# Topic: Demand Driven Master Scheduling

## Demand Driven MRP and Master Production Scheduling (MPS)

A white paper by the Demand Driven Institute

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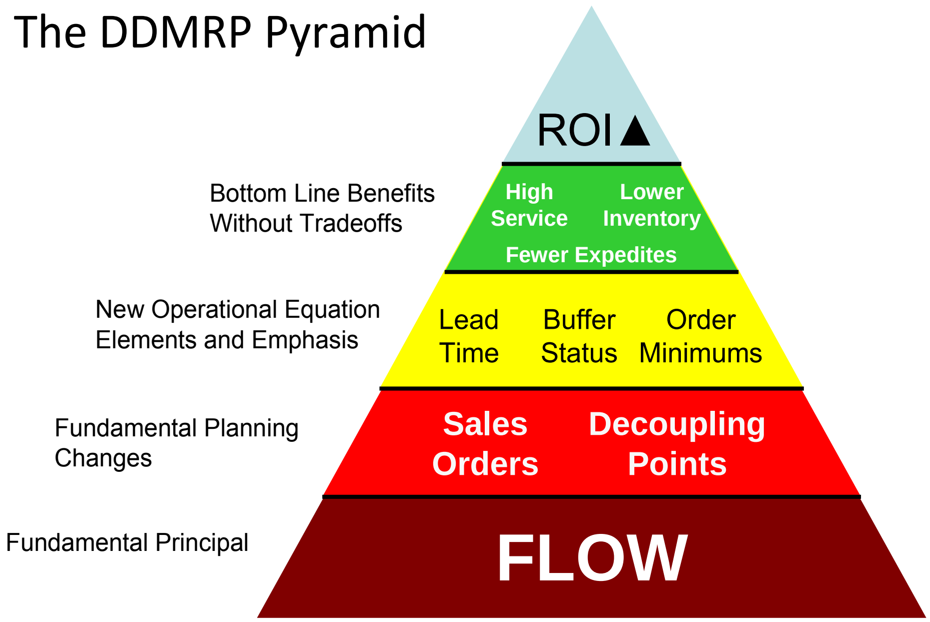
Demand Driven MRP and Master Production Scheduling (MPS)

Chad Smith and Carol Ptak

**What is Demand Driven MRP?**

Demand Driven MRP is a new formal planning and execution method first articulated in the third edition of *Orlicky's Material Requirements Planning* (Ptak and Smith, McGraw-Hill, 2011). The entire foundation of DDMRP is based upon the connection between the creation, protection and acceleration of the **flow** of relevant materials and information and return on investment.

The DDMRP Pyramid




Every for-profit company has the same goal – some form of return on shareholder equity. When the flow of relevant materials and information increases return on investment increases. Conversely, when processes are drowning in oceans of irrelevant data and materials return on investment decreases. Cash, capacity and space is tied up in unnecessary inventory and expedite related expenses are incurred as people attempt to deal with the chronic and frequent shortages. Ultimately, the relevance of materials and information is determined by whether there is a real customer demand – a demand that results in actual payment for the effort and cash expended. This last statement has important implications for the subject of this paper.

This whitepaper focuses on the fundamental differences between demand inputs and capacity considerations of a DDMRP approach versus a conventional MRP approach. The purpose of this paper is to:

1. Offer an in-depth explanation of the impact of Demand Driven MRP (DDMRP) to the conventional demand input to MRP systems (Master Production Schedule)
2. Explain the capacity assumptions and implications of using a DDMRP approach
3. Present the impact of DDMRP's execution components the stability and assumptions behind an executable master schedule.

**Demand Driven MRP (DDMRP) and the Master Production Schedule (MPS)**

Conventional MRP systems take their demand input from what is known as a Master Production Schedule (MPS). The master production schedule is not simply a statement of forecasted demand but also considers actual sales orders, capacity and material availability. The MPS is expressed as specific quantities and dates. Simply put, the definition of the MPS is a statement of **what we can and will build**. MRP then takes that input and combines it with inventory records (on-hand and open supply) and product structure (Bills of Material) records to generate supply order requirements.

Figure 1 is a diagram from *Orlicky's Material Requirements Planning* 3/E that shows how the MPS fits into the conventional MRP landscape.

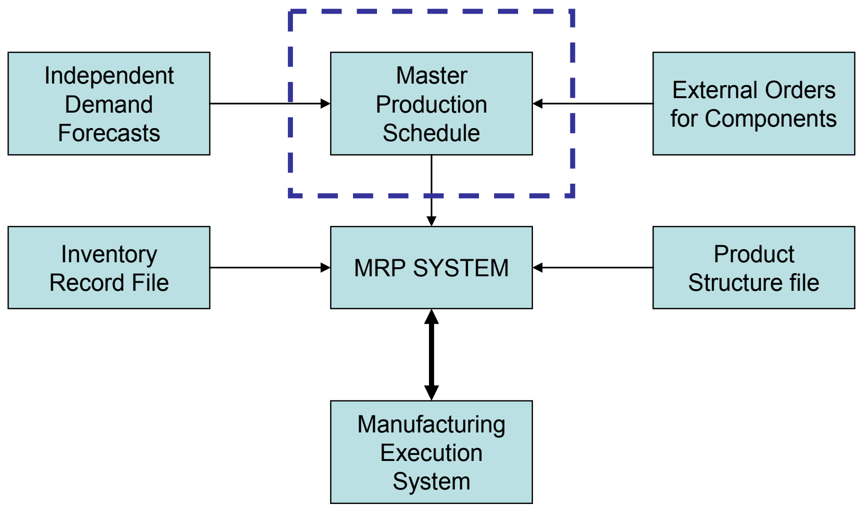



*Figure 1: The relationship of the MPS in conventional MRP schema*

As you can see the demand input for the MPS comes from two sources; Independent Demand Forecasts (Planned Orders) and External Orders (Sales Orders). Traditional MRP will net the projected available balance to zero. If the time that it takes to procure and produce items exceeds the Customer Tolerance Time then planned orders must be tied to supply order generation. Safety stock is used to deal with the inherent misalignments in quantity and timing created by that direct connection of planned orders to supply order generation. It should be noted that the safety stock level simply becomes the "new zero."[1]

**Master Scheduling in DDMRP**

Demand Driven MRP (DDMRP) changes the idea of a conventional MPS. In DDMRP, the demand input is not a statement of what we can and will build but instead it is a statement of **what we can and will sell**. DDMRP recognizes that there is a SIGNIFICANT difference in the error rates associated with planned orders versus sales orders. Sales orders, in most cases, are "real demand"; the equivalent of an un-cashed check. Sales orders are the most accurate demand signals available, representing actual demand even if the customer changes the requirements.

Figure 2 is an equivalent diagram for the DDMRP approach. Independent Demand Forecasts are connected to the DDMRP approach ONLY through the Planned Adjustment Factors.

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[1] Readers should review the technical paper Replenishment Buffers Versus Safety Stock (Ptak and Smith, DDI, 2012)

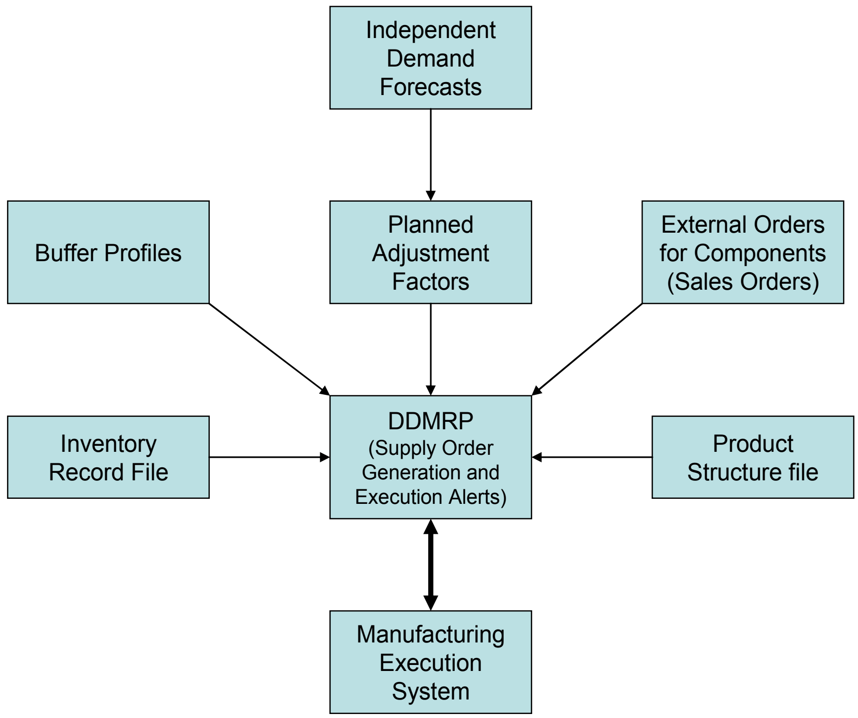


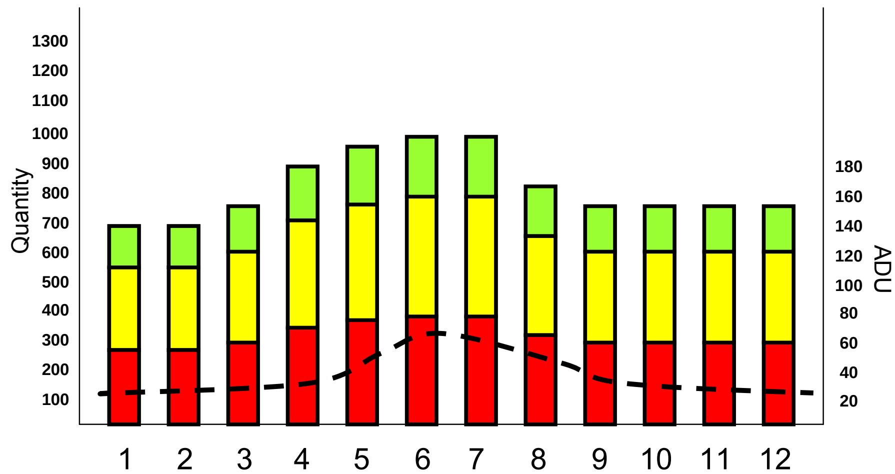

*Figure 2: The DDMRP schema*

DDMRP combines Sales Orders, Planned Adjustments, product structure records, inventory records and buffer profiles in order to produce recommended supply orders and execution alerts for open supply orders. Let's break down each component:

*1. External Orders* –actual sales order demand allocations or work order demand allocations derived directly from actual sales orders. The DDMRP approach further limits the consideration of external orders to qualification criteria that will be discussed later in this paper.

*2. Planned Adjustments* – In DDMRP, actual demand orders DO NOT consume forecast. There is no demand time fence and planning time fence to consider for forecast consumption. In DDMRP, forecasted orders are not placed directly in the demand equation. Forecasts are used in DDMRP but forecasts are not tied directly to order creation. Instead DDMRP uses forecasts to calculate Planned Adjustment Factors (PAF). The Planned Adjustment Factors raise or lower the buffer levels, within specific time ranges, by factoring against Average Daily Usage (ADU). ADU is a primary component to the buffer equation. The most frequent application of the planned adjustment factor is to dynamically adjust buffers for a seasonal business or businesses with heavy promotional activity.

Figure 3 depicts a planned adjustment to incorporate a temporary surge in demand either from promotional or seasonal activity. The product's seasonal profile is displayed in monthly buckets. The left Y axis is quantity associated with the buffer levels over the course of the year. Note that the top of the buffer ranges between 700 and around 950. The right Y axis is the projected Average Daily Usage of the product over the course of the year. Below the monthly numbers is the percentage factor that will be applied to ADU within those time buckets thus creating the flex (up and down) in the buffer.




| PAF % | 97 | 97 | 100 | 110 | 115 | 118 | 118 | 103 | 100 | 100 | 100 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

*Figure 3: A Planned Adjustment Factor analysis*

When these planned adjustments are applied, the buffer flexes up or down thus changing the relative available stock position of the buffer. An available stock position of 100 for a part with no planned adjustment factor is relatively different than an available stock position of 100 for the same part with planned adjustment factor of 125%. When the buffer flexes up, a recommended supply order is generated ONLY if the available stock position after the flex is below the top of the yellow zone.

Planned Adjustment Factors are the primary interface point between S&OP activities and DDMRP. The application and management of Planned Adjustment Factors is a significant topic and will be tackled in future white papers.

*3. Buffer Profiles* – DDMRP assigns parts chosen for strategic replenishment to families or groups based on common attributes. At a minimum, these attributes are lead time (long, medium, short), variability (high, medium, low), part type (made, bought, distributed) and significant order multiple or cycle. The buffer profile the part is assigned to affects the relative distribution of the red, yellow and green zones of that part's buffer.

Figure 4 depicts three different parts with the same Average Daily Usage and lead time but with different profile assignments based on variability (measured through Coefficient of Variability (CoV))[2] and minimum order quantity (MOQ).

The differences in the total buffer and the zonal distributions of the buffer depend on the part buffer profile assigned. In scenario A, the profile corresponds to a buffer profile for bought or purchased items (Buy), with a long lead time (Long) and with low variability (Low). This results in the lowest total top of buffer (called Top of Green) of 340 units (60 + 200 + 80). In scenario B

[2] CoV is defined as standard deviation divided by the mean

the part variability is dramatically increased resulting in an increased Red Zone and a larger Top of Green. In scenario C the part has a significant Minimum Order Quantity (MOQ) which determines the size of the green zone. Not only is this buffer Top of Green larger, this buffer will have a much longer average order frequency duration (12 days on average). Average order frequency is determined by dividing the Green Zone by the ADU.

A

| | |
|---|---|
| Buffer Profile | Buy, Long, Low |
| ADU | 10 |
| Lead Time | 20 days |
| Variability | CoV = .37 |
| MOQ | None |

B

| | |
|---|---|
| Buffer Profile | Buy, Long, High |
| ADU | 10 |
| Lead Time | 20 days |
| Variability | CoV = 3.37 |
| MOQ | None |

C

| | |
|---|---|
| Buffer Profile | Buy, Long, Low, MOQ |
| ADU | 10 |
| Lead Time | 20 days |
| Variability | CoV = .37 |
| MOQ | 120 |

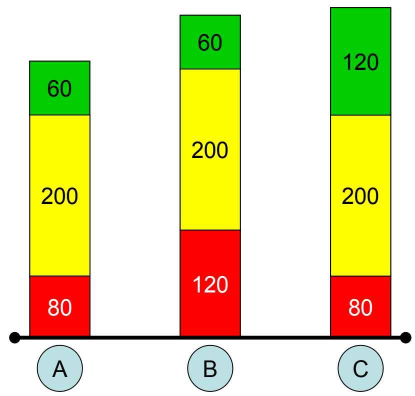



*Figure 4: Same lead time and usage, different buffer profile*

For more information on the equations behind these buffers readers should review the white paper Demand Driven MRP Buffer Explanation and Simulation (Smith, DDI, 2013).

*4. Inventory Record File* – standard on-hand and open supply/on-order records.

*5. Product Structure File* – standard bill of material records.

**The Available Stock Equation**

These five inputs are combined to generate recommended supply orders through an "available stock equation" set against a part's specific buffer level and composition. The available stock equation is unique to DDMRP.

For end items the equation is:

*(On-hand qty) + (On-order qty) – Qualified Sales Order Demand = Available Stock Position*

For purchased and intermediate items the available stock equation is:

*(On-hand qty) + (On-order qty) – Qualified Work Order Demand = Available Stock Position*

Demand qualification is limited to orders that are past due, orders that are due today and orders that qualify as a demand "spike". Spike qualification occurs by establishing an "order spike horizon" and looking for the summation of sales orders in daily buckets against a particular component/SKU that exceeds a defined "spike" threshold within the horizon. The horizon is usually set to at least one ASR Lead Time. ASR Lead Time is defined as the summation of manufacturing lead times on the longest (measured in time) un-buffered sequence in a product's bill of material – it is an innovation unique to DDMRP.

Figure 5 depicts the spike qualification process. In this example the order spike horizon is seven days and there are no past due orders. The order spike threshold is set at 500 units. There are orders due today totaling 400 units – those orders are qualified as demand. Additionally, there is a qualified group of orders for 1000 units that qualify as a spike that has just entered the order spike horizon. These orders are due six days after today. The entire amount of that spike is qualified as demand. In this example, today's demand element of the available stock equation is 1,400 units.

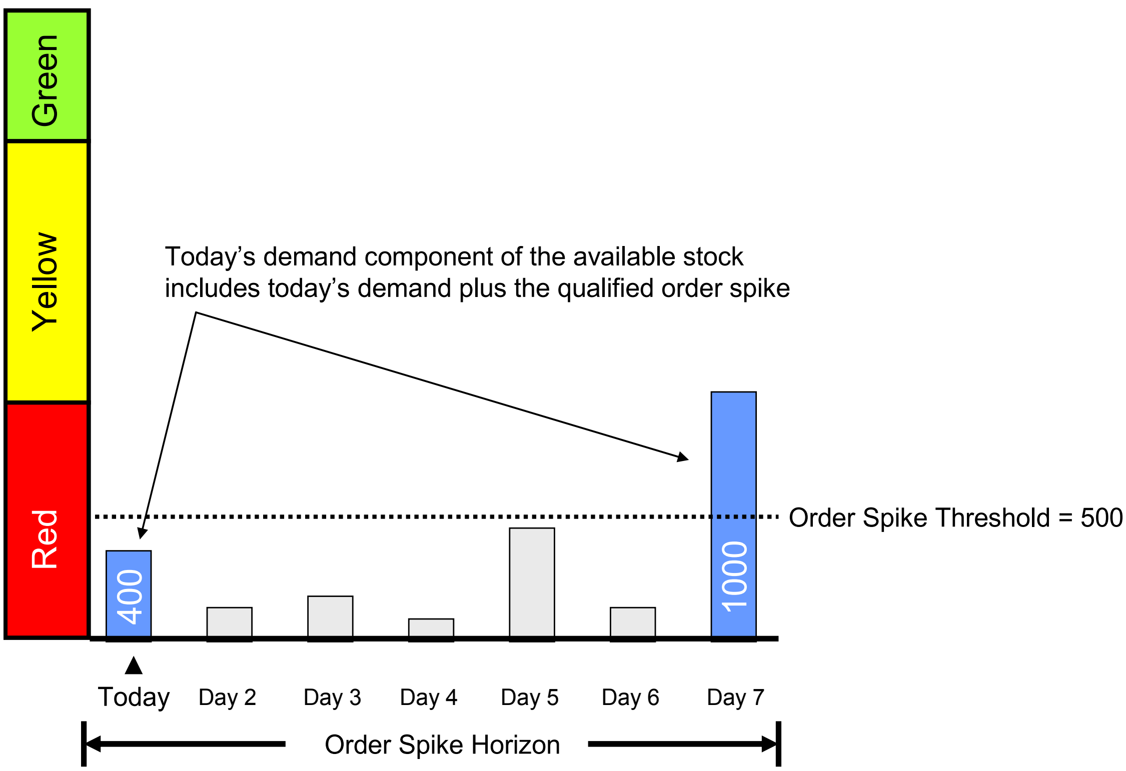



*Figure 5: Demand qualification including spike identification*

For intermediate components, the assumption is that the work orders originated from a supply order from a strategic stock buffer position. The qualification of work order demand adheres to the same criteria as described above for sales orders.

### Short Range Capacity and Materials Considerations

Any type of master scheduling (including DDMRP) makes assumptions about capacity and material availability. In the more complex and volatile environment of the 21$^{st}$ Century, conventional MRP's master scheduling assumptions are becoming more unrealistic. One critical assumption of traditional MRP is that all components are available at time of order release. This is called full allocation. While conventional MPS and MRP attempt to make this occur, the combination of planned orders with certain deficiencies inherent in conventional MRP make this assumption tenuous at best. DDMRP removes these factors and assures improved flow of only relevant materials and information.

At this point a critical difference between MRP and DDMRP is worth noting. For strategically replenished positions, DDMRP is designed to NEVER net the projected available balance to zero. DDMRP specifically plans to have inventory available in order to maintain the integrity of the buffer at the strategic decoupling point. It is the existence of these buffers, when placed properly, that allows lead time compression to be consistent with customer tolerance time. These buffers also have implications for capacity consideration and material availability.

The existence and management of these strategic buffer positions provides for short range capacity and materials considerations. With regard to materials, if the buffers are designed to always have stock based on an appropriate buffer profile then the assumption that material is available is generally correct (especially when order spike qualification is taken into account). For required materials or components that are not buffered, ASR Lead Time is used to create a realistic date for availability. The lack of the ability to recognize ASR Lead Time is one of the critical flaws of the conventional MRP order release calculation.

With regard to capacity, the buffers of manufactured parts represent stored capacity. This can act as a short range capacity buffer to minimize capacity contention as buffers are replenished. Thus we can make an assumption that when strategic manufactured items are buffered, capacity is available in the short run (in the form of stock).

**Enabling Master Scheduling Assumptions with Robust Execution Elements**
Now let's turn our attention to execution. In DDMRP "planning" and "execution" are distinctly different tasks. See Figure 6 below. Planning is defined as tasks associated with generating new supply order requirements while execution is defined as tasks associated with managing open supply order requirements.

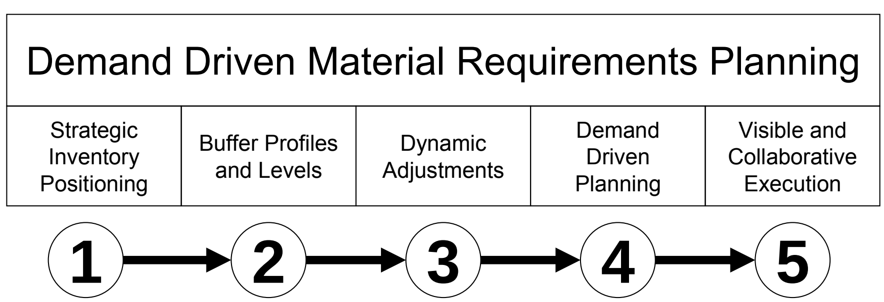



*Figure 6: The five components of DDMRP*

Through an array of execution alerts, DDMRP reinforces the assumptions contained in a reliable master schedule – that planned releases and order synchronization will happen as planned. The existence of these execution alerts dramatically increases visibility and focus to potential materials, capacity and synchronization problems allowing for preventive and/or corrective actions in order to maintain plan and flow. Conventional MRP's lack of integrated execution management tools directly contributes to an often unrealistic or unachievable master schedule.

There are 4 primary alerts used in DDMRP. Two of these alerts (Current On-Hand Alert and Projected Buffer Status Alert) are designed to be used exclusively with strategically replenished items. The Material Synchronization Alert is applicable to both strategically replenished and standard non-buffered items. The final alert is designed to be used for Lead Time Managed (strategic non-buffered) items. Figure 7 depicts the four primary execution alerts of DDMRP.

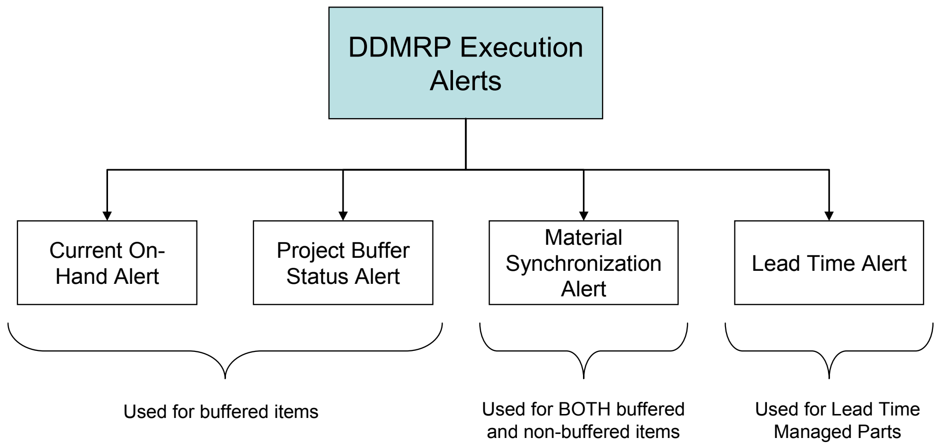



*Figure 7: The four primary execution alerts of DDMRP*

**Current On-Hand Alert**

The Current On-Hand Alert is designed to alert planners and buyers to current on-hand problems with strategic replenishment buffers. The alert uses color as a general reference and the percentage of a buffer's remaining red zone as a discrete reference to generate priority status for a SKU and across SKUs. Below is an example of what a Current On-Hand Alert screen might look like. It represents the minimum amount of information necessary to display a Current On-Hand Alert.

| Part # | OH Status | OH Quantity | Open Supply |
|---|---|---|---|
| PPG | 27% | 54 | 450 |
| SAJ | 45% | 135 | 600 |
| PPL | 67% | 335 | 1200 |

The percentage in the status column is determined by dividing the on-hand quantity by the top of the red zone of the buffer. In this case part # PPG appears to be the highest priority. With only 54 units in on-hand inventory (OH Quantity) it has only 27% of the buffer's red zone remaining. This means PPG's top of red is 200 units (54/200 = .27).

This alert is intended to direct planner and buyer attention to the parts with the most severely eroded buffers to highlight the supply orders associated with them for potential expedite. In this way planners and buyers receive a quick and easy signal of where and how to focus their limited time.

**Projected Buffer Status Alert**

The Projected Buffer Status Alert is designed to warn planners and buyers about potential buffer depletions in the future based on the inventory on hand, the expected rate of use and known sales order demand over its ASR Lead time. Below is an example of what a Projected Buffer Status Alert screen might look like.

| Part # | Projected Status | OH Quantity | Open Supply | ADU | ASRLT | Work Order Demand |
|---|---|---|---|---|---|---|
| SAJ | SOWD in 5 days! | 135 | 600 | 26 | 12 | 153 |
| PPG | Stock-Out in 6 days | 54 | 450 | 9 | 16 | 52 |

This alert is prioritized by the short term projected future buffer status (one ASRLT). It takes the quantity on-hand and compares it against the ADU to compute a projected length of coverage until a stock out occurs. A further level of refinement compares the total known sales or work order demand, the release dates associated with those demand orders and the incoming planned supply order receipts over the same time frame to identify projected days of net negative on-hand quantities. When a net negative position is projected using actual demand allocations, a situation called stock-out with demand (SOWD) is displayed. DDMRP clearly makes a distinction between SOWD and simply being stocked out. Projected SOWD is always prioritized ahead of projected stock outs.

In the above example part SAJ is projected to be in a stock-out with demand (SOWD) status in 5 days. Notice the on-hand quantity is 135 units and the ADU is 26, meaning the buffer has 5 days of coverage remaining under average demand scenarios. Actual demand, however, exceeds average calculated usage within the same time frame and a supply order is not due within that period. There is total open supply of 600 units that are candidates for potential expedite.

Something to keep in mind about potential open supply expedites under DDMRP is there are often multiple incoming orders against a position. DDMRP attempts to order as frequently as possible up to the point where the ordering becomes onerous or infeasible. Expediting smaller orders is usually far more successful than trying to move in large orders.

**Material Synchronization Alert**

Material Synchronization Alerts (MSA) can involve any part (buffered or non-buffered). A Material Synchronization Alert is designed to alert buyers and planner to misalignment between any component availability and any parent release date and quantity needs. If the component quantity is expected or projected to be insufficient to meet a parent order demand allocation then an alert is triggered. Below is an example of what an MSA report, at a minimum, should provide.

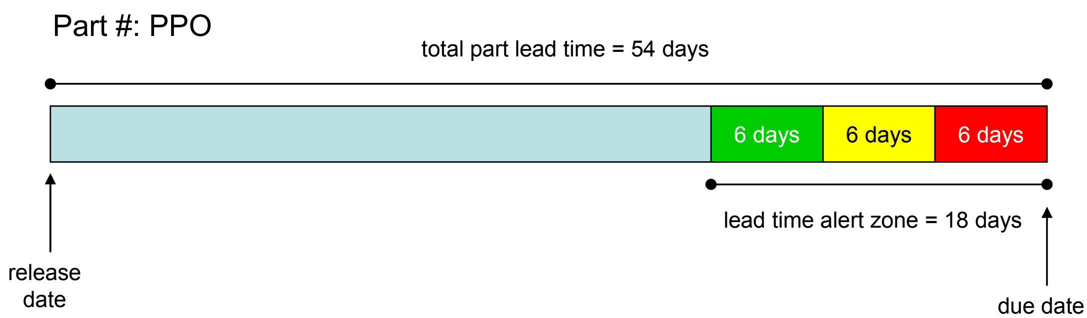
| Order # | Part # | Date | Parent Order Effected | Parent Part # | Parent Requirement | Shortage | Component Open Supply |
|---|---|---|---|---|---|---|---|
| 127-680 | PPL | May 10 | 128-775 | SAK | 1000 | 220 | 4500 |
| 128-045 | SAH | May 10 | 129-342 | FPG | 100 | 20 | 250 |
| 127-799 | PPL | May 11 | 128-994 | SAR | 2000 | 2000 | 4500 |

The MSA report is sequenced by date – the more imminent the synchronization problem, the higher the priority. PPL appears twice on the report because it is either in short supply or its open supply has been delayed.  It is a common component to at least two sub-assemblies (SAK and SAR).  The most immediate priority is PPL's impact on work order #128-775.  The work order requires a total of 1000 PPLs but there will be only 780 available.  The next day work #128-994 requires 2000 PPLs and there will be none available.  There is, however, a total of 4500 units of PPL in open supply that the buyer can choose from to attempt to expedite.

This alert allows the buyers and planners advanced warning of material/component constraints across product structures and orders.  The better the visibility to these warnings the more options are at their disposal to deal with the potential conflicts.  The various alerts have connections between each other.  For example if PPL was a buffered item it would also appear on the Projected Buffer Status Alert as SOWD on May 10.

**Lead Time Alert**

In DDMRP the Lead Time Alert is used exclusively with strategic non-buffered parts called Lead Time Managed (LTM) parts.  These are parts that are not demanded in sufficient quantity to be strategically stocked (including Engineered to Order items) but when required tend to be critical to the success of the overall project or assembly.  The lead time alert is designed to provide a radar screen for planner and buyers of the impending due dates of these parts.  This radar screen is a timed and structured status update to identify potential problems sooner and establish a documented order history trail.




The above graphic demonstrates the notion of a LTM part.  Part PPO has been declared LTM.  It has a 54 day lead time.  The last third of its lead time is the lead time alert zone (18 days) and is divided into three equal portions of 6 days.  Each of these portions is represented by a different color designation.  Green is the farthest away from the due date.  18 days from being due the part enters the green zone of the lead time alert zone.  It remains in the green zone for 6 days until day 12 when it passes to the yellow zone.  Every time a LTM part enters a new color zone a Lead Time Alert is issued to the planner or buyer responsible for the part.  The planner or buyer is expected to follow up on the part and input a note regarding its status.  Below is an example of a Lead Time Alert report.

| Order # | Part # | Due Date | Days Left | Current? |
|---|---|---|---|---|
| 229-681 | PPO | May 10 | 2 | Yes |
| 347-055 | PPY | May 28 | 20 | No |
| 427-700 | PPZ | May 30 | 22 | No |

The report will list the order numbers under a buyer or planner's control that are within their respective lead time alert zones. Order # 229-681 is in the red zone. It is not late; its due date is simply imminent. The column "Current?" is meant to distinguish parts whose status has been updated inside the current color zone. Neither 347-055 nor 427-700 have had a status note placed against the zones they are currently in.

The existence of these alerts directly deals with an inherent problem with MRP. MRP is often described as a binary system. A part is either "OK" or "not OK". In other words, you either have a recommendation for action or you don't. To make matters worse, traditional MRP commonly gives conflicting action messages for the same part. Moreover MRP makes no relative priority differentiation between parts. Every day planners and buyers are drowning in action flags and messages that are both inconsistent and/or irrelevant. Planners know *some* of the flags are important and still some matter *more* than others. Getting clarity on relative priority for managing open supply in conventional MRP is often a time consuming task and usually involves spreadsheets, a lot of intuition and experience and even a little luck. The execution tools inherent in DDMRP directly address these current MRP shortfalls.

**Summary**

DDMRP fundamentally changes the notion of a conventional MPS. The DDMRP method provides inherently more accurate demand signals It creates an environment where the material and capacity assumptions in the plan are fundamentally more sound and the execution facilities and visibility to protect the plan against disruption.

Medium and longer range capacity and material availability concerns will be addressed in our next paper discussing the interaction between DDMRP and S&OP.

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The Certified Demand Driven Planner™ Program was created by a global partnership between the International Supply Chain Education Alliance (ISCEA) and the Demand Driven Institute (DDI). Internationally accredited by the IISB, the purpose of the CDDP™ Program is to educate operations and supply chain personnel on the methods and applications of Demand Driven Material Requirements Planning (DDMRP).

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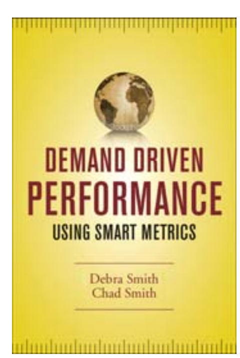


*Demand Driven Performance* details why the outdated forms of measurement are inappropriate for our current circumstances and reveals an elegant set of global and local metrics to fit today's demand driven world. The book shows how to minimize the organizational and supply chain conflicts that impede flow, and eventually, corporate success.

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## About the Authors

Carol Ptak is currently a partner with the Demand Driven Institute, and was most recently at Pacific Lutheran University as a Visiting Professor and Distinguished Executive in Residence. Previously, she was vice president and global industry executive for manufacturing and distribution industries at PeopleSoft where she developed the concept of demand driven manufacturing (DDM). Ms. Ptak spent four years at IBM culminating in the position of SMB segment executive. cptak@demanddriveninstitute.com

Chad Smith is the co-author of both *Orlicky's Material Requirements Planning*, Third Edition (Ptak and Smith, McGraw-Hill, 2011) and the upcoming Demand Driven Performance – Using Smart Metrics (Smith and Smith, McGraw-Hill, 2013). In 1997 Chad co-founded Constraints Management Group, LLC (CMG). Since the late 1990's Chad and his partners at CMG have been at the forefront of developing and articulating the concepts behind Demand Driven MRP as well as building DDMRP compliant technology (Replenishment+®). Additionally, Chad serves as the Program Director for the International Supply Chain Education Alliance's Certified Demand Driven Planner (CDDP) Program. csmith@demanddriveninstitute.com

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- *The State of Demand Driven MRP*
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