White Paper

Simplified Market-Pull Scheduling

Dave Turbide

Dave Turbide, CFPIM, CMfgE, CIRM

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This White Paper report describes an innovative, simple and effective approach to lean manufacturing that was developed and proven by Michael P. Lilly and the staff of Lilly Software Associates (Hampton, NH). Simplified Market Pull (SMP) includes a 'pull' scheduling mechanism with appropriate controls and buffers that supports dramatic reductions in production lead-time and work-in-process inventory while freeing up available capacity and improving on-time performance and reliability. SMP delivers results in just weeks. SMP is appropriate for manufacturing companies that are market constrained, that is, companies with more than enough capacity to fulfill current demands. With slightly different scheduling mechanisms, SMP applies to both make-to-order and build-for-stock situations.

EXECUTIVE OVERVIEW

Most manufacturers today are operating at something less than full capacity. Ironically, many still struggle to get product out the door on time. And manufacturers will often turn down additional business because it is perceived to be unprofitable or too low-margin to be worthwhile. This situation is nothing new. Manufacturers have faced similar challenges many times before – whenever market demands have failed to consume the full capacity of the plant. Past and current methodologies, including MRP, finite scheduling, advanced planning, optimization, etc. have helped in some cases but many more companies have been unable to cure these problems by applying such technologies. Meanwhile, systems and controls get more and more complicated and production has lost touch with the needs of the customer.

Simplified Market-Pull Scheduling (SMP) is an alternative approach that is built on two principles: direct ties with customer demand (pull) and simplification. SMP borrows some ideas from the theory of constraints (TOC) and demand-based flow manufacturing but does not require a rearrangement of equipment as does flow, nor a drastic change in production control mechanisms as does TOC.

SMP directly attacks the problem of having excess capacity accompanied by difficulty in completing work on-time. With SMP in place, production lead-time is dramatically reduced and that excess capacity becomes clearly visible and available for productive use. The second part of SMP is directed at filling that excess capacity with additional business that raises both sales revenue and bottom-line profit.

SMP is lean manufacturing – incorporating the basic objectives of lean including reduced lead-time, reduced inventory, higher productivity (throughput), and "pull" scheduling. Importantly, SMP goes a step further by incorporating mechanisms to apply the newly released excess capacity to bring in new business, increasing revenue and profit.

CHALLENGES

Most manufacturers today have sufficient capacity to satisfy the current order rate (demand) with existing resources – people and equipment. In other words, they are more than capable of producing enough product to satisfy current demand. If additional sales could be captured, they could probably be accommodated without adding people, equipment, or overtime. In today's markets, unless you have no direct competition, product innovation is only a temporary advantage; price is dictated by the market; and high quality is assumed. The primary basis of competition, therefore, is lead-time. All else being equal, you win the sale if you can deliver sooner. In many instances, quicker delivery can justify a higher price.

Arguably the number one challenge facing manufacturers is completing work and shipping orders on time. Even with sufficient production capacity, we find that lead-times are too long and customers expect delivery sooner than we can routinely accommodate and usually sooner than we promise.

It is a fact that, in a traditional discontinuous production environment with work orders, lot sizes, set-up considerations and queues, the actual active production time is a small fraction of the overall lead-time to produce. The rest of the time, the work is waiting in queue or waiting while other pieces in the batch are being processed. Queue and waiting are a normal part of production, except in continuous flow manufacturing. ERP production control applications, finite schedulers, and APS scheduling logic are all aimed at managing the movement of work orders through the waiting times and the active times for the best on-time completion rates possible.

In a typical plant, the total inactive time is more than 90% of the lead-time. In some cases, it is much more than 90%. A product with a 6-week production lead-time, for example, likely has less than 4 hours of actual labor and machine activity. Conceivably, then, these products could be produced in less than one-tenth of the current lead-time if they could be moved through the plant non-stop – without waiting in queues. We actually prove this concept on a regular basis when we expedite 'hot' orders through the plant – bypassing less urgent work and eliminating the waiting time for these specific orders.

SMP is, in a way, like expediting every order. By greatly reducing queues, all orders spend less time waiting and get through the plant to completion much faster. And because there are fewer orders in the plant at any given time, it is much easier to identify which ones need priority treatment.

It is actually quite a simple matter to reduce WIP and lead-time, but you must remember that WIP is there for a reason. WIP inventory is what gives production management the flexibility to sequence jobs to meet priorities and maximize efficiency and utilization. SMP's pull scheduling takes care of the work flow management, eliminating the need for all that inventory, albeit a modest amount of WIP remains to provide some flexibility. One of the first steps to implementing SMP is to drain the majority of that WIP inventory out of the shop. But this can only be done safely with the new pull scheduling mechanism and buffers in place.

Once SMP is in place and WIP and work flow have stabilized, the company will find that the excess capacity that was already there will now become visible. You can quote shorter lead times for your products and meet those dates without expediting. Soon, you will be anxious to find ways to increase sales.

You can increase sales revenue by increasing prices for the same quantity of goods or by selling more goods at the same or lower prices. Unfortunately, in a competitive market you are often challenged to reduce prices in order to maintain historical volume. Not a pleasant situation.

In most markets, shorter lead time and higher reliability (better on-time shipment performance) provide the competitive advantage that will win the business at the same price that competitors charge, or in many cases allows the supplier to charge a higher price. In addition, the excess capacity is there to support new business. But how does SMP help you capture that new business? The shorter lead-time / higher reliability should certainly help. In addition, you can seek out incremental business at lower your prices while maintaining healthy margins. This seemingly contradictory result is possible through a different and more realistic view of costs that flows from the changed dynamics of plant work flow.

MARKET PULL SCHEDULING

The essence of market pull scheduling is to build products in short lead-time according to actual customer demand. Easier said than done? Of course. But once faster work flow is established, judicious release of work to the plant maintains the reduced lead times and keeps product completion on schedule. The two elements of SMP are the mechanism for work scheduling and the lead-time reduction implementation process.

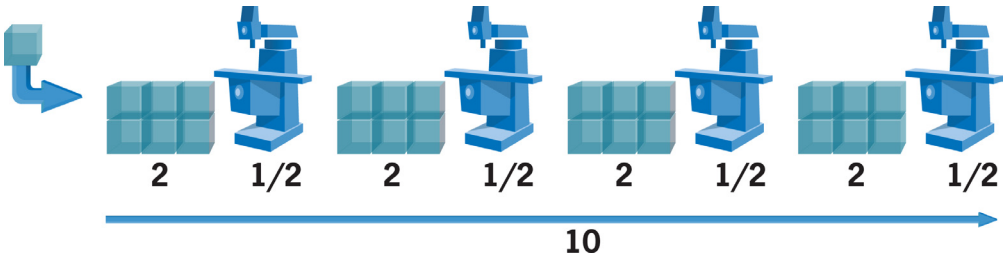
SMP SCHEDULING

An expedited work order moves through the plant more quickly because it bypasses the waiting queues in front of every workstation. The effective lead-time for an expedited order is significantly less than the lead-time for an order that moves through the shop 'normally'. Queues exist, in theory, to provide flexibility – allow operators and supervisors to select from among the accumulated work to (a) minimize set-up and changeover times by properly sequencing work, (b) insure that the workstation is kept busy (high utilization) by making sure that there is always work available, (c) move higher priority orders through the plant faster by changing sequence when selecting work from the queue. Queues are also the result of making product in lot quantities – work accumulates in front of a workstation that is tied up for a period of time processing a large lot – and as a consequence of undisciplined release of work to the plant. Some level of WIP in queues is beneficial in that it provides protection (from running out of work) and flexibility. The down side is that WIP queues increase the average lead-time to get work through the plant.

The smart solution is to reduce WIP and lead-time in such a way that we accommodate the valid reasons why it is there in the first place. One base assumption of this whole discussion is that there is more than enough capacity to complete all the work that is currently scheduled. Therefore, we shouldn't have to worry too much about minimizing set-ups and keeping the workstations busy – within reason, of course. We're not going to do anything foolish like ignore practical lot sizing considerations or engage in unnecessarily complicated changeovers if they are not justified. As far as flexibility to re-sequence work according to priority, we will continue to do that but in a better way – tied directly to customer demand – and we'll keep some WIP in the cycle to insure that we still have that ability.

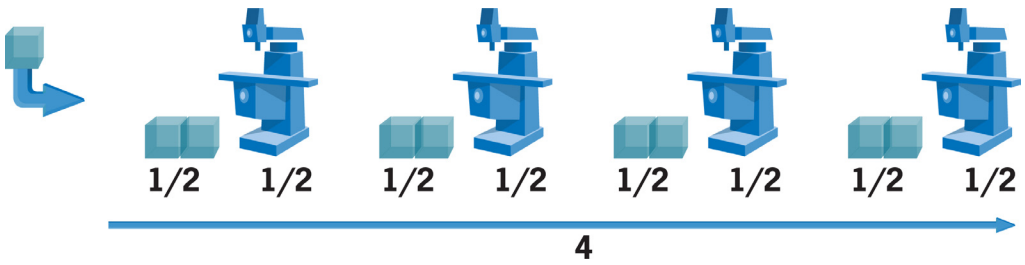
The best way to explain how SMP works is to use an example. Substitute appropriate figures to imagine how it could work in your own situation. Let's say that a manufacturer's products have a typical production lead-time of 10 weeks – not including

any procurement activities or long lead parts or materials. That lead-time is made up of a total of 8 weeks of queue time and about than two weeks active production. In an emergency, the company can expedite a product through the shop in two weeks or less – and they, in fact, do this regularly.



This company routinely quotes 10 weeks to customers, but frequently misses the ship date or makes it only through extraordinary means (expediting, overtime). The plant in not overloaded – sales are below the peak, demonstrated ability to produce and capacity has not been reduced significantly. The delays are the result of working through the queue (wait) times, work flow disruptions caused by expediting late orders, workers choosing the 'wrong' jobs to process next, and general confusion caused by too much work on the floor.

With SMP in place, customer quoted lead-time can be reduced to 4 weeks – a 60% reduction – and still maintain a 100% buffer (quoted lead-time more than twice what's required to make the product). Customer orders are taken with a ship date four weeks out. They are released to the plant four weeks before the due date. Plant scheduling uses a priority system based on due date to manage sequence and queues – keyed to the amount of lead-time buffer that has been consumed; similar to the critical ratio used in traditional production control.



With less WIP and queue, work moves faster and it is much easier to identify priorities. Disruptions are minimized because there is a lot less work to disrupt. The remaining buffer provides 'protection' from shifting priorities, machine breakdowns, set-up considerations, and uneven workloads.

IMPLEMENTING SMP

This all sounds good, and quite simple, but the question most likely to arise is how to reduce the WIP/queue level in the first place and how to keep it there. The answer to the second question is easy – use the SMP scheduling process to maintain work flow and WIP levels. Getting from 12 weeks of WIP to 4 weeks is not as easy. Here's how to do it:

Step one is to stop releasing new work to the shop. Continue to take orders as before, and continue to quote the 12 week lead-time, just don't release the work to the shop yet. At the end of the first week, there should be only 11 weeks of WIP left in the plant.

Continue this strategy for the next several weeks – accumulating orders while clearing the backlog of work from the plant floor. If some of the workstations start to run out of work, it is better to reapply those resources to help out in other areas of the plant, if possible, before judiciously releasing orders from the backlog to keep work flowing to those workstations. Be careful because this is breaking the rules and it can easily and quickly get out of hand, reversing the progress you have made toward your goal of shortening lead-time.

Eventually, you will have to start releasing new work into the plant. In our 12 week example, that point will probably come at about 5 or 6 weeks into the process. Theoretically, it should be at the 8 week point or later, but the reality is that there will be uneven demand on resources and the backlog will not be flushed out evenly and smoothly. The secret to success is to keep on it. Remain vigilant to the flow of work and the nature of the backlog and work into the new stance cautiously. Ideally, new work should enter WIP at about 4 weeks prior to the due date to establish and maintain the desired WIP level. Remember to substitute your own lead-times – existing and desired – in these examples.

Once new orders are moving regularly into WIP according to the new lead-time schedule, excess capacity should reveal itself clearly and obviously. You should apply this capacity to start working through the backlog, releasing work only far enough in advance to complete it by the due date (remember that your 'actual' production lead time is now shorter than it was before). Initially, you will release work only a few weeks later than you would have before. Soon, you will be able to release work much closer to the due date with full confidence that it will be completed on time. You will have to carefully monitor WIP and actual production lead-time through this transition process. In addition, you can seek out additional work (with shorter quoted lead-time) to fill in the gap while keeping the existing backlog entering WIP at the appropriate

time. That requires some additional effort on the sales side of the business but you are giving them new competitive tools – shorter lead-time and highly reliable delivery performance – so they should be able to leverage these for increased success against competitors and, perhaps, increased margins.

Be aware that your production start dates for new customer orders will now be later than previously required, so incoming component and material due dates should be adjusted accordingly. Otherwise, you will be building raw material inventory at almost the rate that WIP is reduced.

INCREASING SALES

Now that you have freed up the additional capacity that you always knew was there, you are ready to apply that capacity to increase production and profit. First, your reduced lead-time and increased reliability should make it possible for you to increase the business you do with established customers and take market share away from competitors. You might even be able to increase prices with existing customers. One company that started with this approach in 2003 reduced lead-time by 90% and cleaned up the entire past due and delayed work in the plant in just two months. At about this time, one of their largest customers began the negotiation of the following year's contract and started out by asking for a price cut. This customer had been placing monthly orders (to get the best quantity/price) but often called to expedite scheduled shipments. The manufacturer responded with a proposal to ship every two weeks and guarantee on-time shipment. The customer agreed to a price INCREASE based on the shorter lead-time and guaranteed performance.

A second part of the SMP approach takes a new look at incremental business for greater sales and profit.
Consider the following:

- A company has sales of $220K per month.
- Material cost is $100K per month
- Labor and overhead cost is $100K per month
- Profit is $20K per month
- Unit production is 10,000 pieces per month
- Unit cost is $20 per piece ($10.00 material, $10.00 labor & overhead)
- Manufacturing capacity is 75% utilized

There is business available in the market for 2000 units at a unit price of, say, $17.50. A traditional cost accounting view tells management to turn down this business as it is unprofitable – the company would lose $2.50 per unit for a total loss of $5,000. If, however, you consider that the labor

> "Perhaps the most important gain from lean, in addition to removing waste and inventories, is that it frees up cash, space, machine time, and human effort. Unless you have a plan to put this freed up capacity to work making additional products, the results are not going to show up on the bottom line. A lean strategy of waste elimination has to be matched with a plan to grow your throughput. We can no longer rely on a buoyant market to do this for us."
>
> – Professor Daniel T. Jones, co-author of Lean Thinking and chairman of the Lean Enterprise Academy, U.K. (www.leanuk.org).

and overhead costs are going to be paid whether you take this additional business or not, then it follows that the incremental costs for this incremental business is barely more than the cost of the materials. Using this logic, the cost per piece is $10.00 for material and the gross profit is $7.50 per unit for a total extra profit of $15,000 for the month. As long as the additional business doesn't interfere with production of the main products, and doesn't increase labor or overhead (overtime, for example), this could be the most profitable business the company has. In fact, in this example, the company can produce up to 3,300 additional units (we said 10,000 units was 75% of capacity) and any unit sales price over $10 each increases the company's overall margin.

INCREMENTAL BUSINESS	TRADITIONAL ACCOUNTING	THROUGHPUT ACCOUNTING
Additional Units	2000	2000
Unit Price / Revenue	$17.50 / $35,000	$17.50 / $35000
Cost per unit / total	$20.00 / $40,000	$10.00 / $20,000
Profit (Loss)	($5,000)	$15,000

Of course, you want to be careful not to cannibalize existing business at these lower costs. Perhaps you could poach on competitors' territory with special offers – or simply beat them on delivery and lead-time along with performance guarantees that your competition will be afraid to duplicate.

RESULTS

Companies implementing SMP have greatly reduced production lead-time, increased on-time delivery, and created opportunities to sell more product and increase profit. A number of these companies are in distressed industries where the improvements have literally saved the company from radical downsizing or worse.

ThermoFab is a Shirley, MA-based manufacturer of high quality molded equipment covers and panels for computers, medical equipment and business equipment. Business volume is down considerably from its peak a few years earlier, yet the company continually struggled to meet due dates and ship orders on time. They would typically quote 6 to 8 week delivery, and customers became used to getting their orders later than promised.

On August 7th of 2003, ThermoFab started an aggressive implementation of SMP principles with a target "live" date of October 30. Soon it became apparent that things were proceeding much faster than anticipated so the "live" date was moved up to September 15th. In the words of company president Tom King: "…only 39 days to transform ThermoFab into a company that can manufacture at warp speed – faster than any of our competition."

Within the first couple weeks of implementing SMP, the company gained a new level of control in the plant that allowed them to ship almost every order on time for the first month in the company's 25-year history – from 70% on-time at best to 98% . Soon, available capacity that they always knew was there became readily apparent – and usable – and the company began to work through its backlog and complete work on-time. ThermoFab saw an average decrease of 50% in lead-time (45 days to 5 days for one difficult part). On one particularly difficult job, a lot of 51 pieces produced in April took 81 days. In August, they completed a similar-sized lot in 8 days. On this same part, the April lot consumed 10.5 hours per piece whereas in August the labor content was measured at 3.125 hours per piece. The improvements in both lead-time and productivity are attributed to the changes that started on August 7.

The dramatic reduction in lead-time is a direct result of removing much of the work-in-process (WIP) clutter from the plant. Doing so, however, can be upsetting to the workers. Throughout this transition, company management continually reassured workers that the reduction in visible work was not a threat to their jobs and that nobody would be laid off or have hours cut as a result. This promise was tested as

the things stabilized and orders were shipping on time while equipment and workforce utilization dropped. This was the excess capacity showing itself clearly.

Rather than cut back on staff or work hours, ThermoFab focused on sales. One of the first opportunities arose when a long-time steady customer came up for contract renewal and another customer came to ThermoFab for a bid on a new job. Naturally, both customers were asking for price reductions. Heretofore, each customer had placed monthly orders in hopes of getting the best price for larger quantity orders. Both, however, frequently called ThermoFab to expedite some of next month's order into the current month.

Tom King reviews his logic: "All of the jobs involved take about a week to get through the plant now and could absolutely, positively, without question get done in two weeks. If (these customers) could get their customers to order bi-weekly instead of monthly, they would need to carry only half as much inventory to accomplish the same level of customer service." ThermoFab's customers could provide superior service to their customers, with less inventory investment, better cash flow, and significantly less floor space.

Tom King and his partner Michael Wahl (in charge of sales) agreed that they would go to each of these customers and offer them a slightly HIGHER price but would guarantee two week deliveries, backed up with a penalty payments if they fail to meet them; a penalty Tom and Michael are sure they will never have to pay. They were also sure that their competitors could not match the offer. This strategy has proved very successful, with ThermoFab securing a significant percentage of next year's business at a premium price.

Among all this good news, however, there are still some challenges. In October, there were some concerns in the plant that there was now too little work and managers began to think about cutting back on work hours. Amazingly, these concerns surfaced as the company was completing the best month in recent history. The increased throughput and productivity had, in effect, expanded the plant's capabilities. To cut hours would send the wrong message, especially since the employees had been promised that hours would not be cut. ThermoFab resisted the temptation, putting the extra worker time to good use in training to develop new skills and worker flexibility, and some plant improvement projects that had been postponed for lack of resources. Meanwhile, a full-out effort to bring in more business is underway to exploit the increased capabilities and increase revenue and profit.

The situation is similar at Platt Luggage in Chicago. Plant manager Walter Smreczak said in mid-October that they were

running through demand faster than ever before and had much of November's requirements completed. For example, an order for 50 special cases came in on a Monday. Although there were no (molded) shells for these cases when the order was accepted, the order went through production and shipped on Thursday afternoon, complete, without expediting and without disrupting other work. Before SMP, an order like this would have taken two weeks (or more).

As with ThermoFab, the accelerating work flow, improved productivity and shorter cycle times are moving the constraint to marketing. Marc Platt, company president, indicated that they are aggressively pursuing new sales, using reduced lead time as the primary competitive advantage and, if necessary, being more aggressive on price.

Marc says that everyone is "very excited' about the results that have been realized so far, like the faster cycle times and the greater throughput and most especially the elimination of the "wall of inventory" of molded shells. He did say that there is still some work force concern with the rapidly dropping inventory levels but that management is addressing the concerns daily in conversations with personnel to reinforce the fact that less is better.

These are just two companies that have seen dramatic improvements due to their implementation of SMP. Both companies have freed up capacity and are now using reduced lead-time and improved reliability to secure new, high-margin business.

SMP is lean manufacturing with a difference – it is quick to implement (and see results), it is simple in its concept and implementation, and it does not require the complete rearrangement of the plant (as with flow manufacturing) or radical changes in management philosophy and technique. SMP tools are straightforward and easy to use, although the 'people issues' can't be ignored.

Dave Turbide, CFPIM, CMfgE, CIRM
883 Ocean Boulevard
Hampton, NH 03842
(603) 926-1435
dave@daveturbide.com
www.daveturbide.com