Short Lead Times = Tall Profits

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Introduction

This paper discusses how, today more than ever, companies are trying to gain a competitive edge and improve profitability through cutting costs, increasing quality and improving delivery. It concentrates on improving delivery through cutting lead times and shows how shortened lead times will both increase sales and reduce costs. It asserts that manufacturers can obtain the largest decreases in lead times through both re-engineering operations and through better capacity management with advanced finite capacity planning and scheduling. The paper then provides examples of the lead-time reductions, work-in-process reductions, and other business benefits of this approach.

Customer Performance Measures

To survive, manufacturing organizations must satisfy the demands of their customers. Customers around the globe demand product as they want it, when they want it, and at the best possible price. In manufacturing terms, customers demand world-class levels of quality, delivery and cost. In today's highly competitive global marketplace, customers will quickly drop any vendor that falls short on <u>any</u> of the three measures. Furthermore, fierce levels of competition are forcing manufacturers to continually strive for an advantage. Due to the efforts of the competition, yesterday's acceptable levels of performance are inadequate today, and today's adequate performance will fall short tomorrow.

Interrelationships among Measures

Traditionally, customers used price as their primary purchasing determinate and manufacturers viewed cost as the most important of the three measures. More recently, customers are placing greater value on quality and delivery. Manufacturers similarly have begun to place more value on quality and delivery. This is due to customer emphasis, but it is also due to interrelationships among the three measures. It is almost impossible for a manufacturer to have low costs without good quality and delivery.

Substandard quality and late delivery invariably mean that there is more waste than necessary; wasteful manufacturers are rarely low cost suppliers. Inferior quality usually results in extra inspection, sort and rework activities, excess inventory on hand to cover quality losses, production delays due to missing components, low resource utilization, and high costs.

Late delivery usually results in expediting, excess inventory on hand to cover against untimely production, excessive overtime, low resource utilization, and high costs.

The Lead Time Payoff

While acceptable levels of quality are crucial, this discussion concentrates on how superior delivery can improve profitability. There are two aspects to superior delivery.

The first involves keeping delivery commitments, or delivering product to customers, internal or external, when promised. The second involves keeping lead times, or the time between receipt of a production requirement and its delivery, at a minimum.

Of the two aspects of delivery, short lead times provide the most leverage. A company can use lead-times that are shorter than the competition's to generate large increases in profitability. First, the manufacturer can use the short lead times to generate increased sales, both in industrial and consumer marketplaces. Second the company can use the short lead times to drive down its costs.

In industrial markets, companies are introducing Just-In-Time production methods, reducing levels of purchased raw materials and components, and requiring suppliers to continually adjust to changes in production requirements. Vendors that can provide a wide range of components on time in the face of shifting demands will increase sales.

In consumer markets, the very nature of our fast paced society helps ensure that short lead times will lead to increased sales. More sophisticated marketing techniques have resulted in better-educated consumers. Technological change has led to a high frequency of new product introductions. The company that can quickly support marketing promotions and new product introductions with product can seize market share from less nimble competitors.

Shortened lead times can also result in drastically reduced manufacturing costs. The best way to understand the relationship between short lead times and low costs is to break lead time up into its segments: set up time, process time, queue time, and move time. During the process time segment of lead-time, a company is transforming components or raw material and bringing them closer to their final shippable state. Only during the process time segment is a company adding value.

If a manufacturer has inventory in house and is not adding value to it, it is incurring cost. Therefore, each lead-time segment, other than process time, costs money. Table 1 highlights these costs:

Table 1

Lead Time	Greater Costs From
Set Up Time	Increased overhead Decreased machine utilization Decreased labor productivity Forcing increased queue time
Queue Time	Lost opportunity cost of capital Greater quality problems Obsolescence Greater space requirements Taxes
Move Time	Increased material handling

Set up time increases costs due to the cost of the people and equipment to perform the set up. Set up time also results in lost machine utilization; typically when a machine is in a set up condition, it is not manufacturing product. When too many machines are in a set up condition, operator productivity decreases. Finally, when a machine is being set up, work is usually queuing up in front of it, building inventory.

Queue time increases costs because material waiting in queue ties up investment dollars that could otherwise be put to more productive use. Also, material waiting in queue ages, often deteriorates, runs the risk of becoming obsolete, consumes valuable floor space, and is often subject to tax.

Move times increase cost because the act of moving product requires people, equipment, and floor space for clear passageway. Like queue time, move time also adds inventory carrying and obsolescence costs. In addition, moving product increases the risk of damage.

It should be clear that reducing lead times could increase sales and trim costs. However, smart manufacturers only spend precious time and resources on activities with large payback. How much benefit can be gained from aggressively shortening lead times?

It is impossible to state how much shortened lead times increase sales. Much depends on the marketplaces in which individual companies are active. However, it is safe to say that the more competitive the industry, the more shortened lead times will help. In competitive industries, short lead times will differentiate a company from its competitors, leading to increased sales.

It is much easier to generalize on the cost savings that are obtainable through shorter lead times. Studies have shown that for many manufacturers 80-90% of total lead-time consists of queue and move time alone. If companies can cut the largely wasteful time product spends sitting or moving, they can also reduce work in process inventory. In many environments, reductions in work in process can have an immediate and significant impact on costs and profitability.

Obtaining the Benefits

How then should manufacturers go about reaping the benefits of shorter lead times? Companies can take many actions to shorten their lead times. These actions fall under two main categories:

1. Re-engineering manufacturing operations.
2. Better scheduling and control of production.

Spurred by offshore competition, companies are re-engineering their manufacturing operations. Many new terms describe the re-engineered production methods that companies are adopting, for instance Just-In-Time manufacturing, lean manufacturing, cellular manufacturing, and customer focused manufacturing. No matter the names, all these techniques can help manufacturers drastically shorten their lead times. It is not the purpose of this paper to exhaustively define and describe each of these methods. Rather, we will concentrate on how re-engineering, or adopting these approaches, improves manufacturing and permits lead-time reductions.

However, re-engineering manufacturing operations does not guarantee shorter lead times under all circumstances. Another step is required. Companies must schedule their re-engineered operations in the best possible manner and with respect to their limited re-engineered resources. To do otherwise would be to waste manufacturing resources. Since in the re-engineered factory waste, and therefore excess resources, is kept at a minimum, adding value to the wrong work can have dire consequences.

Re-engineered Operations

Probably the best way to describe the impact on lead times of re-engineered operations is to contrast them with traditional manufacturing approaches. An overview of this comparison is shown in Table 2:

Table 2

Traditional	Re-engineered
Similar equipment grouped together.	Dissimilar equipment grouped together.
Dissimilar products run on same machines.	Similar products run on same machines.
Wide set up variety.	Narrow set up variety.
Quality through sort and rework.	Quality designed and manufactured in.
Greater move distances.	Shorter move distances.

Table 2 shows that traditional manufacturing approaches group similar production equipment together. So, for instance, a company would group all its lathes together in one department, all its mills in another, and all its drills in a third. Most of the equipment in this approach is "general purpose". Quite often manufacturers produce a wide range of different products on the same piece of equipment. Since each of these products often has different physical characteristics and manufacturing needs, manufacturers are forced into long setups. Often, traditional manufacturers have not embraced quality techniques such as design for manufacturability and statistical process control. Therefore, high levels of sort and rework often plague them. Finally, grouping machines together by function means longer move distances. Product must move around the plant, from one group of similar machines to the next.

Table 2 shows that re-engineered manufacturing is very different than the traditional approach. These differences provide the opportunity for lead-time reduction. The re-engineered approach reduces the setup portion of lead-time through grouping into manufacturing cells different equipment that produces similar parts start to finish. Since similar product runs on the same machine, there is less variety in set ups and set up times naturally become shorter. Since manufacturers typically include aggressive setup reduction programs as part of re-engineering, they usually further reduce the set up portion of lead-time. Finally, re-engineering emphasizes high quality design and high quality manufacturing.

Short setups and high quality allow manufacturers to cut lot sizes. Reduced set ups allow manufacturers to set up more frequently without losing too much machine capacity. Quick set ups also eliminate the need to amortize the cost of the set up with long runs. Excellent quality eliminates the need to run extra production in case there are quality losses. Lot size reductions shorten the queue time portion of lead-time. Small lot sizes mean that product waits a shorter amount of time for lots ahead of it in the queue to be produced.

Re-engineered manufacturing also reduces the move time portion of lead-time. When companies group all the machines required for a products manufacture together, the ensuing compact plant layout leads to shorter move distances and times.

Finally, lead-time reductions feed on themselves and result in additional lead-time reductions. As lead times become shorter, a company can handle more customer demand directly with production. Therefore, the company needs to hold less finished goods (or near finished goods) inventory.

As a manufacturer moves more from a make to stock to a make to order environment, it can further reduce lot sizes because it doesn't need to produce to maintain inventory levels. These lot size reductions result in further lead time reductions.

The Need for Improved Scheduling

Re-engineered manufacturing reduces lead-time through allowing product to flow more quickly and easily through a manufacturing plant. However, queue times, and therefore lead times, are influenced by more than just the set up times and lot sizes previously discussed. The sequence in which companies schedule and run lots can dramatically impact queue time. For instance, if a lot is available to run but manufacturing runs other lots before it, the lot's queue time and lead-time increase. Therefore, the amount of uncertainty over which lot manufacturing should run next determines the need for scheduling. In a re-engineered factory, the amount of excess capacity available and the amount of variability in the environment affect this uncertainty.

Theoretically, if there is unlimited capacity available, each item number could run through its own manufacturing cell or line, making decisions on which items to run next unnecessary. This situation sometimes exists for high volume products in process and repetitive industries. However, most discrete parts manufacturers must maximize their capital expenditures by running multiple items over the same equipment.

Even if companies must produce more than one item type on the same sets of machines, scheduling is relatively easy in environments where capacity is consistently available and demand patterns are stable.

However, in today's manufacturing environment, this is not often the case. While more is being done to increase the dependability of capacity, machines break down, tools fail, and operators call in sick. In today's highly competitive environment, little can be done to smooth demand.

Customers are becoming more demanding and expect to get what they want when they want it, leading to extreme demand variability. In addition, companies are more rapidly introducing new products and phasing out old products. Early and late in product life cycles, demand is choppy and manufacturers have a hard time understanding the burdens products place on capacity.

When capacity availability and demand patterns change on short notice, smooth production flow through the plant becomes impossible to maintain. Then most manufacturers, despite actions to re-engineer operations, can only guarantee reduced lead times through better scheduling.

Finite Capacity Planning and Scheduling

Scheduling involves allocating limited production resources to production requirements. Since there is no need to schedule if excess resources are available, these production resources must be limited or finite. Also, since queue time exists because of limited resources, scheduling finitely is the only way to accurately show the impact of limited capacity on lead times.

The process of finite scheduling can require much detailed calculation. This level of calculation has made manual scheduling impractical except in the most isolated of circumstances, and, until recently, has limited the applicability of computer based scheduling. The arrival of fast, inexpensive computers with interactive graphics for the first time has made advanced finite capacity planning and scheduling a reality in a wide range of situations.

Advanced finite capacity planning and scheduling software starts with a model of the manufacturing facility. The model first requires information on the availability of key resources that the company wants to schedule. These resources include the machines, equipment, tooling or people that affect the capacity of the plant.

The model next requires information on the work to be scheduled. This information includes quantities, due dates of production requirements, and the duration particular resources are required at each manufacturing step.

Advanced finite capacity planning and scheduling software then requires the scheduler to specify rules that determine which production requirements have first access to the resources. These rules can range from simple, such as earliest due date, to more complicated, such as groupings to reduce set up. Given the complexity of the scheduling problem, none of these rules will give good solutions under all circumstances. Therefore, the software should allow the scheduler to intervene at any point in the scheduling process and change or override the scheduling rules.

The software should have graphics and reports to help the scheduler analyze the schedule he or she just created. This output should show when each operation of a production requirement will start and finish and the production requirements that will complete after their due dates. It should also show time phased machine, labor and tooling utilization. Finally, it should show queues building up, and calculate lead times and queue times for both individual production requirements and product families.

The scheduler should also be able to use the software for what-if analysis. The scheduler performs what-if analysis by changing either the model of the manufacturing facility or the scheduling rules, rerunning the effected portion of the schedule, and analyzing the results. The scheduler should be able to make changes at any point in the scheduling process, quickly see the effect, and be able to save multiple what-ifs for comparison purposes. What-if analysis can help with management decision making over the short, medium and long term. Examples of decisions finite capacity scheduling can help make are as follows.

Short Term - operational decisions such as:

- How should we determine individual lot sizes?
- How should we split lots?
- Should we use alternate routings?
- How should we work overtime?
- How should we compensate for machine, tooling or operator downtime?
- What delivery dates should be promised?

Medium Term - policy decisions such as:

- What general lead times should we quote customers?
- What lead times should we use to drive our MRP system?
- Should we add staff?
- Should we out source production?

Long Term - strategic decisions such as:

- Can we justify the addition of new capital equipment?
- Do we have sufficient capacity to handle a new product introduction?
- How should production be allocated over multiple facilities?

Benefits

The author is familiar with a wide range of discrete parts manufacturers who have seen dramatic business improvements through re-engineering operations and through implementing advanced finite capacity planning and scheduling. These improvements have surfaced first in shortened lead times and reduced inventory. Shortly thereafter, the benefits of re-engineering and finite capacity scheduling have cascaded throughout entire organizations.

For example, a manufacturer of mechanical fasteners has seen a 70% decrease in lead times and greatly improved machine and labor utilization. A producer of plastic closures has cut lead times from weeks to days and increased inventory turns from 10 to 40. A corrugated box manufacturer has halved lead times, improved utilization, and cut raw material inventory. A maker of knife blades has slashed lead times 50%, chopped inventory 33%, and cut set up labor by 20%. A machine shop has reduced lead-times 75%.

The manufacturers involved felt these measurable benefits were outweighed by other benefits, which are harder to quantify. Improvements that they attribute to re-engineering and advanced finite capacity planning and scheduling, but which are difficult to account for, include overall decreased costs and heightened competitiveness.

Summary

This paper discussed how manufacturers can reduce lead times and improve profitability through re-engineering manufacturing operations and implementing finite capacity scheduling. Re-engineering improves efficiency and product flow and makes lead-time reductions possible.

Advanced finite capacity planning and scheduling helps manufacturers examine the impact of different production sequences and guarantees lead-time reductions are achieved. In addition, finite capacity scheduling lets manufacturers examine the impact of proposed organizational changes. Together the two techniques can lead to significant decreases in lead times, work in process inventory and cost as well as increased profitability.

References

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More Information

This Paper was presented at the APICS International Conference. It is being provided with compliments from Waterloo Manufacturing Software. For more information about Waterloo Manufacturing Software's advanced finite capacity planning and scheduling system, TACTIC, Mr. Murgiano's other papers, contact:

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