (and heard) in testing operations and for data collection.

Foxconn probably uses automation for SMT placement because manual placement of such small components is difficult and error prone. They seem to use manual placement of through-hole components. There are several scenes showing manual soldering operations.

There is some evidence that Foxconn has been adding automation on the iPad lines. Starting a new product with primarily manual operations and then adding automation gradually is a very sensible approach. It allows them to refine and stabilize the process and it allows demand to stabilize before committing to expensive capital expenditures.

Supervision & Support
The **line configuration requires considerable supervision.** By counting heads in several scenes, it appears that Foxconn has about one supervisor for every four line workers. This is a high proportion compared to typical U.S. manufacturing.

The line approach and large number of manual tasks would **require significant support from industrial engineering technicians** for time study and line balancing. Steve Jobs stated that Apple's suppliers employed about 700,000 workers and 30,000 engineers and engineering technicians. The technicians are thus about 4% of the total workforce, a very high proportion compared to U.S. practice.

Key Manufacturing Tasks

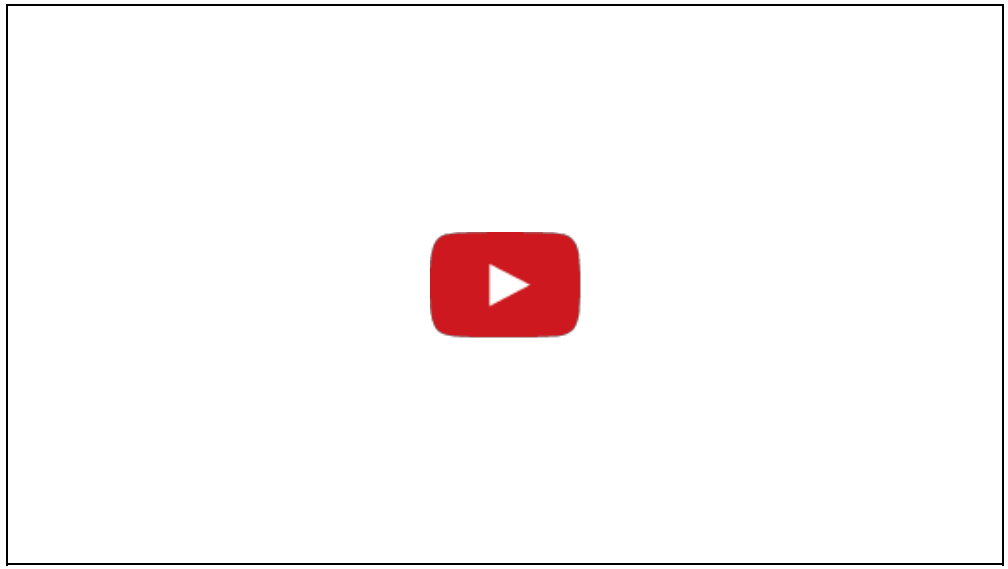
In a previous article we identified Apple's **Key Manufacturing Tasks as Flexibility, Quality and Cost** in that order. With their 1984 Fremont


This appears to be a burn-in area. Compare to the huge burn-in tower at Fremont.


In this packaging area there is a lot of activity and little inventory. Compare to the Fremont packaging area.


Bill Weir and Louis Woo chat in a staging area for an assembly line (immediately to the left). It is not exactly Just-In-Time but compare this to the ASRS at Fremont.

Foxconn Nightline Factory Tour



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factory, Apple failed to address the flexibility and quality tasks and this created a cost problem. Here is how Foxconn's Manufacturing Strategy addresses those three tasks.

Tim Cook, Apple's CEO, has stated that the primary reason Apple uses Foxconn and other Asian manufacturers is their flexibility for new products, design changes and volume changes. There are a number of legends at Apple about Foxconn's ability to adapt. One such legend has it that Steve Jobs demanded a glass screen on the iPhone just weeks before the product launch. Suppliers had to be found, new processes developed and lines reconfigured but it got done.

Foxconn's website defines their product as: Speed, Quality, Engineering Services, Flexibility and Monetary Cost Saving. This fits very well with Apple's Key Manufacturing Tasks.

Flexibility
The line production that Foxconn employs is not generally very good for *product mix flexibility*. While Toyota and some others have adapted lines to mixed model production this requires a wider range of skills and high motivation. It is doubtful that Foxconn could use their lines for mixed model production.

However, **mixed model production is not necessary for Foxconn**. Their lines are simple and the equipment is modular. It would be very easy to rearrange the lines and dedicate a line for each model. Some lines would be short, others longer to adapt to the model, the process and the volume.

Foxconn's lines can **adjust for changing volume** by simply adjusting the staffing, reconfiguring tasks and rebalancing the line. If there were significant and long-term changes in volume, the line can be re-configured fairly quickly. **Foxconn's line approach is very flexible for new products.** A line could probably be configured for a new product within a few weeks or a few months.

Quality
There is evidence **that quality is taken seriously and proactively,** particularly problems related to Electrostatic Discharge (ESD). There were no scenes in the video that showed workers handling boards or components without ESD protection. Several scenes from the video and other sources

Alternate Video Report
This short video shows some additional scenes at Foxconn. It is a much more impartial report about labor conditions and people than the Nightline report.

More at http://www.marketplace.org/

indicate very high-level ESD protection. Compare these scenes to the Fremont factory.

Cost
Foxconn's Manufacturing Strategy should allow the company to adjust to volume changes by shifting labor, space and equipment to other products if volume declines. This is probably where Apple's Fremont factory got into trouble--so much of their cost structure was in capital and overhead-- fixed rather than variable cost. And, Apple's automation prevented the use of the factory for other products.

Challenges for The Future

In the future, Foxconn will face many of the same challenges that Ford faced in the 1930's after its initial success. China will mature into a more modern society and prosperity will eventually filter down to the labor force. Wages are likely to rise and the inefficiencies of line production will overcome the advantage of low wages.

The One-Child birth control policy that China instituted in 1979 is affecting the pool of young laborers. Some of the Eastern factories are now reporting shortages of workers.

As opportunities for young workers increase, these literate young people will demand more from their jobs than just wages and mind-numbing repetition. Such dissatisfaction will likely lead to some form of collective bargaining, higher wages and changes in working conditions that reduce flexibility and worker efficiency. If Foxconn fails to address the motivation issue, as Ford did, their factories will become less and less efficient and more and more costly to operate. Foxconn will have to address the Socio-Technical issues.

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Apple and A U.S. Manufacturing Strategy

What Might Have Been for Apple

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Overview

Previous sections of this article reviewed the Manufacturing Strategy employed by Apple at their 1984 Macintosh factory and contrasted it with the Manufacturing Strategy currently employed by Foxconn to build Apple's products. Steve Jobs once told President Obama that "Those jobs aren't coming back."

- But is that necessarily true?
- What might a well-thought-out manufacturing strategy look like for a U.S. factory?
- Would it be possible?

Steve Jobs' assertion will probably be true in actuality but it is *possible* to manufacture effectively in the US. Intel, for example, has demonstrated that U.S. electronic manufacturing can be viable. A USA Manufacturing Strategy, however, would be different than a China Manufacturing Strategy and certainly very different than Apple's 1984 Fremont non-strategy. This article describes a possible US manufacturing strategy that might be effective for Apple's products and markets.

Key Manufacturing Tasks

Don't Miss the Next Installment
It will discuss other Aspects of A U.S. Manufacturing Strategy— Quality, Supply Chain, Scheduling, Focus.

The Key Manufacturing Tasks along with Terry Hill's concept of "Order Winners" and "Qualifiers" flow from marketing strategy. The Key Manufacturing Tasks are the basis for subsequent strategic policies as outlined below. This is the critical link between marketing and manufacturing. As noted previously, Apple's Key Manufacturing Task is flexibility. For Apple, flexibility is required in three flavors—

- **Volume Flexibility**
- **New Product Flexibility**
- **Product Mix Flexibility**

Cost and quality are qualifiers. Apple need not have the lowest cost because they have premium pricing and high gross margins. Apple does not need the highest quality in the market, only sufficient quality to reassure potential customers that they will not be stuck with a lemon.

Manufacturing Strategy

The Workforce

Lots of people, short-cycles, repetitive operations and simple conveyors are the most striking features at Foxconn.

Hundreds of chinese workers pull a roller. They are building a runway for B-29 bombers during world War II. This willingness to work hard at manual tasks persists to this day in China. But, it is starting to change as prosperity flows from the Eastern cities to other parts of China.

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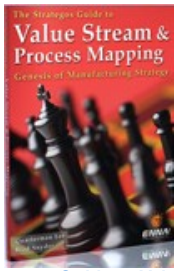

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Warehouse Planning Guide
Human Side of Lean Video

A US factory would not have the vast reserves of inexpensive labor found in China. However, when properly deployed, the American workforce has significant advantages and differences. Here are some key points:

Stability– The majority of Foxconn's workers come from China's Western provinces. They contract to work for a year. After that year they often return to their family or attempt to find other jobs in the large eastern cities. In the U.S., workers are more likely to be settled and seek work near their home. They are likely to be more mature and more stable in their employment.

Skills & Experience– Foxconn's Chinese workers are literate but generally inexperienced in industrial operations and technical skills. Their life in Western China has been centered on primitive agriculture. American workers, in contrast, have grown up with technology in all its forms and would be more comfortable with it.

Motivation– For Chinese workers, the poverty in their home villages, lack of a social safety net and few employment opportunities means that their primary motivation is money— for themselves and their families. Most are at the physiological level in Maslow's Hierarchy of Needs. In contrast, American workers would have few concerns about physiological needs or personal safety. Their motivations will be a mix of social, esteem and self-fulfillment. This will require differnet compensation, organization structure and plant layout.

Supervision
The Ford-style production lines employed at Foxconn require a lot of supervision. Observation of various scenes in the videos indicates about one supervisor for every four workers. A similar assembly line with more mature and stable American workers would require less than half that number of supervisors. Cellular Manufacturing should require even less, perhaps one supervisor for every 15-25 workers.

PDF

Note:
Steve's numbers are suspect— they are very large and very round. In 2008 the entire U.S. automotive industry, including suppliers only employed 880,000 people. this may be an example of Jobs' well-known "reality distortion field."

Since Mr. Jobs' figures may not be accurate, the chart starts with an assumed 1000 line workers and is then based on percentages. So, for every 1000 line workers in Foxconn's factory, a similar factory in the U.S. would probably require about 700. The reduction comes primarily from rational automation of tasks as discussed later. A U.S. Factory employing cellular production would probably require about 500 workers. This reduction comes from eliminating micro line imbalances and from improved motivation.

Total Labor Cost
Comparing labor cost is difficult because of the differences in fringe benefits, wage structures and because of the complexity of exchange rates and taxes. Foxconn workers probably have a base pay of about $2.50 an hour and workers for a U.S. factory would probably be paid, say, $15.00 per hour. Even a reduction in labor hours of 58% would not make a U.S. factory competitive on wages. But, it helps and labor is often only 5%-10% of total cost. GE, for example, is moving some appliance production back from China to Kentucky because of reduced wages for newer workers. Presumably their analysis shows it more profitable to build appliances in Kentucky even with $18.00/hour wages.

Workforce Summary
The differences in workforce background and motivation call for different approaches in several respects. A U.S. factory for Apple would emphasize:

- Hiring of mature, stable, socialized and teachable workers.
- Investment in training and education for workers.
- Team-based organization and work groups.
- Workflow arrangements on the plant floor that encourage teamwork.
- Incorporation of many supervisory, quality and technical support functions into the work teams.
- Compensation that emphasizes longevity and team performance.

Coming Next—
Our next installment will discuss other issues of a U.S. Manufacturing Strategy for Apple. These issues include plant layout, quality, supply chain and focused factories. All of these aspects are related to each other as well as to the workforce.

References

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Platzer, Michaela D. and Harrison, Glennon J., "The U.S. Automotive Industry: National and State Trends in Manufacturing Employment" (2009). Federal Publications. Paper 666.
http://digitalcommons.ilr.cornell.edu/key_workplace/666

Economix Editors, "The iEconomy: How Much Do Foxconn Workers Make?", The New York Times, February 24, 2012 .

Uchitelle, Louis, "Factory Jobs Gain, But Wages Retreat, New York Times, Business Day, May 5, 2012,
http://www.nytimes.com/2011/12/30/business/us-manufacturing-gains-jobs-as-wages-retreat.html?pagewanted=all

Industrial Engineering
Steve Jobs once stated that 700,000 people were employed on Apple products and 30,000 were engineering technicians. That equates to an I.E. Technician for every 22 workers. This is a very high ratio, necessitated by the unstable workforce and the production line arrangement. A factory making similar products in the U.S. would probably have about one IE Technician for every 50 workers.

Headcount for Various Scenarios

Category	Line Production China	Line Production U.S.	Cellular Production U.S.
Line Workers	1000	700	500
Supervisors	250	125	25
IE, Techs	43	20	15
Total	**1293**	**845**	**540**
% Baseline	**100%**	**65%**	**42%**

A Cellular operation requires far less engineering support because the workers are trained to perform these engineering and problem-solving tasks. A cellular operation in the U.S. would probably need about one IE Technician for every 200 workers.

The accompanying table shows estimates of the headcount required for three possible scenarios—1) Production Line Factory in China (Foxconn), 2) Similar Production Line Factory in U.S., and 3) Well Executed Cellular Production in U.S.

Apple and A U.S. Manufacturing Strategy

What Might Have Been for Apple (Continued)

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Automation & Equipment

When Apple built its 1984 Fremont factory, it appears that managed asked only one question about automation—"Is it technically possibly to automate a given task or element." The result was a factory that was very expensive, probably very expensive to maintain and unable to adapt to volume changes or new products. A more rationalized approach to automation, in line with Apple's Key Manufacturing Tasks, would consider at least the following issues:

- Can the task or element under consideration be combined with another task and thereby eliminate the need for automation?
- Is the automation equipment flexible enough to work with other products or plant layouts?
- Can the automation equipment be scaled up or down quickly in case volume changes?
- Is the task or element in statistical control without the automation?
- Will the equipment support requirements (Programming, Maintenance, Material Handling) outweigh the direct labor savings?

For a U.S. Factory, apple will need considerable automation compared to Foxconn's operation. Apple's Fremont factory automated much of the insertion and testing. Similar automation would be appropriate in a new U.S. Factory. Insertion, soldering and test equipment is flexible and, for the most part, can accommodate a range of products with mostly software changes.

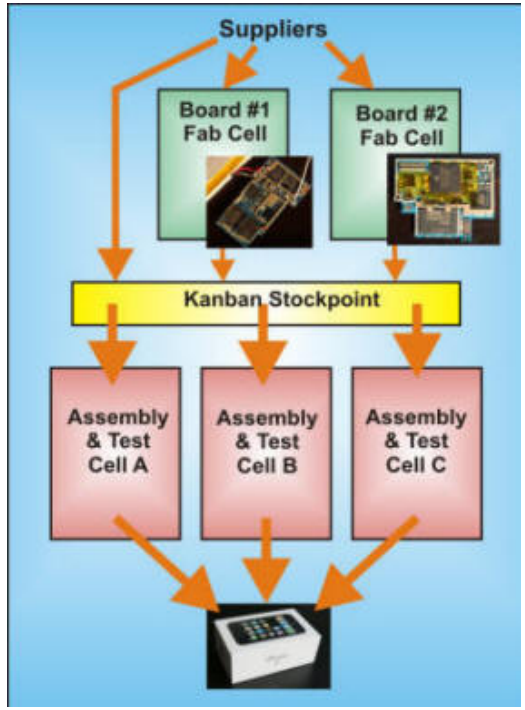
At Fremont, Apple also attempted to automate material handling and storage as well as the actual value-adding steps. This was a mistake for three reasons:

PDF

1. Handling automation tends to freeze the layout, the process and limits the range of products that might be built. This is at odd with the Key Task of flexibility.
2. The type of sophisticated handling automation Apple used was very expensive and had a poor payback.
3. Extensive and complex material handling is often a sign of poor process design and poor layout design. A more rationalized layout

Workflow & Layout

Moreover, their plant was arranged in functional areas which necessarily required considerable handling. A cellular arrangement has many advantages. Among them are improved quality, less handling, less inventory, improved quality and more **flexibility.**



Product Production Module

A module similar to this could perform all operations for final assembly, testing and packaging. The modules could be replicated to increase capacity or rearranged to produce other products as demand changes.

One of several possible arrangements is in the accompanying figure. It would have a board fab cell that would insert, place, solder and test motherboards for a particular product. The board fab cells would feed one or more Assembly-Integrate-Test (AIT) cells that would perform final assembly, testing and packaging. The device would then be ready for shipment.

Ideally, the board fab and AIT cells would be adjacent. However, differing

would have eliminated much of this handling.

environmental and infrastructure requirements may preclude this. The fab and AIT cells would have rough capacity balance. Short term differences in people balance could be resolved by exchanging workers temporarily. Fab cells would use flexible automated equipment that might be used for other products. They would have little or no material handling automation.

These modules of two or more cells become semi-independent **mini-Focused Factories**. They can be replicated in parallel to increase overall capacity or re-arranged for other products, thus providing the flexibility required by Apple's Marketing Strategy. A significant problem with this sort of arrangement involves learning and the experience curve. It will be necessary to have committees or other communication mechanisms so that experience and learning in one cell can be promulgated to other workcells.

Quality

As noted in an earlier installment, **quality for Apple is a "Qualifier"** for the customer's buying decision. Customers purchase from Apple primarily for product features, not because of quality. However, Apple must maintain a reputation for good quality (not necessarily the best quality) because customer's do not want to risk being stuck with a "lemon". Terry Hill [6] refers to such qualifiers as "**Sensitive Order-Losers**," i.e., higher quality will not beget more customers but quality that falls below market expectations could have disastrous effects on sales.

The suggested Manufacturing Strategy should include a strong quality component. It would make use of elements of Total Quality Management and/or Six Sigma. Every associate would receive basic training in SPC and process improvement.

Focused Factories [5]

Assuming that Apple would require multiple factories to satisfy overall demand, each factory should focus on a single product (or small group of products) rather than on a process or geographical region. For more on this topic, see our pages on The Focused Factory.

Scheduling

For the most part, scheduling should be simple and straightforward using Kanban or Broadcast rather than elaborate MRP systems as was done by Apple at Fremont. For more on this topic, see our page on Kanban Versus Other Methods.

Capacity

Apple executives have often commented that Foxconn can hire thousands of workers overnight and employ them to bring new products into production almost instantly [1]. **This is**

A recent article in The New York Times[3] examined the supply chain issue. Here are some quotes:

(a) “The entire supply chain is in China now,” said another former high-ranking Apple executive. “You need a thousand rubber gaskets? That's the factory next door. You need a million screws? That factory is a block away. You need that screw made a little bit different? It will take three hours.”

(b) “They could hire 3,000 people overnight,” said Jennifer Rigoni, who was Apple's worldwide supply demand manager until 2010, but declined to discuss specifics of her work. “What U.S. plant can find 3,000 people overnight and convince them to live in dorms?”

(c) Foxconn Technology has dozens of facilities in Asia and Eastern Europe, and in Mexico and Brazil, and it assembles an estimated 40 percent of the world's consumer electronics for customers like Amazon, Dell, Hewlett-Packard, Motorola, Nintendo, Nokia, Samsung and Sony.

(d) Another critical advantage for Apple was that China provided engineers at a scale the United States could not

When a new product (such as the iPad) arises Foxconn would probably do the following:

- Staff the startup operations by drawing experienced personnel from across the company.
- Use overtime and the capacity reserve to temporarily keep current products on schedule and gradually hire new people to fill in resource needs on current products.
- Rearange operations to consolidate excess space for the new product.
- Pilot the new product with surplus equipment and emphasize manual operations.
- Install more sophisticated equipment as the new product ramps up and the equipment becomes available.

None of the above measures are particularly novel nor are they peculiar to China. The aerospace industry, for example, has been doing them since the 1940's.

The Supply Chain

> match. Apple's executives had estimated that about 8,700 industrial engineers were needed to oversee and guide the 200,000 assembly-line workers eventually involved in manufacturing iPhones. The company's analysts had forecast it would take as long as nine months to find that many qualified engineers in the United States. In China, it took 15 days.

nonsense. It is probably true that Foxconn can hire 3000 17-year-old farm kids overnight. But then what? Where do they work? Where are their dormitories? They must be trained; their work must be organized and standardized. Is the industrial engineering being done by the 8700 brand new engineers they just hired? It seems unlikely.

What gives Foxconn the ability to bring new products online quickly is a **deliberate decision to build capacity in advance and hold a capacity reserve** of both people and facilities. This is an important issue of Manufacturing Strategy. This decision flows directly from a marketing strategy that emphasizes fast startup of new products.

Precisely how Foxconn does this is unknown but here is a pretty good guess:

- Physical facilities (dormitories, factory space, equipment) are built ahead of need and normally have some unused capacity.
- Because Foxconn builds many products for many other companies, some of these products will be in the declining phase of their life-cycle and have excess space, equipment & people.
- Throughout the company Foxconn uses temporary expedients such as overtime to increase overall capacity.
- Foxconn tends to use general purpose equipment and labor rather than specialized automation. This allows both people and equipment to be re-allocated quickly.

An argument has been made by Apple's people and others[1] that the entire supply chain has moved to China and, thus, a large-scale economic restructuring would be necessary to manufacture in the USA (Quote (a) from the Times article).

It may be true that much of the IC component manufacturing has moved. But what about printing and packaging? Or molded plastic parts? Or bare boards? The New York Times article quote (sidebar (c)) contradicts the proposition that this kind of manufacturing performance can only be found in China.

A recent article in *Apple Insider*[7] gives evidence that the processors and a significant portion of components are already made in the U.S..

Apple currently air freights most of their products between Asia and the US [2]. Approximately 70%-90% of a finished product's bulk and weight is in packaging, plastic and the bare boards. Importing IC components by air freight is much less expensive than importing finished and packaged product by air freight [2]. And, while it is desirable to have suppliers geographically close, it is not necessary. Toyota, for example, imported many components from Japan when they first started assembly in the USA.

And what about the willingness of suppliers to go the extra mile? There ***are*** suppliers in the US willing to do so but they must be sought out, nurtured and supported. In our consulting work, we have seen few corporate purchasing departments that are willing and able to do so. Such willingness is more often found in small and medium size manufacturing companies.

Should Apple Have Manufactured In The U.S.?

These articles argue that Apple probably ***could*** have continued to manufacture in the USA. A more open question is ***should*** Apple have continued to manufacture in the USA?

Tim Cook recently made the point that **Apple's forte is Product Design and Marketing** [4] and the company is better

References

[1] Samawi, Bachar, "Is there Apple Without China", Seeking Alpha, http://seekingalpha.com/article/460771-is-there-apple-without-china, 27 MAR 2012.

[2] "Apple's massive 'iPad 3' air freight deal with DHL shaking up shipping rates", Apple Insider, 5 MAR 2012, http://www.appleinsider.com/articles/12/03/05/apples_massive_ipad_3_air_freight_deal_with_dhl_shaking_up_shipping_rates.html

[3] Duhigg, Charles and Bradsher, Keith, How The U.S. Lost Out on IPhone Work, The New York Times, 21 JAN 2012.

[4] Video Interview, "Cook on Apple's Role in China and Manufacturing", All Things D, 29 MAY 2012, http://allthingsd.com/20120529/cook-on-apples-role-in-china-and-manufacturing-i-hope-people-rip-us-off-blindly/.

[5] SKINNER, WICKHAM, The Focused Factory, Harvard Business Review, May-June, 1974. Buy From Amazon

off leaving the manufacturing to companies like Foxconn whose forte *is* manufacturing. This is a compelling argument, It is certainly supported by Apple's experience at Fremont. However, it does leave open the possibility of finding a manufacturing partner in the U.S..

Another argument for Asian manufacturing is that the **future market growth** is most likely to be found in Asia and, particularly in China.[1] This too, is a compelling argument that goes beyond issues of Manufacturing Strategy.

We do not contend that Apple made a wrong decision when partnering with Foxconn for manufacturing in China. Apple's stock price alone refutes that proposition. **We do argue that there were viable alternatives; that Apple's decision was not inevitable.**

The Larger Context

In 1984 Apple did not understand the dynamics of factories or how factory design fits with marketing and product development. Foxconn, today, *does* understand the dynamics and the need for a fit. Together, these two large firms have forged a remarkable partnership and have enjoyed great success.

These same issues arise in most manufacturing firms today, not just Apple. It has been almost 40 years since Wickham Skinner originated the idea of Manufacturing Strategy. To this day these concepts are rarely appreciated.

SKINNER, WICKHAM, Manufacturing: The Formidable Competitive Weapon, Wiley, 1985. Buy From Amazon

[6] HILL, TERRY, Manufacturing Strategy, Macmillan, London, 1985. Buy From Amazon

[7]Hughes, Neil, Apple Insider, 19 JUL 202, http://www.appleinsider.com/articles/12/07/19/made_in_america_apples_supply_chain_increasing_us_production.html

LEE, QUARTERMAN, Facilities & Workplace Design, Engineering & Management Press, Norcross, Georgia, 1997.

HAYES, ROBERT H. and WHEELWRIGHT, STEVEN C., Restoring Our Competitive Edge, John Wiley & Sons, New York, 1984. Buy From Amazon

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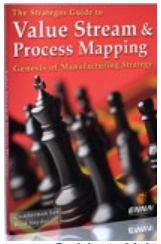

Strategos Guide to Value Stream & Process Mapping

Also...
Guide to Cycle Counting
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Why Draw Pictures?

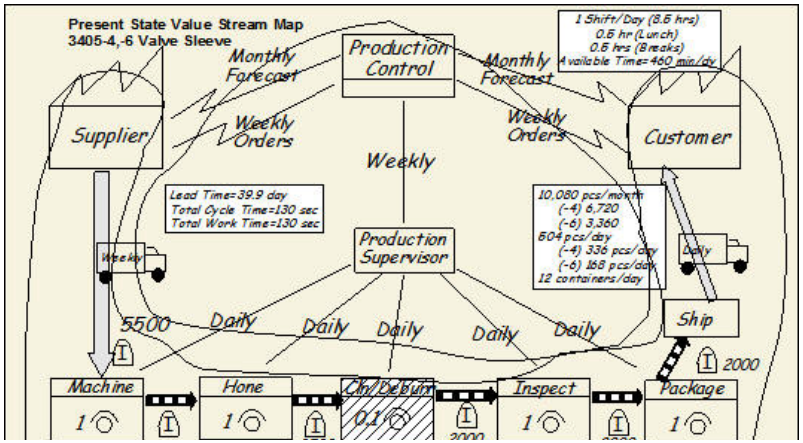
A factory is enormously complex. Only visuals convey enough information to understand the pieces, relationships, hidden waste and time-domain behavior.

Visualization brings a deep understanding and major breakthroughs in productivity and other performance. It leads to consensus on systemic problems and remedies. While finished charts communicate information about a situation, the real value is the mapping itself. This is where insights grow, paradigms shift and consensus builds.

Value Stream and Process Maps take different perspectives, but, the work they visualize is the same. Both have a place

Value Stream Maps

These show major process steps and often take a broader and wider view. They may group a wide variety of products into a single "value stream." Here is an example:

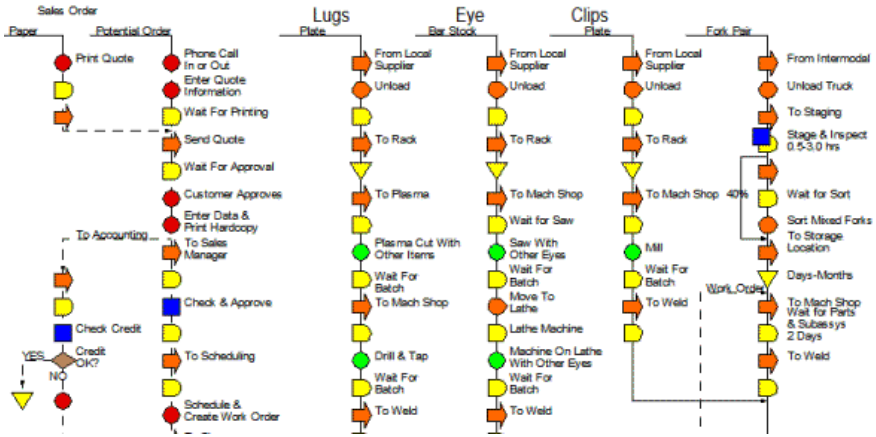


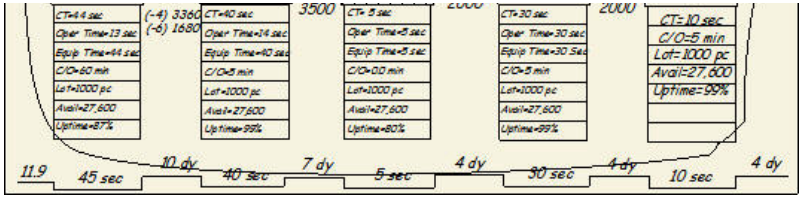
Process Maps (charts)

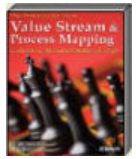
These are also known as "Process Charts" or "flow Process Charts". They trace the sequence of events for a single product. While they can be done at any level, the most useful charts are quite detailed. This is important because most waste is at a micro- level.

Frank Gilbreth's symbology, which we prefer, is simple and visual. One does not need the Rosetta Stone to decipher hieroglyphics. It dramatically displays waste. In this example, all but the green circles are waste.

Process mapping is a great tool for Kaizen events. Their simplicity makes them ideal when training time is limited.

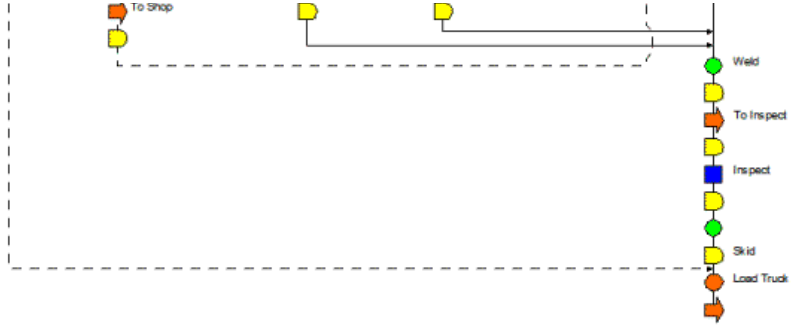






The Strategos Guide To
Value Stream & Process Mapping

Quarterman Lee's latest book on Value Stream Mapping and Process Mapping goes far beyond symbols and arrows. It tells the reader not only **how to do it but what to do with it.** More Info >>



Which To Use?

The short answer is both:

- Value Streams to identify opportunities
- Process charts to identify specific wastes and improvements

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