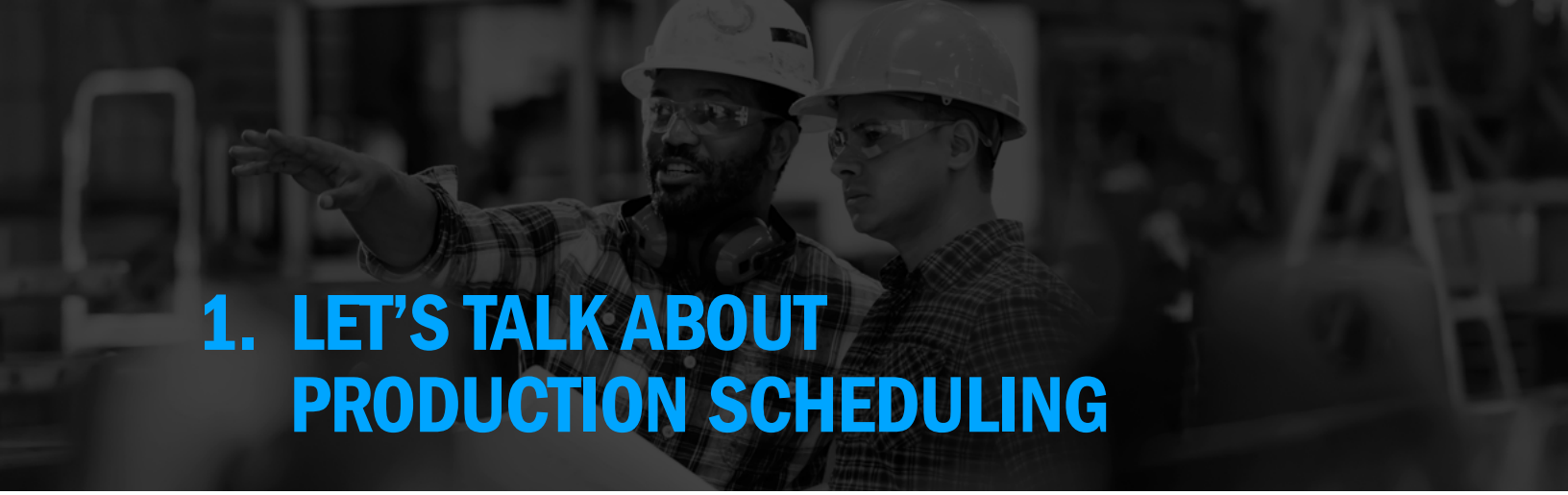
MCA CONNECT

LEAN MANUFACTURING PRINCIPLES AND WHAT THEY CAN DO FOR YOU

A Guide to Lean Manufacturing

TABLE OF CONTENTS



1. LET'S TALK ABOUT PRODUCTION SCHEDULING

Working with many complex manufacturers, we have found production scheduling to be a huge challenge. Some manufacturers use point solutions or customize to try to get their schedule to work smoothly. Other organizations have just given up on rigorous production scheduling and adopt a "launch and hope" approach (it's a bit hard to call it a strategy.) They count on the firefighting skills of their most senior workers to get product out the door.

However, when business volume is high enough, production scheduling must be automated, and operations must be in control all the time. Because these companies cannot afford to suffer a shop floor meltdown, they are continually exploring various operational excellence initiatives.

As we work with these high-volume and high-mix manufacturers, part of our job is to help design their future states. We specifically focus on their production scheduling. Our criteria to evaluate a future-state design are those lean design guidelines – but applied to a high-mix world.

Let's define production scheduling as the process of preparing work for release to manufacturing to build. Every ERP system supports at least some level of production scheduling. Mostly commonly, the ERP system will create production orders or work orders indicating what should be manufactured to meet demand. Demand can come from either actual customer orders or forecasted orders. Even in very lean operations, companies have some level of production scheduling.

The first rule for production scheduling is that work should not be scheduled if it can't be completed. Both capacity and materials must be available. Releasing work without both capacity and materials is a guarantee that WIP will increase. And that will inevitably result in lowering profitability. We'll start with building to takt time next.

2. WHAT EXACTLY IS TAKT TIME?

Takt time is the rate at which customers order your products. That classic definition sounds easy, but in high-mix manufacturing, customers order some products frequently and others infrequently.

The truest way to produce to takt time is to make to order (MTO). By making to order, you prevent overproduction which is the costliest waste. So MTO is always the ideal state. But pure MTO can be hard to achieve with high on-time delivery due to the inevitable spikes and dips in demand and the varying mix of products ordered.

The challenge with shortening the production schedule

As companies get leaner in operations, the production schedule length can drop from a week to a day to even every few hours. Shorter production schedules create a challenge because they reduce the flexibility of the value stream to respond to dips and spikes in demand. Flexibility is key to being able to build to takt time for high-mix manufacturers.

Avoiding overproduction

Many manufacturers we work with only adopt MTO for final assembly. Indeed, different feeder operations like machining, stamping, foundry, or painting are much more difficult to move to MTO. This is because of requirements to produce products together in large batches to minimize non-production time for changeovers or batching. From a lean perspective, batching for any reason is overproduction, so batching should be avoided or minimized wherever possible. That's why SMED or setup reduction is such a useful lean tool. When a company can extend MTO into feeder areas, they can realize the financial benefit of freeing up cash as inventory levels decrease.

Taking a hybrid manufacturing approach

If pure MTO is not possible, then a hybrid of MTO and MTS (make to stock) manufacturing is the next best approach. The company then has some inventory on hand that can be used to provide a buffer for spikes and dips in demand. Inventory is pulled during a spike in demand and replenished when there's a dip.

An MTS strategy assumes that you can confidently forecast what your customers will order. That's a key assumption because forecast accuracy is often quite low. When a forecast is too high, you must keep that extra product in your inventory. Products held in inventory must be stored, counted, and managed for obsolescence until they are ordered next. In addition to the cost of the inventory and inventory holding costs, your overall risk has increased as well.

Which products should you consider for MTS?

You should first look at the most frequently ordered products. In lean terms, your runner products are candidates for MTS, while your repeater and stranger products are best as MTO.

5 RECOMMENDATIONS FOR MTS AND MTO MANUFACTURING

- Apply MTS and MTO considerations based on order frequency to every level of your bills of materials.
- Design your production schedule to cover all end-products and sub-assembly levels.
- Build as close to takt time as possible with just a few MTS products as a buffer.
- Continually review your forecasts and measure your rate of accuracy.
- Make continual efforts to reduce anything that forces work by batches.

3. WHAT IS FLOW?

Flow is manufacturing production that is done one piece at a time from process to process without stopping. The lean manufacturing industry ideal state is to have a one-piece flow with a batch size of one.

Using the wrong manufacturing performance metrics

CFOs often want to look at asset utilization and labor efficiency rates. However, in a manufacturing operation, optimizing for these two metrics can be a mistake because you have to:

- Process large batches that reduce the downtime required for changeovers.
- Isolate each process so it can run independently.
- Create an inventory buffer so there's always work for the operator and machine to do.
- Optimize for efficiency, freeing the operator from any upstream interruptions, but at quite a cost.

What's the downside of large batches?

When you are running large batches, instead of focusing on flow, you will experience:

Increased inventory

You not only have more inventory holding costs and cash flow tied up, but you increase the risk of inventory obsolescence.

Longer lead times

To hold all the inventory buffers you need between processes, you extend lead time. Longer lead time makes it harder to move to make to order (MTO).

More product quality problems

When you produce large batches, you also produce problems in large batches. Often defects aren't discovered until later in the overall process, which result in more scrap and/or rework.

Process problems remain hidden

When every process in flow must stop for any issue, the visibility is immediately raised.

Moving to flow instead

Moving to flow reduces inventory and lead time and can contribute to reductions in scrap and rework. Flow forces a “horizontal” view of the interrelationships between manufacturing processes rather than a more siloed vertical view. That’s why flow exposes all kinds of process problems, highlighting every issue that forces a stoppage anywhere in the flow line. Equipment breakdowns, changeovers, yield issues, even bill of material inaccuracies will stop a line from producing. Production is also impacted by these same issues in a traditional manufacturing environment, but the issues remain hidden behind big piles of inventory.

Using FIFO for flow

In situations where flow is not strictly possible due to machine limitations of differing cycle times or changeover requirements, flow can be implemented by using a FIFO lane to accommodate small amounts of buffer inventory in order to smooth the process. So long as FIFO lanes strictly observe the first in, first out rule, they can be classified as flow.

Production scheduling using flow

From a production scheduling perspective, flow is very simple. You just launch the work for the first flow process. The rest of the processes in flow are automatically scheduled based on the work started. Production automatically stops when the upstream process stops. When using FIFO lanes, the process stops when the inbound FIFO lane is empty or when the outbound FIFO lane is full. This process is easy for operators to understand. Production scheduling just got a whole lot easier!

As we develop a future state, we should implement as much flow as possible but then continuously look at what causes stoppages and eliminate those stoppages. Doing so will reduce inventory, reduce lead time, and increase profitability.

4. SUPERMARKETS AND PULL

The fourth of the seven guidelines for designing a lean future state is to use supermarkets to control production where continuous flow does not extend upstream. Ideally, in a lean manufacturing industry environment, every operation flows from the first, but that may not be possible due to limitations you just can't get around. That's not to say we don't continually poke and prod these limits, but we are often up against what our production equipment can support.

What limits continuous flow?

Typical factors that prevent flow include:

Changeover times

Changeover times include activities such as switching colors on a paint line, changing temperatures for a heat treat, or refreshing chemicals in a plating process.

Inherent batch requirements

Process manufacturing processes hit this limitation all the time with engineering constraints of vessel size and surface area.

Limitations of resources

This limitation happens when you are waiting for tools, fixtures, or other scarce resources to free up from one process so they can be used by another.

Without continuous flow, how do you prevent downstream delays?

When flow cannot be supported, we recommend you establish a buffer inventory (commonly referred to as a supermarket) after the process where flow is not possible. This supermarket will allow the downstream process to always have inventory to draw on as needed.

The process itself is responsible for maintaining a supermarket inventory to protect its downstream processes from stockout delays. When inventory is removed from the supermarket by the downstream process, a pull signal is sent to replenish that supermarket. Ideally this is "use one, make one" but sometimes you end up making several at a time for the same reasons that flow wasn't possible. The pull signal or kanban can be anything – a physical card is common, but an empty tray, an empty rack, or a depleted spindle are equally valid.

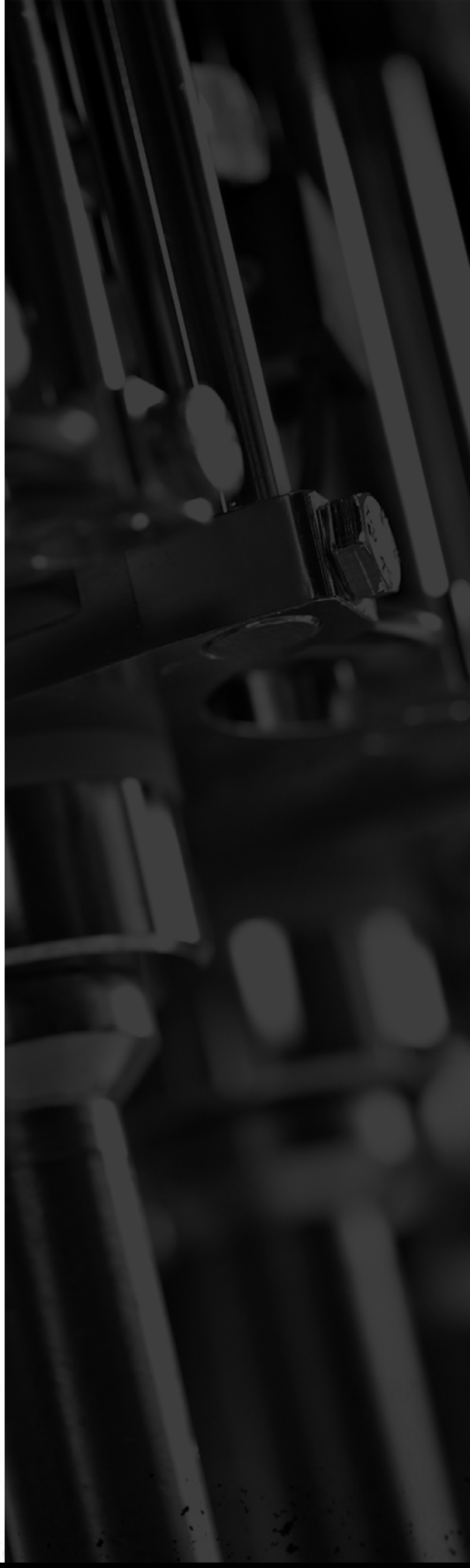
Now you can calculate targeted stock levels for supermarket items

Because you have a supermarket, you are back to a make-to-stock (MTS) scenario. As such, you can calculate a targeted stock level from actual history, forecasted demand, lead time, and safety time understanding the service level of the inventory that must be supported. The service level reflects the level of stockouts that you are willing to allow. There is a direct relationship between the amount of inventory, the lumpiness of spikes and dips in demand, and your tolerance for disruption to downstream processes due to stockouts. This calculation of the targeted stock level lets the team know how many kanbans are needed.

How do supermarkets impact production scheduling?

For production scheduling, supermarkets with pull signals are very simple. Each process supports its own supermarket on an as-needed basis only. There is no independent scheduling needed, the process simply responds to replenish the supermarket as it is drawn down.

Future state design must include supermarkets for every process which cannot flow and must include not just the concept of kanbans but the number of kanbans needed by item and the targeted stock level. Beyond that, you need processes for continual review of targeted stock levels to "resize" the kanbans. Kanban itself is not an inventory reduction strategy until it is tied with processes to review and reduce the number of kanbans needed. Our lean manufacturing software can help you map out your value streams and lean manufacturing future state design – with supermarkets when needed.



5. THE PACEMAKER PROCESS

Quick review

Our previous guidelines called for developing as much flow as possible and then introducing supermarkets with pull-based replenishment where we could not flow from an upstream process. Everything downstream from the process that initiates flow is automatically scheduled based on one-piece flow from the prior process or flow through a FIFO lane.

Upstream from the initial flow process are supermarkets that hold buffer stock. Each of these supermarkets is replenished by a process exclusively dedicated to maintaining the targeted stock level for that supermarket. When the supermarket is drawn down below its reorder point, the replenishment process is triggered with a kanban or pull signal to build more, but only enough to replace what was used. So, all these replenishment processes are likewise scheduled.

Moving from pull to flow

The process where we move from pull to flow is called the pacemaker process, also known as the schedule point. The pacemaker production process is controlled by the customer's orders and is the single point of scheduling for the entire value stream. Work launches at the schedule point and the rest of the value stream responds in flow downstream and pull upstream.

Optimizing the pacemaker process

The design guideline is to try to release customer-scheduled work at a single point. In simple operations that's not hard to do. In high-mix operations, finding a single pacemaker can be challenging. There may not be a single process through which all work flows. You may end up with pacemaker processes by product family. There may be multiple independent production lines to build the total volume required each of which has a pacemaker process.

Scheduling pacemaker processes

Just how do we schedule our pacemaker processes? If we go back to our first principle of production scheduling, while we launch work at the pacemaker or schedule point, that process may not be our overall capacity constraint (or bottleneck) and we may have material shortages that limit how much we can build. That means that we should not release work to the pacemaker processes without considering the capacity limits anywhere in the value stream – including considering the material availability not just of end products, but of every sub-assembly and raw material component as well. In high-mix manufacturers, here's where lean manufacturing software is essential.

When you have more work than material

Let's consider what happens if we release more work than we have material to build. Work will start and products will be partially built when we hit the last of a needed component. What's the impact to the production line? One option is that all work stops until the part arrives. But in a high-mix world, just because we have run out of a component for one product may not mean that the entire line must stop. We may have plenty of components to build other products. In order to keep going, we may be tempted to pull semi-finished products off the line and hold them aside until later. As you can easily imagine, these unfinished products clutter up your operation and require you to keep track of where they all are, how far you got, and what's left to go on each unit. You also risk damage due to multiple movements. In addition, you are consuming material resources for un-shippable inventory, which may cause a shortage of those common components that could be used to build other (shippable) products.

When you release too much work

What happens if we release more work than we have capacity? The first step is to identify the capacity bottleneck. Recognize that capacity constraints are not always at the same process and not all products may require the constrained process. In that case, when we hit the actual capacity constraint, the work ahead of that process must wait. On its own in one-piece flow or with FIFO, that will cause the upstream processes in flow to stop as well. And with supermarkets and pull, the constraint process will reduce the pace of withdrawals from each supermarket. Of course, we still must deal with where to put the work that is queueing up ahead of the capacity constraint. What can make this even more challenging is that the mix of products ordered can vary from period to period so the capacity bottleneck can move from one process to another.

Our future state design must then identify the pacemaker processes where work launches into the value streams and identify the means to ensure that the scheduled work does not exceed available capacity or material across our entire operation. That can be a challenging order!

6. LEVELING THE MIX

This section will discuss the sixth of the seven guidelines for designing a lean future state, which is to level the production mix by distributing production of different products evenly over time at the pacemaker process.

Unconventional thoughts on batching

While it's easier to schedule long runs of one product type to avoid changeovers, larger batches create serious problems for the rest of the lean manufacturing value stream. Larger batches increase the lead time to fulfill any order and makes your operation less flexible.

Rather, we recommend you level out the product mix by spreading out the work as evenly as possible over time and running with as small a batch as you have capacity. While this is contrary at every level of conventional thinking, you should use all of your capacity to run as many changeovers as possible in order to keep your batch size as small as possible.

Why smaller batches can be better

Let's say you schedule production weekly and the pacemaker is producing three different products. We could accomplish our work by running each product once a week and incur only three changeovers. That would mean that we are producing in batches of 1.67 days with a lead time of over three days. If we can absorb the changeover time to run each product each day, then we have moved from three-day lead time to just one-day lead time. Do the math! That strategy can free a lot of cash tied up in inventory. If we can move that from eight hours to two hours, we now have a four-hour lead time and may be able to move our entire operation to make to order.

Look at it graphically

Without leveling the mix:	**AAAAAABBBBBBCCCCCC**
First improvement to level the mix:	**AABBCCAABBCCAABBCC**
Ideal state of leveling the mix:	**ABCABCABCABCABCABC**

You produce the same number of units but reduce the frequency that you produce each unit.

Leveling production in a high-mix manufacturing environment

For high-mix manufacturing, the pacemaker process may have many products that can be produced. However, not all these products may be ordered in any schedule period. Some manufacturers plan for a rotating cycle of their highest running products and then reserve a certain amount of time on each schedule to accommodate the infrequently ordered items. Of course, some products take more time to build than others and some have higher volumes.

Leveling might result in the following:

High-mix leveling:	**AAABBCAAABBCAAABBC**

There's a repeating cycle of all products being produced subject to capacity constraints at the pacemaker.

The more you can level out the product mix at the pacemaker, the more your manufacturing operation will be able to reduce lead time and reduce inventory. This guideline helps us come ever closer to being able to produce to our ideal state of one-piece flow with a batch size of one.

7. LEVELING THE VOLUME

This guideline is perhaps the least known of lean principles – pitch. Our goal is to release work to the pacemaker processes in small increments and then manage each schedule to ensure completion.

Understanding the pitch process

Pitch is the lean term for the consistent increment of work released to production. The pitch period is the length of time that the increment of work covers. The value of pitch is to set the timeframe for management feedback and reporting. If you release work with a pitch period of a week, you'll only know at the end of the week whether you achieved your week's production. If you release work daily, you'll know day by day but not more frequently. If you release by shift, each shift can know if they are ahead or behind. Better yet, if you release with a four-hour, two-hour, or even hourly pitch, you can know if you are ahead or behind much more frequently. The more frequently that you can monitor your production progress, the shorter your time to respond to issues that may impact your delivery to customers.

The broader concept is called fixed interval scheduling. With fixed interval scheduling, work is released to all operations in a consistent rhythm with all work linked to each schedule to track start and end time. Schedules produced for each pitch period must be confirmed to have available capacity and available material.

Working with limited staging space

Fixed interval scheduling is an effective mechanism when there is a limited amount of space to hold products coming off production before shipping. In some very high-volume plants, there may not be physical space to hold and stage products for shipping for more than a couple of hours. In these situations, the fixed interval scheduling process must also observe any requirements for shipping complete orders. That may be especially challenging with products for a single order produced across multiple production lines. In these situations of very high-volume manufacturing, production scheduling must be highly controlled.

Fixed interval scheduling must be planned at least as far ahead as the lead time of make-to-order (MTO) sub-assemblies plus final assembly. In doing so, true MTO flow can be supported from feeder areas into final assembly. When feeder areas are not in flow, supermarkets provide an intermediate buffer to isolate upstream operations.

The future state design of your value streams across all operations must identify the pitch period and other requirements for fixed interval scheduling. Once in place, continuous improvement efforts should focus on the obstacles to reducing pitch to shorter and shorter intervals. The pitch period will be limited by the batching that remains necessary despite our best efforts to eliminate or reduce it.

CONCLUSION

You don't hear about these lean manufacturing guidelines much these days. The lean manufacturing talking points have shifted away from "tools" toward an emphasis on "culture". While we believe culture is still important, we think that manufacturing companies miss many of the concrete bottom-line benefits of lean when they ignore these key principles.

Every lean journey begins with a first step, but sometimes manufacturers don't know what that first step should be. Download our Lean Starter Guide for step-by-step instructions on how to begin a successful lean journey or contact us to talk more about lean solutions.

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GET STARTED BY SCHEDULING AN INTRODUCTORY MEETING.

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