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Making Enterprise Business Systems Pay Dividends

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PROTECTED FLOW MANUFACTURING

A NEW APPROACH TO PRODUCTION PLANNING AND EXECUTION OVERCOMES LIMITATIONS OF MRP AND FINITE SCHEDULING

MRP veteran Richard T. (Dick) Lilly was an early pioneer. Working alongside Ollie Wight, he helped make MRP the game-changer that it was in the 1960's. Yet he saw MRP's limitations and continued to seek "a better way" to plan and execute production. Ultimately, he found it.

Back in the day, Material Requirements Planning (MRP) was a game changer. In taking a combination of actual and forecasted demand, cascading it through multiple levels of bills of material, netting exploded demand against existing inventory and planned receipts, it was able to create a plan that included purchase orders, shop orders and reschedule messages. Given these bills of material can be many layers deep and encompass hundreds or even thousands of component parts and subassemblies, without automated MRP there is simply too much data and complexity for a human to possibly work with.

Yet, while MRP was able to replace other archaic, clumsy and inaccurate planning methodologies, it has always had its limitations. Because MRP only planned for materials, it ignored labor and equipment resources and assumed infinite capacity. Finite scheduling helped but both were slow and static (and often clumsy), while the pace of business accelerated and change became the only constant. The harsh reality is: Even today, production planning and execution are still largely dependent on spreadsheets, hand-written schedule boards and the ubiquitous daily production meeting, leading many to desperately think, "There has to be a better way!"

That is exactly what MRP veteran Richard T. (Dick) Lilly thought. As an early pioneer, working alongside Ollie Wight, he helped make MRP the game-changer that it was in the 1960's. He later went on to become the founder of three successful software companies, including Lilly Software Associates where he obtained a United States Patent (5,787,000) for his concurrent (finite) scheduler. He later sold that business to Infor, but he still continued to search for "a better way." And he found it.

It's called Protected Flow Manufacturing, a new methodology that simplifies planning and execution. Protected Flow Manufacturing prevents premature release of work, reduces time jobs spend waiting, protects promise dates and provides a clear priority to each operation, without complicated finite scheduling. It accurately predicts when each job will arrive at a specific work center (resource), monitors risk and makes the decision about what to work on next dead simple.

WHAT'S WRONG WITH MRP?

The introduction of packaged Material Requirements Planning (MRP) software for the masses (of discrete manufacturers) back in the late 1970's was transformational, although nobody really called it that back then. "Transformative" innovation is very much a 21st century term. But MRP truly was game-changing back in the day.

While the concept dates back to the 1950's, for years afterwards, many struggled to apply the methodology. Although the concept was simple enough, bills of material could be many layers deep and encompass hundreds or even thousands of component parts and subassemblies. Without software to automate MRP there is simply too much data and complexity for a human to possibly keep track of. Adding to the dilemma in the period from the 1950's through the 1970's, the concept of packaged software solutions was scoffed at. The prevailing sentiment was that (of course) everyone is different and needs a custom-designed system. This left automated MRP systems available only to those with large information technology (IT) staffs capable of developing their own custom versions of MRP.

MRP didn't turn out to be the savior many expected it to be.

That started to change in the late 1970's when packaged applications made an entrance, not just on massive mainframes, but on "mini-computers" as well. But MRP didn't turn out to be the savior the experts expected it to be. Why not?

INFINITE CAPACITY THROUGHOUT THE BLACK HOLE OF PRODUCTION

MRP assumes infinite capacity and "trusts" production run times and supplier lead times implicitly. These assumptions proved to be troublesome for some and a fatal flaw for others. Lead times are variable and capacity is limited.

First of all, MRP assumes infinite capacity and "trusts" production run times and supplier lead times implicitly. These assumptions proved to be troublesome for some and a fatal flaw for others. First of all, lead times are treated as constants, even though they can be quite variable. Even when the lead-time of a manufactured product is calculated from setup and run times, it can be inaccurate because of the added lead-time component of wait (or queue) time. MRP treats this as a constant as well when in fact it is anything but.

MRP took a demand due date and backed off the lead-time to give you a release date for production orders. It didn't really concern itself with what happened in between those two dates. It was up to you to figure that out. Most manufacturers used backward scheduling for the individual operations…again ignoring capacity. Capacity requirements planning (CRP) modules were used to highlight trouble spots, but didn't offer much else.

Some might argue that finite scheduling is the answer. But the reality is: Finite schedulers are beyond the reach of many companies, require a lot of work and assume standards are more accurate than they typically are. And even if those setup, run and wait times are an accurate measure of the average time, they are just that – an average. Finite schedulers treat them as a constant, when again, they can often be quite variable.

Finite schedulers must determine relative priorities of tasks and tend to do so on an order-by-order basis. Traditionally finite scheduling assumes jobs have the same relative priority throughout all operations. But that's not necessarily the case, sometimes sacrificing efficiency and due dates unnecessarily in order to preserve that priority.

SPEED AND COMPLEXITY

MRP never creates a perfect plan. So while most planners were relieved of the burden of crunching the numbers, they were also burdened with lots of exceptions and expedited orders.

And then there is the issue of speed and complexity. It was not unusual for early MRP runs to take a full weekend to process, and during that time nobody could be touching the data. This didn't work so well in 24X7 operations or where operations spanned multiple time zones. Of course over time, this was enhanced so that most MRPs today run faster and can operate on replicated data, so that operations can continue. But that only means it might be out of date even before it completes.

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HUMAN NATURE: IT'S A TRUST ISSUE

MRP is not rocket science but not everyone intuitively understands it. It is hard to rewind, step through and "see" all that is going on. It's basically a trust issue.

And finally, there is human nature. MRP required a paradigm shift and the planning process executed by MRP is complex. Not everyone intuitively understands it. While MRP is not rocket science it is hard to rewind, step through and "see" all that is going on. And if planners and schedulers, or even operators don't really understand it, they are unwilling to relinquish control, hence the end-runs and work-arounds with spreadsheets, scheduling boards and meetings.

It's basically a trust issue. Without complete and implicit trust, it's just human nature to pad standards to create a buffer, allowing for disruptions along the way and Murphy's Law (if something can go wrong, it will). As these estimates (vendor lead times, production and wait times) get inflated, performance might look good on paper, but in reality it declines along with productivity and utilization.

Yes, MRP brought a new dimension to material planning. But has it really helped manage the execution of the plan? No. Some might even argue it was never intended to. It might help get the materials to supply the production process on time, maybe even just in time. It can tell you when to release an order and when to complete it. But it does little to help in between, which is where the real execution happens.

Yet through the past three decades, planning and execution hasn't changed all that much. Yes MRP has gotten faster. Yes, there are viable finite schedulers on the market. But in general, solution providers have primarily addressed issues by throwing technology at solutions, assuming the functionality was perfected decades ago.

Protected Flow Manufacturing is the first completely new approach to production planning and execution in decades.

Next generation solutions add speed. They are moving to the cloud, becoming accessible through mobile devices and are perhaps even enhanced with analytics. But little has been done to improve the methodology or the functionality. Protected Flow Manufacturing is the first completely new approach to production planning and execution in decades.

IT'S TIME FOR A FRESH APPROACH

Recognizing all these limitations, Mr. Lilly and his associates formed a new company called LillyWorks, and set about re-evaluating how MRP and other scheduling tools were implemented in the real world. In doing so, the group challenged assumptions that were made decades ago, but were somehow never revisited. This resulted in a new concept they call Protected Flow Manufacturing.

Little's Law

"In queueing theory, a discipline within the mathematical theory of probability, **Little's result**, **theorem**, **lemma**, **law** or **formula** is a theorem by John Little which states:

The long-term average number of customers in a stable system (L) is equal to the long-term average effective arrival rate, λ, multiplied by the average time a customer spends in the system (W); or expressed algebraically: $L = \lambda W$."

Wikipedia

The concept is based on Little's Law. Since few manufacturing folks are interested in queuing theory, suffice to say it is based on the same theory we all intuitively employ in our daily lives. When you walk into a bank (or store, or registry of motor vehicles), the fewer people there, the less time you wait.

Applying that same reasoning to a work center or piece of equipment, the less work you bring out to the shop floor, the less time jobs wait between operations. And you know that wait (or queue) time is the reason why it takes you four weeks to complete a job even though run and setup times add up to a single week.

So Protected Flow Manufacturing prevents the premature release of work. You might think you are being smart in starting early, in order to allow yourself some extra time, but doing so can result in unintended consequences that have a negative impact on this and other jobs. Everyone would agree releasing a job too late is bad. But releasing it too early can be equally bad. That implies there is a "right" time to release it. And Protected Flow Manufacturing will calculate that.

In doing so, Protected Flow Manufacturing uses setup, run and move time to calculate the "operating time," but ignores queue times at individual work centers or operations.

In a perfect world, with nothing else competing for resources, this operating time is how long it would take you to manufacture the product. But of course we don't live in a perfect world and of course you don't simply work on one job at a time. You have different orders competing for the resources on the shop floor.

Even though traditional queue time is defined as a constant, it is indeed quite variable. Trying to predict that variability at the level of granularity of each operation is complicated, maybe even impossible.

Therefore we have to budget in some protection. But even though traditional queue time is defined as a constant, it is indeed quite variable. Trying to predict that variability at the level of granularity of each operation is complicated, maybe even impossible. But you know generally how long it takes to get something all the way through the process. Maybe that is four weeks. And you know the operating time. Let's say that is one week. That means you are actively working the job for a week and it spends another three weeks waiting. So you have a 3:1 ratio of buffer time to operating time and in this case, a **buffer** of three weeks.

So that's exactly what Protected Flow Manufacturing has you do: Define the ratio of work to buffer time for the entire work order, or maybe even a category of work orders. If you have a 3:1 ratio today and are largely hitting your due dates, maybe you set it at 2.5:1. See how it works for you. Chances are you will find yourself whittling that down over time as you build more confidence in the system.

Protected Flow Manufacturing provides a clear priority to each operation without finite scheduling.

Sounds simple enough, but your next question might be, "Without queue times for each operation, how do I schedule the order?" The answer is, you don't. Not in the traditional "order by order" sense. Instead, you predict what will happen at each of the resources (work center, machine, etc.) at future moments in time. After the work order has been released, that's actually where the decisions must be made. With multiple jobs sitting in the queue, which should the operator work on next? Protected Flow Manufacturing provides a clear priority to each operation without finite scheduling.

Once these decisions are made, you find you actually have an implicit schedule for each work order, step by step, indicating when the work will arrive at the resource and when the operation will start. If you follow the rules, you will be able to predict when the job will be completed. And along the way, you can assess the risk of missing that due date. But Protected Flow Manufacturing is designed to minimize that risk and protect promised dates.

Sounds like a lot of work? Perhaps if you had to do this manually, but of course all these predictions can be automated, just like MRP was automated.

HERE'S HOW IT WORKS

Protected Flow Manufacturing calculates when each operation of each job will start and finish, based on

- Resource capacity
- Estimated setup and run times (and move times if applicable)
- A defined buffer to operating time ratio
- Other jobs also waiting for the same resources

- Material availability (which may include lead time for ordering additional material)

Protected Flow Manufacturing starts with a due date for the job. It then calculates the operating time from the setup, run and move times for each operation and adds a buffer of time protection.

Protected Flow Manufacturing starts with a due date for the job. It then calculates the operating time from the setup, run and move times for each operation and adds a buffer based on the ratio you define. Let's say you have Job A where you will spend 3 days working and you have 12 days of buffer (a ratio of 4:1). Protected Flow Manufacturing would make the order available to be worked on 15 days prior to the due date, and not before.

At that point you **could** start working on the first operation, but obviously only if the resource is available. It might sit waiting for that resource. No work is being done, but some of the buffer is being eaten up. When released, it has 100% of its buffer left. After two days of no activity, it has 83.3% of its buffer remaining. If there is another job (Job B) waiting for that resource, when it is projected to free up, Protected Flow Manufacturing says you should work on the one with the smallest percentage of its buffer remaining. If Job B has less than 83.3% of its buffer remaining, it goes first. Meanwhile more buffer will get eaten away on Job A until it is the job projected to have the smallest percentage of its buffer remaining at the next (future) moment in time when you would need to decide "what's next?"

*Protected Flow Manufacturing travels forward in time, making priority decisions based on how much of your buffer has been eaten away, based **not** on the conditions of the present moment, but on conditions projected for that future moment in time.*

In order to accurately predict outcomes, Protected Flow Manufacturing travels forward in time to these future moments. That might be when capacity will become available (an operation is predicted to finish) or an operation is predicted to arrive at a resource. Protected Flow Manufacturing then answers the question of "what's next?" based **not** on the conditions of the present moment, but on conditions projected for that future moment in time. It then "loads" that job.

Ultimately Protected Flow Manufacturing loads all work left to be scheduled and completed. With all the parameters established (capacity, operating times and buffer ratios), this can all be automated. Operators simply need to follow the rules and suddenly planners/schedulers can turn their attention to improving processes rather than figuring all this out and then fighting fires when the best laid plans go astray.

WHAT ABOUT MATERIALS?

The accuracy of predicted start and completion of operations is predicated on the needed materials being available. So even if the resource has the required capacity available when the operation is predicted to arrive, Protected Flow Manufacturing will not load the job unless the materials are available. How does it do that without MRP? It links them directly to the operation. Of course it can "see" existing inventory and looking out into the future, it can determine from scheduled receipts when additional material is due to arrive. If there are no (or insufficient) scheduled receipts, it uses the lead-time.

This is fairly intuitive for simplistic, single level bills of material (BOMs), but unless you are running a simple repetitive manufacturing process, seldom do you have the luxury of a single-level or a simple linear and sequential process. If you do, you are probably using much simpler methodologies than MRP.

In a more complex environment, perhaps in a job shop, there is a lot more involved than just a multi-level BOM. You might have multiple processes overlapping or running in parallel, perhaps making subassemblies or semi-finished goods, then converging in a final stage. Or perhaps you start with a common process and then diverge. Think of cutting a piece of sheet metal and then sending different cuts to different work orders.

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So instead of relying on a multi-level BOM, the Protected Flow Manufacturing concept assumes a multi-level work order, where the interdependencies are not just implied, but defined specifically. This might add a level of complexity to your operation, but it also makes it a lot more like the real world.

This approach also addresses an additional limitation of MRP. MRP assumes a shop order for each level in the BOM. Even a very simple product assembled from two manufactured items requires three shop orders: one for each of the components and a third to assemble them. Also, MRP requires you to receive these components back into stock even if you never keep an inventory of them on hand. You might record the receipt to inventory and then immediately issue them back out to the shop floor. Oftentimes this is a paper-only transaction that never really occurs, which creates extra, unnecessary transactions.

Also, each shop order has its own due date. Yet the due dates of the shop orders making the components are not directly connected to the final assembly order. So when the due date from the customer changes, someone has to remember to go back and adjust the due dates for the shop orders making the manufactured components. These limitations are most troublesome in a job shop environment where work is driven by actual orders for non-standard products.

Protected Flow Manufacturing's multi-level work order approach eliminates these problems. So, does this mean Protected Flow Manufacturing is applicable only to job shops where material is purchased directly for individual jobs and nothing is ever made to stock? No, it just means it needs to accommodate stock orders for both purchased and manufactured parts.

BONUS: RUSH ORDERS BECOME SELF-EXPEDITING

With the automation of MRP, planners /schedulers really became expediters.

With the automation of MRP, planners/schedulers really became expediters. MRP came up with a plan, but no plan is ever perfect and neither is supplier or shop floor performance. Capacity is proven to not be infinite. Due-dates change. Suppliers miss scheduled deliveries. And of course a rush order trumps all other exceptions. So how does Protected Flow eliminate expediting of a rush order?

Remember Job A? It had 3 days of work and 12 days of buffer. So we released it 15 days before it was due. What if all of a sudden you only have 10 days to complete a similar job? When you release the job with the rush due date, it has already lost 5 days of its buffer. So it hits the first operation and instead of having 100% of its buffer remaining, it only has 58.3% of its buffer remaining. It will automatically get prioritized ahead of those released with the full buffer, with absolutely no manual intervention.

CONCLUSION

Protected Flow Manufacturing obviously takes a new and novel approach to execution. But is it better? It is definitely a lot more simple and easy to understand than MRP and finite schedulers. It addresses the real-life challenges job shops have perennially faced and reflects the realities of actual operations, whether you are operating in the mode of make-to-stock, make-to-order or somewhere in between.

Protected Flow Manufacturing is "better" because it makes predictions that respect the reality that job priorities change over time, while also acknowledging limited capacity resources.

It is "better" because it makes predictions that respect the reality that job priorities change over time, including the ripple effect to upstream and downstream operations. It reflects what is likely to occur in the future when workers perform according to the priorities that it calculates for them, while also acknowledging limited capacity resources. And it enhances the material plan with a production schedule that can be trusted and executed simply by following the rules.

But the proof is in the execution. Next up: We investigate how Mr. Lilly and his associates at LillyWorks have incorporated Protected Flow Manufacturing concepts into a new solution.

Read Next - *LillyWorks Applies Protected Flow Manufacturing Concepts*

About the author: *Cindy Jutras is a widely recognized expert in analyzing the impact of enterprise applications on business performance. Utilizing over 40 years of corporate experience and specific expertise in manufacturing, supply chain, customer service and business performance management, Cindy has spent the past 10 years benchmarking the performance of software solutions in the context of the business benefits of technology. In 2011 Cindy founded Mint Jutras LLC (www.mintjutras.com), specializing in analyzing and communicating the business value enterprise applications bring to the enterprise.*

