



# Topic: Demand Driven MRP Buffers



## Demand Driven MRP Buffer Explanation and Simulation

A white paper by the Demand Driven Institute

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[www.demanddriveninstitute.com](http://www.demanddriveninstitute.com)

The Demand Driven Institute (DDI) was founded by Carol Ptak and Chad Smith, co-authors of the third edition of *Orlicky's Material Requirements Planning* in order to proliferate and further develop demand driven strategy and tactics in industry to enable a company to transform from “push and promote” to “position and pull.”

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# Demand Driven MRP Buffer Explanation and Simulation

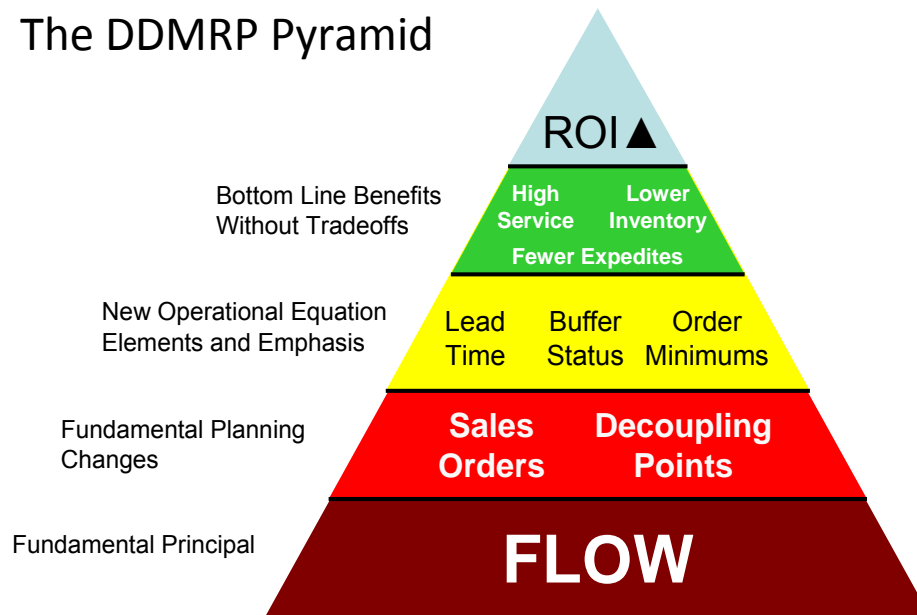
Chad Smith

## What is Demand Driven MRP?

Demand Driven MRP is a new formal planning and execution technique first articulated in the third edition of *Orlicky's Material Requirements Planning* (Ptak and Smith, Mc-Graw-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.

Every for profit company has the same goal – some form of return on shareholder equity. When the flow of relevant materials and information improves return on investment increases. Conversely, when processes are drowning in oceans of irrelevant data and materials, return on investment decreases as cash, capacity and space are tied up in unnecessary inventory. In addition, expedite related expenses are incurred to deal with chronic and frequent shortages even as inventory rises. Ultimately, the relevance of materials and information is determined by whether there is a real customer demand – a demand that results in actual cash payment.

## The DDMRP Pyramid



The above diagram depicts important aspects of DDMRP beginning with its foundation rooted firmly in **flow**. Once the importance of flow is embraced fully, there are huge implications and changes for planning and execution. This whitepaper will focus on the middle stratifications of the pyramid; the heart of the planning, execution and measurement methods of DDMRP – the strategic decoupling buffers. The purpose of this white paper is to:

1. Offer an in-depth explanation of the nature of the strategic buffers of Demand Driven MRP (DDMRP).
2. Discuss the purpose of each zone of the DDMRP buffers (Green, Yellow and Red)
3. Provide examples of their performance through the use of simulations



## Demand Driven MRP (DDMRP) Buffers

DDMRP revolves around the use of strategic stock positions called buffers. These buffers are placed at critical “decoupling points”<sup>1</sup> to accomplish the following functions:

- Shock absorption – dampening both supply and demand variability in order to significantly reduce or eliminate the transfer of variability which creates nervousness and bullwhip effect.
- Lead time compression – by decoupling supplier lead times from the consumption side of the buffer, lead times are instantly compressed
- Supply order generation – all relevant demand, supply and on-hand information are combined at the buffer to produce an “available stock” equation for supply order generation. The buffers are the heart of the planning system in DDMRP.

A buffer or stock position must pass five tests in order to be compliant to DDMRP principles:

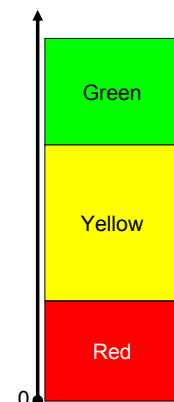
1. It must decouple the supply side lead time – it must provide a clear break in the lead time chain dependency
2. It must provide benefit for both sides of the buffer – the supply side gets an aggregated order requirement that corresponds to actual demand/consumption while the consuming side gets compressed lead time and high availability
3. It must be order independent – stock in the buffers is not allocated to any specific order, it is available on demand to any order as required. This distinguishes DDMRP stock buffers from WIP buffers as WIP, by definition, is connected or committed to a specific order.
4. All supply order signals for a buffered part must be generated through or from the buffer – if a part is chosen for strategic buffering all relevant demand, on-hand and open supply information is combined at the buffer to plan that position.
5. It must be dynamically adjusted based upon rate of use changes over a user defined horizon.<sup>2</sup>

If a stock position does not pass these four tests it is NOT DDMRP compliant buffer. An example might be the conventional form of Safety Stock<sup>3</sup> or Work in Process.

### How Does the DDMRP Buffer Work?

DDMRP Buffers are comprised of three color coded zones; Green, Yellow and Red. Each zone has a specific purpose and will vary in size and proportion depending on the “buffer profile” that the buffered part is assigned to. The buffer profile is a group of settings applied a group of parts that have similar attributes. These attributes include:

1. The type of part (made, bought or distributed)
2. Lead time category (long, medium, short)
3. Variability category (high, medium, low)



<sup>1</sup> The locations in the product structure or distribution network where inventory is placed to create independence between processes or entities. Selection of decoupling points is a strategic decision that determines customer lead times and inventory investment. (APICS Dictionary, 12th Edition, page 34, Blackstone 2008)

<sup>2</sup> The one exception in DDMRP is the use of “Replenished Override” buffers which are strategic and static positions to account for certain imposed limitations or restrictions like mandated/contractual constraints. These positions are the exception in DDMRP.

<sup>3</sup> For more information about the differences between Safety Stock and DDMRP buffers please see the white paper, “Replenishment Positions versus Safety Stock, Why Are They so Different?” (Smith and Ptak, DDI, 2011)



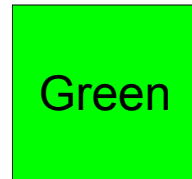
#### 4. Batching limitations (significant minimum order or run quantities)

Understanding the purpose of each zone is crucial to understanding how DDMRP buffers produce their results as well as how they compare to other stock management techniques.

#### The Green Zone

The green zone is the heart of the supply order generation process embedded in the buffer. It determines average order frequency and typical order size. The green zone is determined by one of three factors. Whichever factor yields the greatest number determines the size of the green zone.

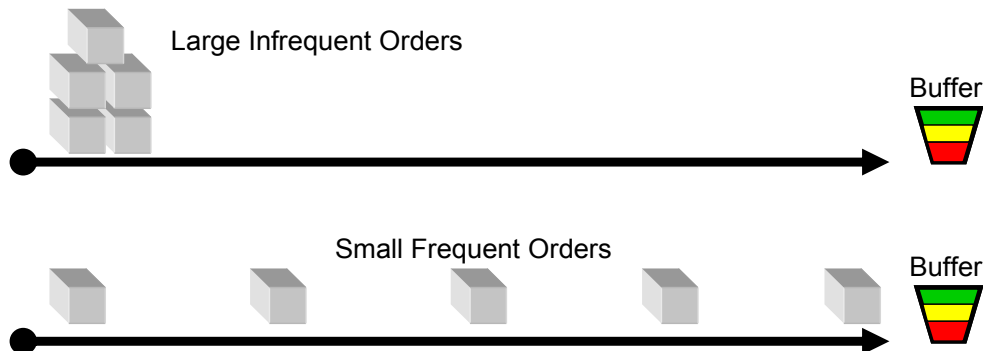
1. A percentage of Average Daily Usage over one full lead time
2. A significant minimum order quantity (if applicable)
3. An imposed minimum order cycle (if applicable)



Calculating the green zone as a percentage of usage over a lead time requires knowledge of what lead time category the part/SKU belongs (short, medium or long). This percentage will be called "The Lead Time Factor." Below is a table of recommended Lead Time Factor ranges for SKU in the different lead time categories. The ASRLT (ASR Lead Time) is the qualified cumulative lead time defined as the longest unprotected/unbuffered sequence in a bill of material.

	Lead Time Factor Range
Long Lead Time	20-40% of ADU over ASRLT
Medium Lead Time	41-60% of ADU over ASRLT
Short Lead Time	61-100% of ADU over ASRLT

The rule of thumb is **the longer the lead time of the SKU the smaller the Lead Time Factor** should be. This may seem counterintuitive for many people. The DDMRP approach forces as frequent ordering as possible for long lead time parts (until MOQ or an imposed order cycle becomes the green zone determining factor). Since the green zone determines average order size and frequency, a smaller lead time factor produces a smaller green zone.



Remember, first and foremost DDMRP is about creating and protecting the flow of information and materials. For long lead time parts DDMRP is attempting to create a supplying "conveyor belt" delivering a steady stream of supply orders. With large infrequent orders, a disruption of a boat, port, truck, etc. could disrupt the entire inbound supply. With smaller more frequent



orders, you spread your risk and extend the buffer upstream in the supply chain (this understanding then corresponds to using a smaller lead time factor in the red zone as well). Additionally, there can be a cash flow advantage to paying smaller, more frequent invoices as opposed to large infrequent invoices.

As an example we will take a part with the following characteristics:

Average Daily Usage <sup>4</sup>	10 per day
ASR Lead Time	12 days
Lead Time Category	Medium
Lead Time Factor	50%
Minimum Order Quantity (MOQ)	50
Imposed order cycle?	7 days - only one delivery per week

Step 1: Calculate the Green Zone using the Lead Time Factor.

ADU (15 per day) x ASR LT (12 days) x Lead Time Factor (.5) = 60

Step 2: Compare the calculated green zone against the minimum order quantity or imposed order cycle factor and take the greater. The calculated green zone (60) is larger than the minimum order quantity (50). The imposed order cycle of 7 days, however produces the largest green zone (70). When an imposed order cycle is present the order cycle is multiplied by ADU and then compared to MOQ and the green zone calculated through the lead time factor. This part's buffer green zone will be 70 pieces.

70

The average order frequency is determined by dividing the green zone by the ADU. In this case it is 7 days. If the order cycle was not present it would be 6 days (the green zone produced by the Lead Time Factor (60) divided by the ADU (10 per day)).

### The Yellow Zone

The yellow zone is the heart of the inventory coverage in the buffer. The yellow zone is always calculated as 100% ADU over ASR Lead Time. In our example the yellow zone of this part would sized at 120 pieces.

120

The relationship between the green zone and yellow zone can also tell us how many open supply orders we can expect to at any one time. In our example, by dividing the yellow zone (120) by the green zone (70) we will see that we can typically expect to see an average of around 2 open supply orders at any one time. For longer lead time parts this tells us how many "orders on the conveyor belt" we should expect to see. This can provide a quick way to analyze whether the part fits the buffer profile provided for it and whether the buyer/planner is launching supply orders when they should be (when available stock is just below top of yellow).

### The Red Zone

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<sup>4</sup> Average Daily Usage (ADU) is typically calculated using a rolling past horizon. The length of that rolling horizon can vary based on the type of environment and/or part.



The red zone is the embedded safety in the buffer. The higher the variability associated with the part or SKU the larger the red zone will be. Calculating the red zone requires three sequential equations.

1. Establish the “Red Base.” The Red Base is established through the reapplication of the Lead Time Factor multiplied by the Average Daily Usage. This Lead Time Factor corresponds to the same ranges used for the green zone calculation but can be selected as a different actual percentage from the Green Zone.

Red Base	Lead Time Factor Range
Long Lead Time	20-40% of ADU over ASRLT
Medium Lead Time	41-60% of ADU over ASRLT
Short Lead Time	61-100% of ADU over ASRLT

In our example the part falls in the medium lead time category. For simplicity in the example we will use the same percentage Lead Time Factor (50%) that we used in the Green Zone calculation. Thus for this example Red Base = 60 units.

2. Establish the “Red Safety.” The Red Safety is calculated as a percentage multiplier to the Red Base. The percentage used is called the Variability Factor. Like the Lead Time Factor tables above there are ranges of variability factors depending on whether a part experiences high, medium or low variability.

80

Red Safety	Variability Factor Range
High Variability	61-100% of Red Base
Medium Variability	41-60% of Red Base
Low Variability	0-40% of Red Base

Variability is unique to an environment. What is “high variability” in one type of environment might be moderate in another. Selecting the various thresholds and percentages is typically done by calculating the coefficient of variability (CoV) of each strategic part and based on the CoV distribution of all of these parts determining the boundaries of high, medium and low.<sup>5</sup> There can be more than just those three distinctions. For example, distributions with very long tails may produce a variability category of “Very High.” A very high Variability Factor range may be 80%-100% or even higher. For our example, we will say that this part falls in the low variability category with a Variability Factor of 33%. Our Red Base of 60 is multiplied by .33 to produce a Red Safety of 20.

An additional note on variability concerns whether order spikes are visible or not. The DDMRP available stock equation calls for the qualification of order spikes when possible. This is done by looking at sales orders (or work order demands derived from sales

<sup>5</sup> CoV is calculated as the standard deviation of demand or supply (depending on the part type) divided by the average daily usage (ADU)



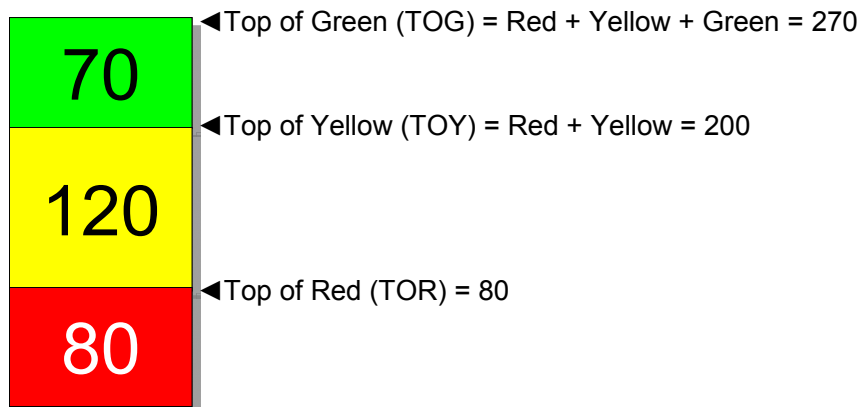
orders) over an “order spike horizon” (typically one ASR Lead Time) in the future and qualifying them against an “order spike threshold.” If order spikes are NOT visible due to the lack of actual sales order visibility within the ASR Lead Time then the ability to compensate for variability through the available stock is equation is impacted. This should push the Variability Factor used higher. Conversely, if sales orders are typically visible within one ASR Lead Time then the Variability Factor should pushed lower.

3. Calculate the total Red Zone by adding Red Base plus Red Safety. Red Base (60) + Red Safety (20) = Total Red Zone (80)

Many times the question is asked why the red zone contains two separate parts (Base and Safety). The answer is the safety related to both lead time and variability are visible. Red Base is a factor of usage over lead time and relates to the Lead Time Category that the part falls within. Red Zone Safety factors that number based on the Variability Factor within that lead time period. Thus parts that have the same Variability Factor applied but are in different Lead Time Categories will have Total Red Zones that are proportionately different.

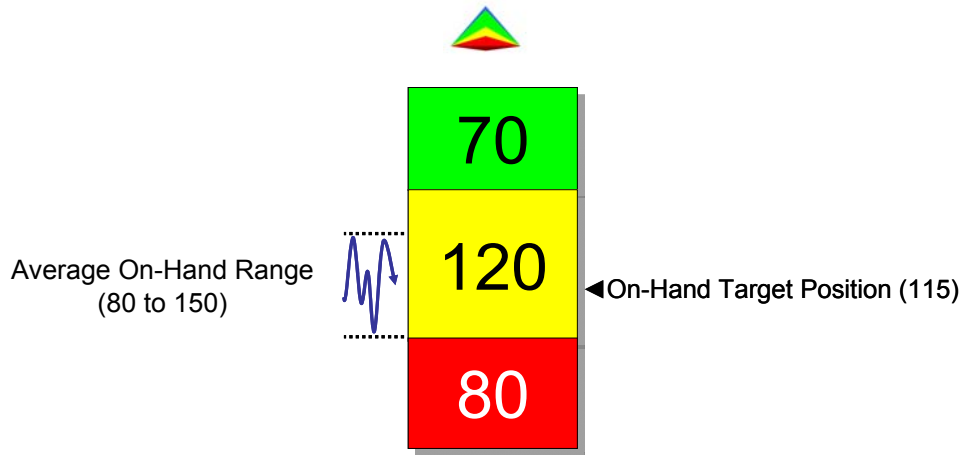
### Complete Buffer

Below is a picture of our newly constructed buffer.



In this case the top of the buffer is 270 units. It is important to note that in DDMRP this is from a planning perspective only. A DDMRP buffer that is properly profiled and sized results in significantly less on-hand inventory. The average on-hand inventory position under normal variation can be calculated as the Red Zone plus one half of the Green Zone. In our example that would yield an average on-hand position of 115 units (80 + 35).<sup>6</sup> This is typically called the “on-hand target” position. The average inventory range is defined as the top of the red zone to the top of the red zone plus the green zone. In our example (depicted below) this would be 70 (top of red zone) to 150 (top of red plus green). The on-hand target position and range is a primary performance measurement for DDMRP systems.

<sup>6</sup> The average on-hand position and range equation is explained in the technical paper “The Average Question” (Ptak and Smith, DDI, 2012).



### Simulating Demand Driven MRP Buffers

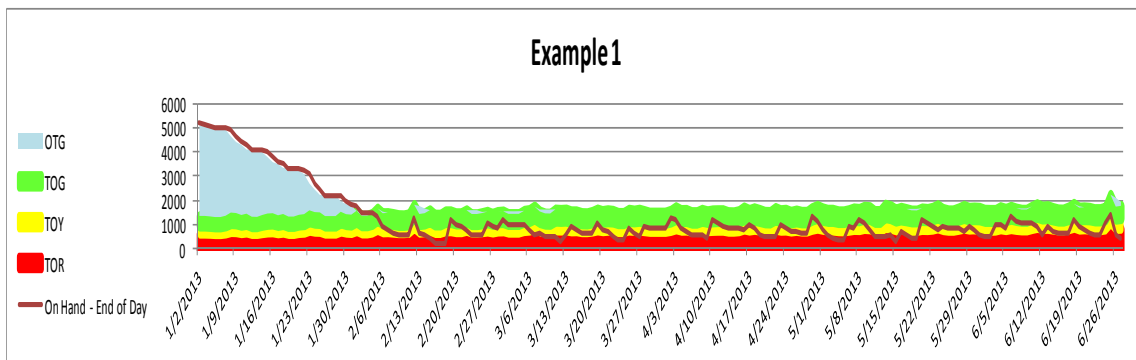
Now we will turn our attention to understanding how the DDMRP buffers perform under different scenarios using a simulation engine created by [Demand Driven Technologies](#). The following simulations were based on actual demand patterns provided by various companies. Using the companies' opening on hand inventory balance, daily demand and applicable part parameters such as Lead Time and Minimum Order Quantity the simulation can show how DDMRP buffers would have supported the demand history provided. Variability is measured as the Standard Deviation of the demand divided by the average daily usage. This measure is the Coefficient of Variability (CoV) and is documented for each of the scenario cases.

#### Scenario 1 – Base Example

The first scenario illustrates a part with high variability and a high starting on hand position. Due to this high on hand position at the start of the simulation the part is well above Top Of Green. It remains in this zone until the demand drains the inventory down towards the target range. The buffers do not generate a new supply order until the second month of the simulation. Please note that there is no order spike qualification used in this model as it reflected a distribution environment with very limited forward visibility to sales order demand.

You'll notice that the buffer zones are trending upward over time reflecting increasing customer demand for the part. There is a greater level of movement in the zones on a weekly basis. This is due to the company's interest in using a 30 day rolling ADU calculation that updated weekly.

The result of the simulation was that the DDMRP buffer would have yielded an average on hand inventory level less than half the size that the company had carried during the same period.



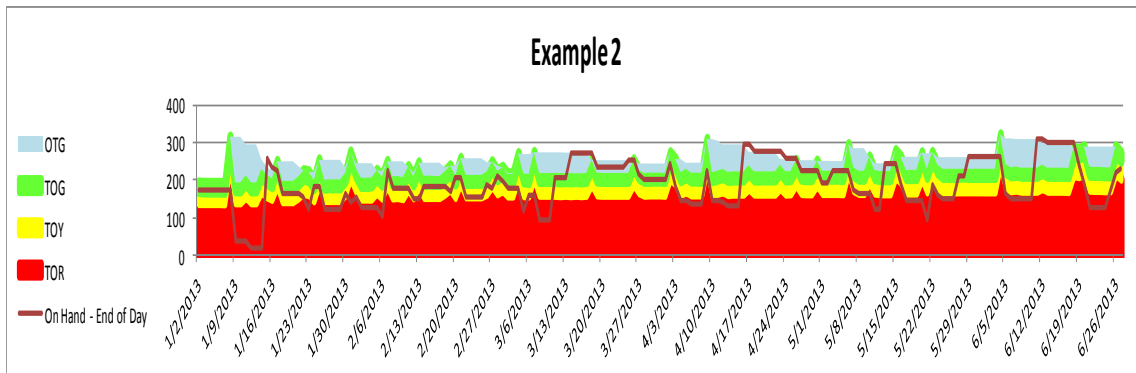




Lead Time	6 days
Average Daily Usage	59.00
Minimum Order Quantity	N/A
Total Demand	21,342
Average On Hand	2,076
CoV	180.90

### Scenario 2 – High Variability

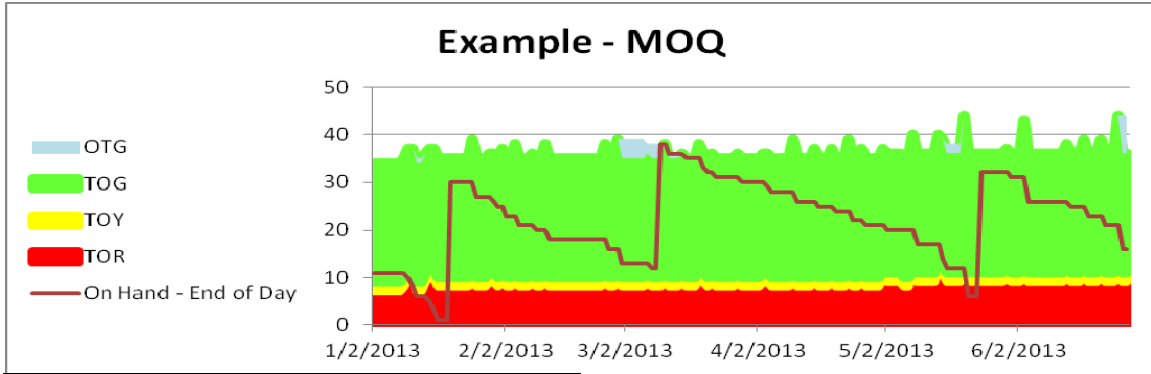
Scenario 2 is another part from a distribution environment with a higher level of demand variability (note the “thicker” red zone). Again, as in example 1, the buffer is not benefiting from Order Spike protection. This part was also experiencing an increase in demand during the analysis period. As such, the buffer size flexes up slightly over the simulation time frame. Average on hand decreased roughly 20%. You’ll note a deep penetration in the second week of the analysis. This was due to not including any open supply at the start of the simulation because the data were not available.



Lead Time	6 days
Average Daily Usage	5.93
Minimum Order Quantity	20
Total Demand	2,136
Average On Hand	151
CoV	293.34

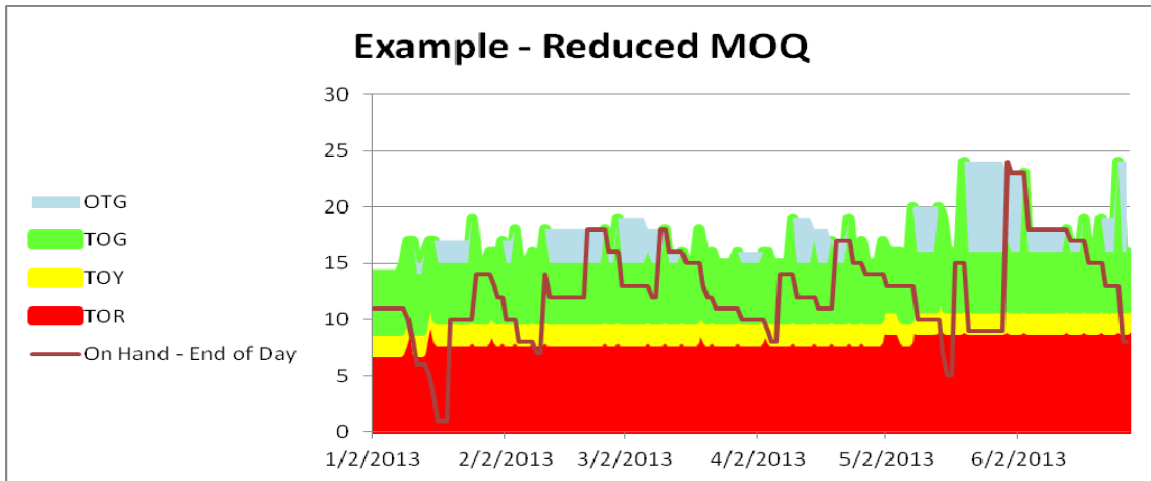
### Scenario 3 – Significant Minimum Order Quantity

This scenario illustrates a part which has a significant Minimum Order Quantity relative to its Average Daily Usage. In this case, the MOQ represented more than ten times the usage of the part over its lead time. As a result, note that the green zone in this case reflects the MOQ value and is very large in relation to the red and yellow buffer zones.



Lead Time	9 days
Average Daily Usage	.21
Minimum Order Quantity	25
Total Demand	76
Average On Hand	22
CoV	339.08

The simulation demonstrates potential reductions to the MOQ that enabled 100% service level with a 45% reduction in inventory. In the below example notice a much thinner green zone and more frequent ordering.



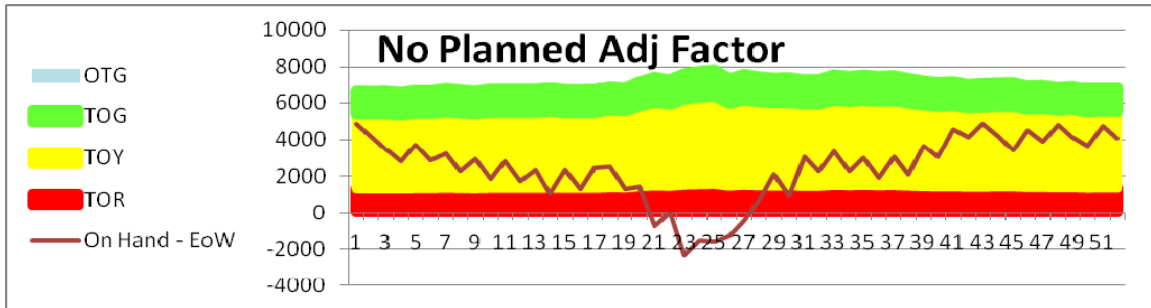
Lead Time	9 days
Average Daily Usage	.21
Minimum Order Quantity	5
Total Demand	76
Average On Hand	13
CoV	339.08

#### Scenario 4 – Planned Adjustment Factors (PAF)

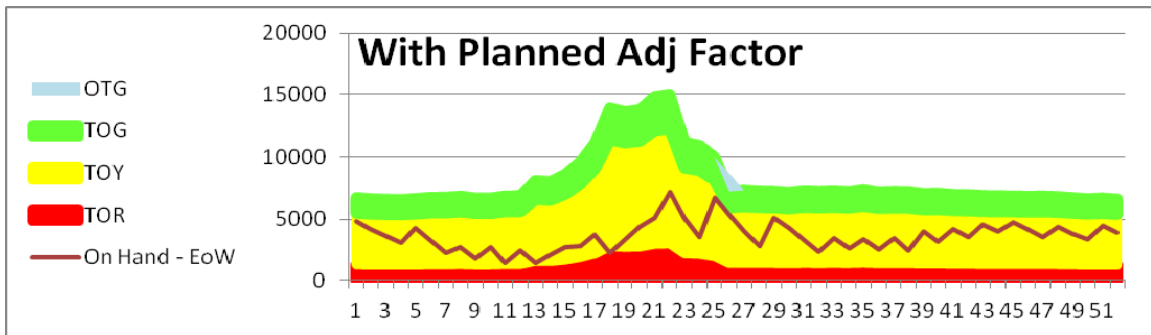
In this example we modeled the impact of using Planned Adjustment Factors (PAF) to address seasonal demand. This example is a skin care product from a cosmetic manufacturer that routinely experiences substantial demand during the summer months.



The first graph reflects the buffer behavior without the use of Planned Adjustment Factors while the second graph includes the use of a Planned Adjustment Factor to address the expected seasonality.

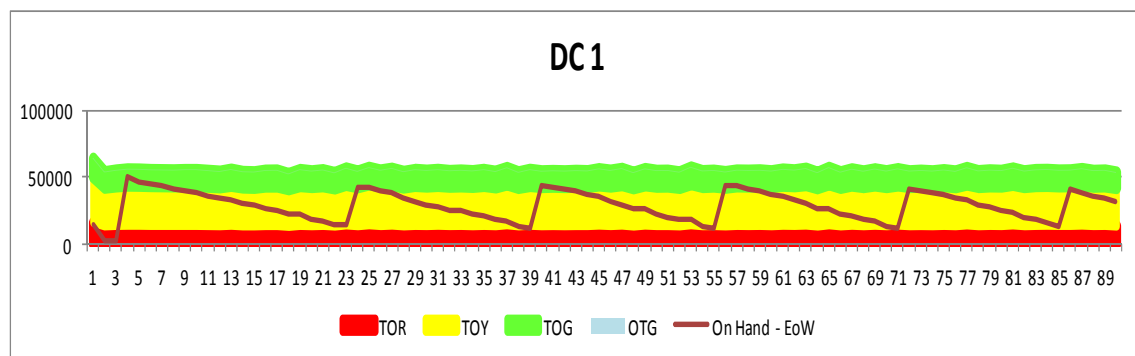


It's clear that the use of the PAF substantially improved material availability and addressed the seasonal demand in a very effective manner. Note the aggressive build-up of the buffer zones using the PAF in advance of the peak demand that comes in weeks 20 through 28.



### Scenario 5 – Distribution

The following graphs illustrate a distribution example with a Distribution Center supplying four forward locations. Note the suffix NS in the names of the forward locations which indicates that there was no Order Spike Qualification utilized for those locations. This was due to the retail nature of those facilities which have no advanced notice of sales order demand.

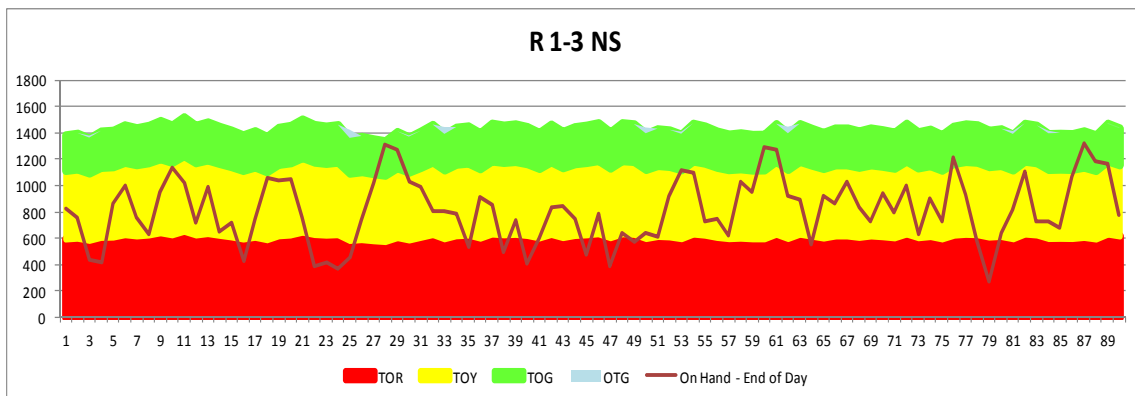
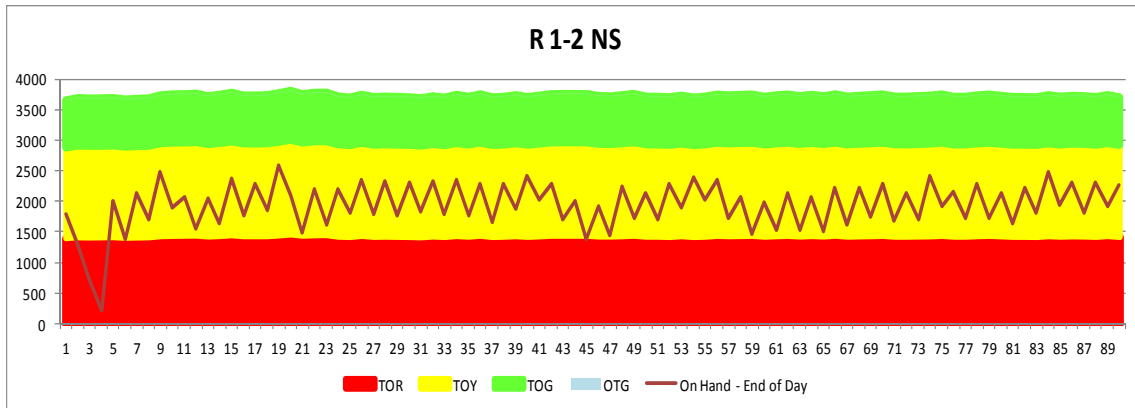
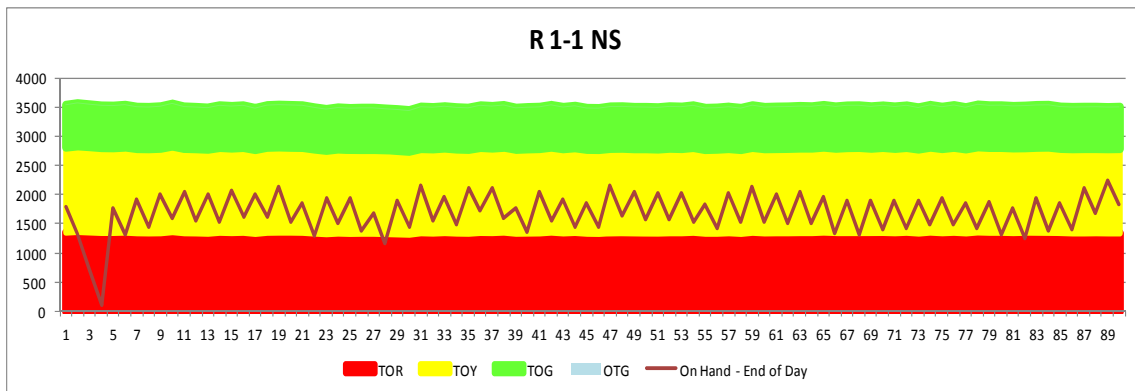


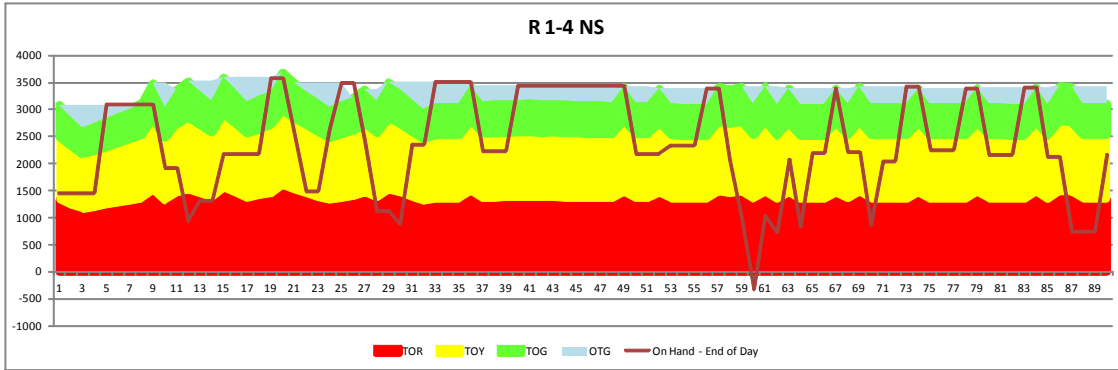
Forward locations 1 and 2 had low variability. Location 3 had moderate variability while location 4 was experiencing high variability for this part.



Note that the DC experienced a regular pulse of demand and predictable arrival of new supply indicated by the upward jumps in on hand inventory. The Distribution Center's replenishment lead time is 21 days while its supply lead time to the forward locations was 2 days. This 'hub and spoke' approach enables fast replenishment times and low stocking levels in the forward locations and helps to address the heavy variability in locations 3 and 4.

Note that in location "R 1-4 NS" that there is a stock out in week 60 which was the result of a very large spike of demand. This represents a case where a business judgment can be made to increase the buffer zones to ensure 100% availability vs. experiencing an infrequent stock out situation. The stock out, however, was very short lived as the Distribution Center had inventory and was only two days away (transportation lead time).





## Summary

The buffers of DDMRP are strategic points and tools to protect flow in a given environment. By decoupling at critical points a system gains the ability to quickly compress lead times and isolate or contain variability from being transferred or amplified at those points. Employing the DDMRP buffering methodology at those points creates an effective, robust and intuitive planning mechanism. Experience and the above simulation tools suggest that the more volatile and/or complex (product structure depth and breadth) an environment is the more effective these buffers are at maintaining high service levels, containing working capital growth and minimizing expedite related waste.

## DDMRP News and Notes

### Become a Certified Demand Driven Planner (CDDP)

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).



CDDP™ sessions are held at various locations around the world.

**NEW Online CDDP Program!**, Did you know there is a new online version of the CDDP™ Program? **The next online session starts September 25<sup>th</sup>.**

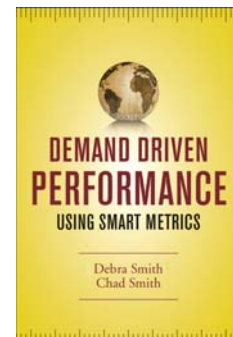


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### Upcoming Book that Incorporates DDMRP Principles

In the Fall of 2013 look for the newest Demand Driven book called *Demand Driven Performance – Using Smart Metrics* by Debra Smith and Chad Smith.

*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.

[Available for pre-order at Amazon!](#)

### **About the Author**

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](mailto:csmith@demanddriveninstitute.com)



### **A Big Thank You**

A special thanks to the people at Demand Driven Technologies for sharing their simulation tool!



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