Demand Driven Material Requirements Planning (DDMRP)

Version 2

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CHAPTER 13

The Demand Driven Adaptive Enterprise Model

Authors’ Note: Version 2 of this book offers a significantly altered version of Chapter 13, as the Demand Driven Adaptive Enterprise Model replaced what was previously defined as the Demand Driven Adaptive System. The Demand Driven Adaptive Enterprise Model and the driving need behind it are discussed at length in Chapters 6 and 7 of Precisely Wrong: Why Conventional Planning Fails and How to Fix It (Ptak and Smith, Industrial Press, 2017).

Consider the broader implications that a flow-based strategy has for an organization—the impact on the necessary strategic and tactical components to control, measure, adapt, improve, and innovate in the New Normal. The better that organizations are at understanding and implementing these components, the more successful and sustainable a Demand Driven Material Requirements Planning (DDMRP) implementation will be and the more sustainable the resulting ROI.

This book describes the components and details behind DDMRP. In Chapter 5, DDMRP is described as a component of the Demand Driven Operation Model (DDOM). In Chapter 11, the “master settings” of DDMRP are described as a component of a larger process known as Demand Driven Sales and Operations Planning (DDS&OP). In Chapter 12, DDMRP metrics and analytics that drive improvements are discussed—these metrics and analytics are also part of DDS&OP. Thus DDMRP is a component of a larger management framework for the successful navigation of today’s complexity and volatility. This larger framework is the Demand Driven Adaptive Enterprise (DDAE) Model.

The DDAE Model spans the operational, tactical, and strategic management ranges of an organization, allowing it to continuously and successfully adapt to the complex, changing, and volatile markets that exist today. The fundamental principles of flow management are combined
with the emerging new science of complex adaptive systems to provide a complete management methodology that successful businesses need in the twenty-first century.

Figure 13-1 illustrates the essential components and basic mechanics of the DDAE Model. It is neither simply right to left nor left to right in nature. It is both at the same time. It is a bidirectional nonlinear system that drives adaptation through a cycle of configuration, feedback, and reconciliation through the three components.

The three components of the DDAE Model are:

1. **The Demand Driven Operating Model.** A Demand Driven Operating Model is a supply order generation, operational scheduling, and execution model utilizing actual demand in combination with strategic decoupling positions and control points protected by stock, time, and capacity buffers to create a predictable and agile system that promotes and protects the flow of relevant information and materials within the operational relevant range (hourly, daily, and weekly). The DDOM’s key parameters are set through the Demand Driven Sales and Operations Planning process to meet the stated business and market objectives while minimizing working capital and expedite-related expenses.

2. **Demand Driven Sales and Operations Planning.** Demand Driven Sales and Operations Planning is a bidirectional tactical reconciliation hub in a Demand Driven Adaptive Enterprise Model between the strategic (annual, quarterly, and monthly) and operational (hourly, daily, and weekly) decision-making relevant ranges. DDS&OP sets key parameters of a Demand Driven Operating Model based on the output of the Adaptive S&OP process (strategic information and requirements).
DDS&OP projects the DDOM performance based on the strategic information and requirement inputs and various DDOM parameter settings. Additionally, DDS&OP uses the variance analysis based on past DDOM performance in relation to critical system operational flow-based metrics (reliability, stability, and velocity) to adapt the key parameters of the DDOM and/or recommend strategic changes to the business plan.

3. Adaptive Sales and Operations Planning. Adaptive Sales and Operations Planning is the integrated business process that provides management the ability to strategically define, direct, and manage relevant information in the strategic relevant range across the enterprise. Market driven innovation is combined with the operations strategy, go-to-market strategy, and financial strategy to create the requirements inputs for the tactical reconciliation process in addition to providing strategic projections to effectively evaluate scenarios to drive adaptation and innovation.

At each side of the model there is a market interface. On the left-hand side the DDOM takes the input of actual demand to drive operational planning, scheduling, and execution. On the right-hand side, Adaptive S&OP leverages market innovation. Market innovation is unique to each company and rests largely in the vision of its executives to understand and articulate where and how the company will meet future opportunity in the market.

Demand Driven Operating Model

The Demand Driven Operating Model is a flow-based operating approach incorporated in the DDAE Model. Figure 13-2 is a restatement of Figure 5-6 showing the detailed schema of the
Demand Driven Operating Model. The heart of the DDOM is the innovative method of supply order generation and execution known as Demand Driven Material Requirements Planning. As discussed throughout this book, DDMRP utilizes strategically determined decoupling points protected by buffers to compress lead times and mitigate the distortion to relevant information (the transfer and amplification of demand signal distortion) up the supply chain and the distortion to relevant materials (supply continuity variability) down the supply chain.

DDMRP utilizes actual demand as part of its unique net flow planning equation to generate supply order signals. Manufacturing orders (MOs) with request dates are sent to demand driven scheduling, while purchase orders (POs) and stock transfer orders (STOs) are sent directly to demand driven execution. Real-time status signals are then returned from each. Demand driven scheduling provides manufacturing promise dates, and demand driven execution provides on-hand and synchronization alerts.

Detailed resource scheduling is accomplished through a demand driven scheduling process. Scheduling sequences manufacturing orders for shop floor execution, and execution returns order progression information against the schedule. Demand driven execution is where stock, time, and capacity buffers are actively managed in relation to all open orders and scheduled activity.

One unique feature about the Demand Driven Operating Model is that there is no master production schedule in use. The conventional MPS is replaced by the master settings input. Now it is possible for a company to build what can and will be sold because the operational capability aligns with the strategic requirements and the immediate market. The settings and configurations for the entire DDOM (including DDMRP) are managed through DDS&OP. Feedback loops are connected to DDS&OP from each of the three components of the DDOM providing valuable variance analyses for future DDOM reconfiguration or adaptation.

The DDOM is designed around four basic elements.

Element #1: Pacing to Actual Demand
The Demand Driven Operating Model uses only actual demand rather than a forecast for supply order generation. There are no planned orders for decoupled parts and no master production schedule used in the DDOM. As discussed in Chapter 3, actual demand is the most relevant and undistorted demand signal available to companies. When actual demand drives end item replenishment, then subsequent exploded dependent demand is directly connected to that actual demand. Decoupling points then allow for the accumulation of demand to trigger the next level of explosion through the net flow equation.

Element #2: Strategic Decoupling Points
The Demand Driven Operating Model uses strategically placed decoupling points to compress lead times, shorten planning horizons, and dampen demand and supply variability. The placement of these decoupling points was discussed extensively in Chapter 6. It is a strategic decision
that will impact how the company meets customer expectations and what it has to invest to meet those expectations (including working capital levels and fixed- and variable-expenses bases).

**Element #3: Strategic Control Points**

The Demand Driven Operating Model uses strategically placed control points for scheduling in addition to resource and order synchronization. Control points are places to transfer, impose, and amplify control through a system and within certain parts of a system. There are four types of control points:

1. **Pacing resources** determine the total system output potential. The slowest resource or consistently most loaded resource will often limit or define the system’s total capacity and output capability. These are commonly called a drum (consistent with the Theory of Constraints). Drums are finitely scheduled based on actual demand or stock buffer replenishment orders. This finite schedule will then determine promise dates, material release times, and all other entry and exit point schedules.

2. **Exit and entry points** are the boundaries of your effective control. Carefully controlling the entry and exit determines whether delays and gains are generated inside or outside your system.

3. **Common points** are points where product structures or manufacturing routings either come together (converge) or deviate (diverge). One place can control many things.

4. **Points that have notorious process instability** are good candidates because a control point provides focus and visibility to that resource and forces the organization to bring it under control or plan for, manage, and block the effect of its variability from being passed forward.

**Element #4: Dynamic Buffering**

The Demand Driven Operating Model protects its decoupling and control points through dynamic stock, time, and capacity buffers.

**Stock Buffers**

The dynamic stock buffers of DDMRP are a primary topic of this book.

**Time Buffers**

Demand driven time buffers are planned amounts of additional time inserted in the schedule in order to cushion a control point schedule from disruption. Time buffers create a small queue of work waiting to be processed by a control point at the appropriate time. Time buffers are sized based on the reliability of the string of resources feeding the control point. The less reliable or more variable that string is, the larger the time buffer requirement.
Capacity Buffers
Capacity buffers protect control points and decoupling points by giving resources in the preceding work flow the available capacity to “catch up” with variability. Thus, a capacity buffer is protective capacity that provides agility and flexibility. The size of the capacity buffer directly affects the sizing of both stock and time buffers—they are interdependent.

Protective capacity is available today in every resource that is not capacity constrained. Capacity buffers are not being used to improve unit cost or to maximize a resource’s utilization or efficiency. In fact, the entire notion of a capacity buffer is the antithesis of conventional costing policies. Capacity buffers require that a resource maintain a bank of capacity that goes unused.

Exploring ways to minimize the investment and expense associated with this unused capacity is absolutely valid. What is not valid is encouraging a resource to misuse its spare capacity to improve unit cost or resource efficiencies by running unnecessary production; that is purely distortive. When that happens, market responsiveness goes down, and the stock and time buffers are jeopardized, forcing them to be increased to compensate for this self-imposed variability. This then results in increases in lead times and inventory levels. This is precisely the wrong way to “utilize” a company’s assets—by destroying ROI.

Readers wishing to learn more about the details of the Demand Driven Operating Model should read Demand Driven Performance: Using Smart Metrics (Smith and Smith, McGraw-Hill, 2014).

Demand Driven Sales and Operations Planning
Now we turn our attention to the tactical reconciliation hub of the DDAE Model. This tactical reconciliation hub is the pragmatic missing link between Sales and Operations Planning processes and day-to-day operations. S&OP has traditionally tried to manage the portfolio and new activities, demand, and supply plans while reconciling these with the acceptable range of the business plan through a management business review. Successful S&OP implementations have provided a robust process where management considers marketplace information to pass a doable business plan to operations that meets the financial business requirements. However, that connection traditionally has been through a master production schedule, a statement of what can and will be built—a single number by a specific date—that feeds the formal planning system. These single-number detailed master schedules that drive supply order generation and operational activity will be precisely wrong and will result in massive amounts of corrective actions to adjust the outcome to be even close to approximately right. Readers wishing to understand this issue at a detailed level are encouraged to read Chapters 1 to 3 of Precisely Wrong: Why Conventional Planning Fails and How to Fix it (Ptak and Smith, Industrial Press, 2017).

An effective S&OP plan is a range—an expected number with a pessimistic lower range and an optimistic upper range. This range represents the intended strategic direction including the tolerance range in the business plan from the executive team. However, traditional formal planning cannot calculate from a range. The MRP system needs a demand plan that is precise in
quantity and timing. This is the chasm that must be crossed from the strategic range to the operational range, and traditionally the MPS is used. In reality, this is like trying to cross the Grand Canyon on a single wire. If you can balance precisely, there is no wind, and nobody disrupts that wire, you may get to the other side rather than falling to your death. The volatile, uncertain, variable, and complex world we must now manage is like someone shaking that wire and having gale force winds coming through the canyon at the same time.

A new bridge is required to cross this canyon—Demand Driven Sales and Operations Planning. DDS&OP is a bidirectional tactical reconciliation hub in the Demand Driven Adaptive Enterprise Model between the strategic and operational relevant decision-making ranges. DDS&OP sets key parameters of a Demand Driven Operating Model based on the strategic information and capability requirements output of the Adaptive S&OP process. DDS&OP also projects the DDOM performance based on these scenarios in addition to various DDOM parameter settings. Additionally, DDS&OP uses variance analysis based on past DDOM performance with regard to critical relevant metrics to adapt the key parameters of the DDOM and to recommend strategic changes to the business.

Figure 13-3 displays the DDS&OP schema. To the left, the bidirectional connection to the DDOM can be observed. Master settings configure the DDOM, while a return loop in the form of variance analysis comes back to DDS&OP. To the right, the bidirectional connection to Adaptive S&OP can be observed. The validated business plan is provided by the Adaptive S&OP process. That plan has an estimated demand range, required capabilities, and future performance targets for the DDS&OP team to configure the DDOM. The DDS&OP process then returns model projection and strategic recommendations (as part of the Adaptive S&OP scenario evaluation process). Within the DDS&OP process, tactical exploitation will influence the tactical demand plan to maximize ROI.

With DDS&OP, the strategic range can be coupled to a compatible operational capability range—no MPS is required. The S&OP plan at the family level is translated to the required decoupling positions in the DDOM that are necessary to provide the required operational capability. This is not simply a disaggregation of the product family forecast to the SKU-level schedule.
by time frame. The intended strategy with respect to response time, inventory investment, and space utilization is reflected in the DDOM design. There are six elements of DDS&OP.

**Tactical Configuration and Reconciliation**

DDS&OP configures the DDOM to match the evolving business plan through the DDOM master settings. Figure 13-4 lists the DDOM master settings managed by the DDS&OP process. Changes to these settings or the migration of parts between profiles allows the DDOM to adapt operational capability to changing circumstances of the business.

**Tactical Review**

DDS&OP performs operational variance analyses of DDOM performance (reliability, stability, and velocity) over the past tactical relevant time range. The variance analyses identify areas or processes in the DDOM that jeopardize performance, cause additional spend, or present opportunities for model refinement. Typically these analyses are done through the Pareto charts complementing the run and control charts. This was discussed extensively in Chapter 12.

**Tactical Exploitation**

DDS&OP can bring short-range supplements to flow when or if capacity is available as well as look for ways to minimize cash outlays while maintaining flow. Tactical exploitation requires

<table>
<thead>
<tr>
<th>DDMRP</th>
<th>Demand Driven Scheduling</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stock buffer profiles.</strong> The groupings and settings for replenished parts (part type, variability, and lead time)</td>
<td><strong>Time buffer profiles.</strong> The time buffer groupings and settings for scheduled parts</td>
</tr>
<tr>
<td><strong>Planned adjustment factors.</strong> The adjustment factors to be applied to buffered items or groups of buffered items</td>
<td><strong>Time buffer profile assignment.</strong> The assignment of scheduled parts to time buffer groupings</td>
</tr>
<tr>
<td><strong>Part ADU.</strong> The average rate of use for each replenished part</td>
<td><strong>Resource assignment.</strong> The assignment of a resource to a resource type (control point, resource, buffered resource)</td>
</tr>
<tr>
<td><strong>Part profile assignment.</strong> The assignment of each replenished part to particular buffer profile</td>
<td><strong>Resource properties.</strong> Applicable scheduling properties for each resource (capacity, calendar, shifts, operators, etc.)</td>
</tr>
<tr>
<td></td>
<td><strong>Part properties.</strong> Applicable scheduling properties for each part (routings and run rates)</td>
</tr>
</tbody>
</table>

**FIGURE 13-4** DDOM master settings
visibility to DDOM capability in the short term. Is there additional capacity available that can be sold?

*Examples*

1. Are there stock buffers that make an ideal candidate for a close-in promotion due to slower-than-normal recent sales?
2. If a company's heat treat facility is loaded well below capacity for the week, are there companies that would pay for that heat treat capacity? Anything charged above truly variable costs results in additional cash flow with the same fixed-cost base with the final effect of increased ROI.
3. If our paint operation was underscheduled and we currently send some things out for painting to a third party, can we bring that work back? Forget about fully absorbed unit cost—instead focus on the increased recovery of cash back to the company within a certain period. That cash drives improved ROI.

*Tactical Projection*

The DDS&OP process projects model performance under different scenarios within the future tactical relevant range (one cumulative lead time into the future). In order to perform these projections, the DDS&OP team must have an awareness of current and potential problems regarding capacity, supply disruptions, quality and yield problems, and anomalous sales activity.

*Examples*

1. Are there stock buffers that should *not* be promoted due to potential disruptions to decoupling point integrity?
2. Is there a critical resource that is in limited supply and decisions must be made about where to best utilize it?
3. Has a major quality problem resulted in severe depletion of certain buffers and a recovery plan must be constructed?

*Strategic Recommendation*

The DDS&OP team presents ideas for better DDOM performance needing senior-level approval to the management business review. These are internal innovations designed to make the DDOM more agile, more stable, or more reliable but are above and beyond the authority of the DDS&OP team to authorize. Examples may include the recommendation for a third shift, a new piece of equipment, or the reengineering of a specific product to be manufactured differently. While these recommendations are beyond DDS&OP authority, the DDS&OP team has the ability to make the defensible case for change and relate the options to both tactical and strategic quantifiable metric objectives.
Strategic Projection

The DDS&OP process also helps project potential outcomes in the strategic relevant range based on the Adaptive S&OP integrated reconciliation output. This is a vital aspect of the Adaptive S&OP validation process. DDMRP allows the evaluation of different supply strategies through the calculation and comparison of the necessary buffers to each scenario, similar to the evaluation of different demand strategies. These performance projections typically include working capital, space, and capacity implications. The DDMRP methods described in this book make these projections relatively easy to derive.

Chapter 7 described the critical inputs to the buffer equation. Figure 13-5 is a restatement of Figure 7-18 showing the key elements of the buffer equation. Any one of these elements can be changed and the equation rerun in order to judge the impact of that change. For example, the implication of moving a part to a different profile can easily be determined by changing the lead time or variability factor. The implication of changing any of the part traits can also easily be determined.

One of these part traits is average daily usage. Chapter 7 described the various considerations for determining the average daily usage in order to calculate current decoupling point buffers. This is one of the master settings of the Demand Driven Operating Model.

DDS&OP can also project more remote periods of time using a projected ADU input. This input will then provide a point-in-time picture of what the buffers for a particular part should look like. This picture can then be used to judge the working capital, space, and capacity implications of demand at that level.

The connection from the operational planning using the ADU as described above, through the tactical planning in the DDS&OP process, is accomplished through the use of medium- and long-term forecasts by product families. These medium- and long-term forecasts are then translated to the strategic decoupling buffer ADUs to calculate the strategic buffers that would be necessary to support that level of business. Once these buffers are calculated, then the buffer can be converted to required working capital investment, space, or critical resource capacity. These buffers are simulated over the planning horizon to ensure that sufficient resources exist to execute the desired plan range. If there is insufficient capacity in future time periods, then the

<table>
<thead>
<tr>
<th>Part Trait</th>
<th>Buffer Profile Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Daily Usage (ADU)</td>
<td></td>
</tr>
<tr>
<td>Lead Time</td>
<td>X</td>
</tr>
<tr>
<td>Minimum Order Quantity (MOQ)</td>
<td>Lead Time Factor</td>
</tr>
<tr>
<td>Location (Distributed Parts Only)</td>
<td>Variability Factor</td>
</tr>
</tbody>
</table>

Buffer and Zone Levels

**FIGURE 13-5** Buffer equation elements
planned adjustment factors can be used to level the load by building the surging product ahead of the actual demand surge.

As opposed to the traditional planning by product family that is typical in S&OP, DDS&OP translates that forecast by product family into the projected ADU for strategic buffer items according to the Demand Driven Operating Model, and hence this supports the financial expectation from the business plan to calculate critical resource requirements. Once these calculations are completed, then the information can be used to support follow-up Adaptive S&OP reconciliation meetings.

It should be noted that any projected ADU input into this process creates a projected output with ranges built in. The ranges include the projected on-hand inventory that can subsequently be used to determine ranges for working capital commitment, space, and capacity. Of course, different ADU inputs can also be used representing different scenarios (aggressive versus conservative) to see the impact on the subsequent output ranges.

As an example, consider a company that makes four products (Items XYZ, ZYX, ABG, and GJK). Through the demand management process, a projection has been made for six months from now as described in Figure 13-6. This projected rate of demand is displayed in the “Projected ADU” column. Additionally, Figure 13-6 has the necessary components of the buffer equation (lead time and buffer profile attributes).

XYZ has a current ADU of 100. Six months from now its projected ADU is 150. Its decoupled lead time is 5 days. The parentheses in the lead time column represent the lead time category and lead time factor in use. XYZ is in the short lead time category using a 75 percent lead time factor. The desired order cycle for XYZ is 3 days. Its MOQ is 500. Finally, XYZ is in the medium-variability category using a 50 percent variability factor.

Given these inputs, it is relatively simple to produce the projected buffer levels using the projected ADU. Figure 13-7 shows current versus projected buffer zone values for all four items. Additionally, Figure 13-7 shows the current versus projected targeted on-hand inventory position (red zone value plus one-half green zone value). The row titled “Green” displays the green zone quantity of the buffer as well as the method of calculation (MOQ = minimum order quantity and LTF = lead time factor).

<table>
<thead>
<tr>
<th>Item #</th>
<th>Current ADU</th>
<th>Projected ADU</th>
<th>Decoupled Lead Time</th>
<th>Desired Order Cycle</th>
<th>MOQ</th>
<th>Variability</th>
</tr>
</thead>
<tbody>
<tr>
<td>XYZ</td>
<td>100</td>
<td>150</td>
<td>5 (short—75%)</td>
<td>3</td>
<td>500</td>
<td>Medium (50%)</td>
</tr>
<tr>
<td>ZYX</td>
<td>50</td>
<td>75</td>
<td>7 (medium—50%)</td>
<td>3</td>
<td>250</td>
<td>Medium (50%)</td>
</tr>
<tr>
<td>ABG</td>
<td>25</td>
<td>10</td>
<td>5 (short—75%)</td>
<td>3</td>
<td>250</td>
<td>Low (25%)</td>
</tr>
<tr>
<td>GJK</td>
<td>20</td>
<td>200</td>
<td>5 (short—75%)</td>
<td>3</td>
<td>250</td>
<td>High (70%)</td>
</tr>
</tbody>
</table>

**FIGURE 13-6** Example company for DDS&OP projections
As described in Chapters 7, 9, 11, and 12, DDRMP buffers are intended to always have stock to maintain their decoupling protection. The average quantity (number of units) of stock is calculated using a simple equation (red zone value plus one-half green zone value). Given this equation, an additional equation allows us to convert the average quantity to an average amount of working capital. Figure 13-8 compares the current versus projected average working capital represented by the average on-hand quantity for each of the four items. In each case, the average on-hand inventory levels (both current and projected) are multiplied by the working capital per unit. This working capital per unit represents the direct material cost per unit only. This is consistent with the Company ABC example used in Chapters 6, 7, and 9.

To support the predicted future rates of use, an additional $108,160 in average working capital will be required. This is neither good nor bad. The feasibility is for the business leadership to decide given the circumstances of the business. It simply means, given the current assumptions (same buffer profiles and same part attributes), that the buffers will need to contain more capital to support the increased business level. It should be noted that Figure 13-8 simply uses the average (projected target inventory level) within the anticipated or planned range (top of red value to top of red value plus the green zone), which would represent a projected low on-hand value to a projected high on-hand value. For example, XYZ would have a projected low on-hand value of $84,500 [845(top of red) × $100] and $140,800 [1,408(top of red + green) × $100].

<table>
<thead>
<tr>
<th>Item #</th>
<th>Working Capital per Unit</th>
<th>Current Target Inventory Level</th>
<th>Current Average Working Capital</th>
<th>Projected Target Inventory Level</th>
<th>Projected Average Working Capital</th>
</tr>
</thead>
<tbody>
<tr>
<td>XYZ</td>
<td>$100</td>
<td>813</td>
<td>$81,300</td>
<td>1,127</td>
<td>$112,700</td>
</tr>
<tr>
<td>ZYX</td>
<td>$90</td>
<td>388</td>
<td>$34,920</td>
<td>527</td>
<td>$47,430</td>
</tr>
<tr>
<td>ABG</td>
<td>$80</td>
<td>243</td>
<td>$19,440</td>
<td>173</td>
<td>$13,840</td>
</tr>
<tr>
<td>GJK</td>
<td>$50</td>
<td>253</td>
<td>$12,650</td>
<td>1,650</td>
<td>$82,500</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Total</td>
<td>$168,310</td>
<td>Total</td>
<td>$256,470</td>
</tr>
</tbody>
</table>
Those current assumptions can all be challenged over the next six months in order to change the projection. For example, reducing part lead times, reducing direct material costs, or using a lower-variability profile would all yield different projections. If there are real capital constraints, then these avenues can be explored to improve the feasibility.

**Space**

In a similar fashion the current and projected average targeted on-hand levels can be converted to space requirements such as pallet positions. Figure 13-9 compares the current versus projected pallet position requirements represented by the average on-hand quantity for each of the four items. In each case the average on-hand inventory levels (both current and projected) are multiplied by the units per pallet.

In this case another column has been inserted called "Projected Maximum Pallet Positions." This represents the number of pallet positions required when all buffers are at the top of their average on-hand range (red zone value + green zone value). This is done to give a sense of range in pallet positions that could be required even when the buffers are deemed to be operating within tolerance. This range might be important if a company has real warehouse or storage limitations. Under the projected rates of demand, 84 more pallet positions will be needed on average. As many as an additional 133 positions could be needed if all items are at the top of their average on-hand range.

Again the relevant question—is this feasible? That is for the business leadership to decide given the circumstances of the business. It simply means, given the current assumptions (same buffer profiles and same part attributes), that the buffers will need more pallet positions to support the increased business level. This could be of strategic importance, as additional storage space, if required, could be difficult or costly to obtain in a short period of time. For example, building extra space will require design, permitting, and construction time. Using a third-party warehouse might require a complex logistics plan calling for more personnel and transportation as well as significant expense. No matter what the specific circumstances, it is important that the business gain this visibility well in advance of actual projected need so that contingencies can be discussed.

<table>
<thead>
<tr>
<th>Item #</th>
<th>Units per Pallet</th>
<th>Current Target Inventory Level</th>
<th>Current Average Pallet Positions</th>
<th>Projected Target Inventory Level</th>
<th>Projected Average Pallet Positions</th>
<th>Projected Maximum Pallet Positions</th>
</tr>
</thead>
<tbody>
<tr>
<td>XYZ</td>
<td>10</td>
<td>813</td>
<td>81</td>
<td>1,127</td>
<td>113</td>
<td>161</td>
</tr>
<tr>
<td>ZYX</td>
<td>20</td>
<td>388</td>
<td>20</td>
<td>527</td>
<td>27</td>
<td>33</td>
</tr>
<tr>
<td>ABG</td>
<td>50</td>
<td>243</td>
<td>5</td>
<td>173</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>GJK</td>
<td>30</td>
<td>253</td>
<td>9</td>
<td>1,650</td>
<td>55</td>
<td>68</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>115</td>
<td>Total</td>
<td>199</td>
<td>248</td>
<td></td>
</tr>
</tbody>
</table>

**FIGURE 13-9** Pallet position requirements comparison (current versus projected)
Capacity
A significant part of the DDS&OP process is to determine if sufficient capacity exists to support the proposed future. Using DDMRP as the operational planning and execution methodology allows a company to ensure that overall sufficient capacity exists without committing to a master production schedule that forces production to build what is on the schedule, rather than possessing the agility to build what the customer desires to purchase. This is an excellent example of where roughly right will outperform precisely wrong.

Assume that the resource being considered is the lathe department. Currently the lathes are not a constrained resource, but the management team has concerns about the growth in business relative to the overall load on this department. The company has five lathes that are available each for 1,200 minutes per day (20 hours) of total production capacity, meaning there are 6,000 minutes each day of total lathe capacity. For simplicity, all five lathes have the same process capability and rate—they are identical in nature.

For calculation of rough cut capacity requirements, the current and projected ADU is multiplied by the minutes per unit on the lathe. This gives us a rough cut lathe capacity requirement per day to support the current and projected ADUs. Figure 13-10 shows that there is sufficient current capacity. However, given the current demand projections, it can be seen that the projected load six months from now far exceeds the current lathe capacity. This is detailed in Figure 13-11.

Now choices must be made in the management meeting. Changing buffer profiles will have no impact since this analysis is based on demand projection, available capacity, and a specific part attribute (minutes per unit on the lathe). One or more of the following things must be considered for manipulation to increase capacity or decrease load.

Lathe Capacity
Currently the five lathes work 20 hours per day. An additional 1,200 minutes per day could be added to the total lathe capacity if all lathes went to 24 hours per day. That would bring total capacity to 7,200 minutes, still below the 8,575 minutes required. It would also require more operators and leave no time for preventative maintenance.

<table>
<thead>
<tr>
<th>Item #</th>
<th>Minutes per Unit on Lathe</th>
<th>Current ADU</th>
<th>Current Average Daily Load</th>
<th>Projected ADU</th>
<th>Projected Average Daily Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>XYZ</td>
<td>30</td>
<td>100</td>
<td>3,000 minutes</td>
<td>150</td>
<td>4,500 minutes</td>
</tr>
<tr>
<td>ZYX</td>
<td>25</td>
<td>50</td>
<td>1,250 minutes</td>
<td>75</td>
<td>1,875 minutes</td>
</tr>
<tr>
<td>ABG</td>
<td>20</td>
<td>25</td>
<td>500 minutes</td>
<td>10</td>
<td>200 minutes</td>
</tr>
<tr>
<td>GJK</td>
<td>10</td>
<td>20</td>
<td>200 minutes</td>
<td>200</td>
<td>2,000 minutes</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>Total 4,950 minutes</td>
<td>Total</td>
<td>8,575 minutes</td>
</tr>
</tbody>
</table>

**FIGURE 13-10** Lathe department capacity load (current versus projected)
An additional consideration would be to add more lathes. If all lathes were available for 1,200 minutes per day, it would take at least three extra lathes to meet the load. This is not a trivial investment. And it would take more lathe operators. In many parts of the world, it is more difficult to find qualified operators than to pay for the acquisition of the machines.

**Load Manipulation**

One critical factor in calculating this load is the time it takes per unit for each item. The item requiring the heaviest load per unit is XYZ. It takes 30 minutes per unit of lathe capacity. Six months from now it is projected to require 75 percent of available daily lathe capacity. One way to manipulate the load requirement is to attempt to reengineer the product in a way that requires much less lathe time or to move operations that can be done on another machine.

Another way to decrease lathe load would be to outsource production of one or more of these items. But which items are the right candidates? In order to answer this question, the company will need to understand the financial return generated by each item that goes across the lathe. A basic tenet of management accounting is that companies’ profits maximize when the companies make and sell the products with the highest contribution margin per unit of the scarcest resource. The scarcest resource six months from now is projected to be the lathes. Thus
we will need to calculate the contribution margin for each product in relation to its impact on lathing capacity. Figure 13-12 shows the relative cash contribution per lathe minute for each item. Part XYZ has the largest per load and the lowest rate of cash return on the lathe. What this means is that when the company is making XYZ, it is getting $5.83 in cash contribution versus $7.00 when making GJK.

In this contribution margin calculation, we are considering only the price minus truly variable costs (in this case direct material cost). This is because the only truly variable cost in this environment is the direct material; all other costs are assumed to be fixed within the operational relevant range. The variable cost represents a real cash outlay directly related to each unit of each particular item. We must understand the rate of cash generation at the lathe only—the scarcest resource. Total labor and overhead are irrelevant and will distort the picture. Obviously, this is not the traditional margin as calculated in the ERP system item master, because the item master provides the standard cost and this considers nonrelevant costs in the determination of fully loaded costs. Readers that wish to know more about this concept are encouraged to read *Demand Driven Performance: Using Smart Metrics* (Smith and Smith, McGraw-Hill, 2013).

What does this mean from an outsourcing perspective? If a company has a capacity constraint and it is going to outsource, then it should outsource the item that produces the least return on that capacity constraint. It should keep the items that produce the best return on that resource in-house. In this case that product is XYZ. It should be a candidate for outsourcing to bring the required lathe load down to 6,000 minutes per day. That would mean outsourcing at least 86 pieces per day on average.

**Demand Manipulation**

If the business is incapable of meeting all the demand, then demand could be manipulated down by raising the price of certain items in order to maximize the rate of return. Which items should be chosen for a price increase? The answer to this also lies in examining the cash contribution from the lathe for each item. XYZ is projected to sell 150 per day in six months. It is the lowest cash contributor in terms of the lathe.

By raising the price to $180 per unit on XYZ, the contribution margin per lathe minute becomes identical to that for ABG. If this does not erode demand enough, then XYZ and ABG should be considered for additional price increases. ABG is a low-volume item, and so its impact in terms of relieving total lathe capacity is limited.

<table>
<thead>
<tr>
<th>Item</th>
<th>Minutes per Unit on Lathe</th>
<th>Direct Material Cost</th>
<th>Price</th>
<th>Contribution Margin</th>
<th>Contribution Margin per Lathe Minute</th>
</tr>
</thead>
<tbody>
<tr>
<td>XYZ</td>
<td>30</td>
<td>$100</td>
<td>$275</td>
<td>$175</td>
<td>$5.83/min</td>
</tr>
<tr>
<td>ZYX</td>
<td>25</td>
<td>$90</td>
<td>$250</td>
<td>$160</td>
<td>$6.40/min</td>
</tr>
<tr>
<td>ABG</td>
<td>20</td>
<td>$80</td>
<td>$200</td>
<td>$120</td>
<td>$6.00/min</td>
</tr>
<tr>
<td>GJK</td>
<td>10</td>
<td>$50</td>
<td>$120</td>
<td>$70</td>
<td>$7.00/min</td>
</tr>
</tbody>
</table>

*FIGURE 13-12  Contribution per margin per minute of lathe time*
Figure 13-13 shows the price required for XYZ and ABG to provide the same contribution margin as the next-lowest product, ZYX. XYZ's price would have to move to $292 per unit. ABG would have to be priced at $208 per unit. At this point XYZ, ZYX, and ABG could all be considered for additional price increases if the projected ADU erosion was insufficient for the available lathe capacity. One thing is for certain; the company would be making a significantly higher return for the same fixed-cost structure.

**Projected Order Frequency**

An additional factor to consider in managing supply is the current versus projected order frequency. This could be relevant when considering the impact on the number of setups and/or the impact on inbound logistics.

For simplicity we have not dealt with setups related to the lathe example. Yet looking at projected-order frequency will give us a good indication of what the impact will be. Figure 13-14 shows the current versus projected order frequency for the four products from our example. As can be seen in the figure, the frequency of production for GJK changes dramatically—from every 12.5 days to every 3.75 days. This increase in the frequency of production could dramatically impact capacity if the setup time for GJK is significant on a constrained resource.

The production of ABG will change from every 10 days to every 25 days on average. If the product has a shelf life, this is an issue that may need to be escalated to the management review. This product may be a candidate to discontinue since the contribution margin per unit of constrained capacity is relatively low and there would be a high risk of the product's shelf life expiring, meaning inventory that will need to be scrapped.
In a distribution environment, order frequency will typically relate to the average number of inbound receipts. The more that items are ordered, the more shipments that tend to be received. This can put pressure on the receiving and inspection operations. Is there enough inspection space? Are there enough dock doors? Are there enough personnel?

**Adaptive Sales and Operations Planning**

An explanation of the DDAE Model cannot be complete without explaining the final component—Adaptive Sales and Operations Planning. As described earlier, Adaptive Sales and Operations Planning is the integrated business process that gives management the ability to strategically define, direct, and manage relevant information in the strategic relevant range across the enterprise. Market driven innovation is combined with the operations strategy, go-to-market strategy, and financial strategy to create strategic information and requirements for tactical reconciliation and strategic projection to effectively create the desired future, drive adaptation, and manage change.

There are some starting assumptions with regard to Adaptive S&OP:

1. The company has the ability to define an offer to a market.
2. The future will look different from the past.
4. The basic difference between managing for flow and managing for cost is understood by the organization.
5. The organization has at least a partial flow-based operating model (DDOM) in place.
6. The organization will have the capability and personnel to perform tactical reconciliation activity to the flow-based operating model (defined DDS&OP activities).
7. Information should be presented as a roughly right range rather than precisely wrong discrete numbers.

The Adaptive S&OP process assumes an existing (at least partially established) business plan to begin. The Adaptive S&OP process adapts the business plan based on things like:

- New directives from senior management
- New opportunities in the marketplace
- New product timing
- Deviations from the business plan
- Supply/DDOM problems
- Impact of external factors (currency shifts, new regulatory requirements, global crises, competitive threats, etc.)
There are seven steps in the Adaptive S&OP process. In all cases it is crucial that the assumptions involved in each step are well documented.

1. **Portfolio and new activities strategy input.** What is and will be the composition of our offerings? This is no trivial question, and answers can and will shift over time. The Adaptive S&OP process forces the team to understand the types of products the company does and will offer. This will have implications for other critical inputs.

2. **Forecasted demand input.** What is going to be made and sold at the family level over the strategic time frame? Forecasts are absolutely relevant in the strategic time frame. These forecasts should be presented in ranges.

3. **Supply strategy input.** What capabilities does the DDOM need in the strategic time frame? These are the planned capabilities of the DDOM in the future including capacities and process capabilities.

4. **Financial requirements input.** What financial factors are relevant over the strategic time frame? These factors include working capital availability, cash generation rates, financial restrictions (e.g., bank covenants), fixed-cost structure, and shareholder expectations for the future.

5. **Integrated strategic reconciliation.** The previous inputs are then reconciled. Through this reconciliation there will be changes and adjustments to the inputs as different scenarios are considered.

6. **DDS&OP review and validation.** Part of the reconciliation process is the involvement of a DDOM validation by the DDS&OP team. The Demand Driven S&OP process provides validation and simulation capability for the business plan by evaluating desired parameters and scenarios that may lead to adjustments in the business plan.

7. **Management review.** Senior leadership reviews the updated version of the business plan and either approves it or sends it back for further reconciliation.

These seven steps are shown in the Adaptive S&OP schema in Figure 13-15.

The senior management team now has a robust process to develop a doable business plan that is responsive to the market. These business plan parameters are then sent to the tactical part of the S&OP process, Demand Driven S&OP, for tactical reconciliation. The Demand Driven S&OP process returns signals about the performance of the operating model, validates the business plan parameters, and then suggests validation and innovations needing senior-level approval. These can be things like new potential markets or market offerings, new products, or additional capital investment requirements.

Together Demand Driven S&OP and Adaptive S&OP create a robust and complete organizational S&OP process that can exploit the capability of the DDOM and ensure the financial success of the enterprise. The DDAE model essentially has two adaptation loops: the tactical and strategic. Figure 13-16 depicts these two loops. Selection means selecting new traits for the
relevant range (tactical or strategic). Emergence means configuring or enacting those new traits. Feedback is studying how those traits perform (or might perform).

The DDAE Development Path

The DDAE Model has a defined development path for companies to achieve increasing levels of success and maintenance of a demand driven transformation. This path has five distinct stages. Figure 13-17 depicts the DDAE development path.
The Demand Driven Adaptive Enterprise development path

**Stage 5: DDAE Level III**

<table>
<thead>
<tr>
<th>Operational Objectives</th>
<th>Demand Driven Characteristics</th>
<th>Primary Metrics</th>
<th>Analytics</th>
<th>Personal Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sense, adapt, and innovate across the organization and supply chain (customers and suppliers)</td>
<td>A mature DDOM with mature DSS/OF and Adaptive S&amp;OP, thoughtfully installed</td>
<td>DACE/ROIC improvement rate</td>
<td>Strategic conflict definition and resolution</td>
<td>Strategic personnel are able to analyze complex problem areas (internal and external), define strategic conflicts, and constraints, and recommend strategic policy/ejection changes. They are able to invent new key personnel through the DDMRP Model</td>
</tr>
</tbody>
</table>

**Stage 4: DDAE Level II**

<table>
<thead>
<tr>
<th>Operational Objectives</th>
<th>Demand Driven Characteristics</th>
<th>Primary Metrics</th>
<th>Analytics</th>
<th>Personal Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leverage the Demand Driven Operating Model capability across the enterprise and into the market</td>
<td>A mature DDOM with the strategic and tactical reconciliation process of CDS&amp;OP with Adaptive S&amp;OP in place; A full flow-based metric suite in place</td>
<td>Strategic contribution, waste improvement, operating expense control, DACE/ROIC</td>
<td>Order analysis (time, capacity, and stock buffers), buffer compression, contribution margin rate, and volume improvement</td>
<td>Other functional personnel now understand the requirements and capabilities of the DDOM. Personnel are able to successfully bridge the tactical and strategic relevant ranges. They can project, recommend, and adapt</td>
</tr>
</tbody>
</table>

**Stage 3: DDAE Level I**

<table>
<thead>
<tr>
<th>Operational Objectives</th>
<th>Demand Driven Characteristics</th>
<th>Primary Metrics</th>
<th>Analytics</th>
<th>Personal Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully synchronize and leverage operational capability for better flow performance</td>
<td>Trial and expanding implementation of the Demand Driven Operating Model with supporting tactical flow-based metrics</td>
<td>Reliability, stability, velocity</td>
<td>Buffer run charts, reason code analysis, flow exercise reports, flow indices</td>
<td>Personnel understand the broader implications of DDMRP to the organization. Personnel understand how to implement demand driven scheduling and execution. Personnel are capable of adjusting the DDOM based on performance analytics</td>
</tr>
</tbody>
</table>

**Stage 2: Operational Efficiency (Flow)**

<table>
<thead>
<tr>
<th>Operational Objectives</th>
<th>Demand Driven Characteristics</th>
<th>Primary Metrics</th>
<th>Analytics</th>
<th>Personal Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow protection and promotion</td>
<td>Trial and expanding implementation of Demand Driven Material Requirements Planning</td>
<td>Signal integrity, decoupling point integrity, average inventory, service</td>
<td>OTD, OEC, O10, O5, and O10 inventory target, OTD, and/or fill rates</td>
<td>Personnel are aware of and capable of describing the problems with conventional planning systems. They are well versed in DDMRP principles and are capable of implementing a canary level decoupling point buffers</td>
</tr>
</tbody>
</table>

**Stage 1: Operational Efficiency (Cost)**

<table>
<thead>
<tr>
<th>Operational Objectives</th>
<th>Demand Driven Characteristics</th>
<th>Primary Metrics</th>
<th>Analytics</th>
<th>Personal Capabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost reduction and responsiveness</td>
<td>Conventional MPS, MRP, ERP, and MES practices. Demand driven principles are limited to the incorporation of actual demand into supply order generation in the demand timeline. Strategic conflict between cost and service</td>
<td>OEC, fully absorbed unit cost, service</td>
<td>Absorption rates, total days of inventory, OTD, and/or fill rates</td>
<td>Traditional supply chain management and cost accounting approaches</td>
</tr>
</tbody>
</table>

**FIGURE 13-17** The Demand Driven Adaptive Enterprise development path
Stage 1: Operational Efficiency (Cost)

The development path starts where most companies find themselves today—locked in a constant struggle trying to drive operational efficiency by controlling or minimizing cost. It’s not that the importance of flow goes unrecognized in these companies, but any flow-based metric such as on-time delivery constantly struggles against directly competitive cost-based metrics and objectives. This is a recipe for failure in today’s hypercompetitive and volatile markets.

Stage 2: Operational Efficiency (Flow)

Stage 2 begins a company’s transformation into a Demand Driven Adaptive Enterprise. Moving from Stage 1 to Stage 2 requires a dramatic philosophical shift in thinking and understanding about what is truly “efficient” from a system perspective. This shift is not trivial, as it requires a fundamental break from the conventional emphasis on cost. Stage 1 assumes ROI improvement connected to better cost performance, while Stage 2 connects ROI improvement to better flow performance. These two views are not compatible with each other—they are, in fact, in direct opposition to each other. Figure 13-18 depicts this critical difference in fundamental assumptions.

The initial shift to Stage 2 typically occurs at a relatively local level (plant) and is led by a local champion implementing DDMRP principles in a limited fashion. The results, however, are significant and quickly realized. Planners and buyers, once skeptical of another new “improvement” method, quickly embrace DDMRP because it is intuitive, aligns with their common sense, and promotes better visibility than the conventional approach of MRP with disjointed, disconnected, and inconsistent spreadsheets.

Additionally, DDMRP represents the least amount of system “shock” and resistance in beginning to prove the beneficial difference of the Stage 2 flow emphasis over the Stage 1 cost emphasis. The benefits come quickly and are tangible in terms of service, working capital, and expedite expenses, all of which are easily connected to ROI improvement. This provides the organization with the confidence to proceed further by expanding the DDMRP implementation to the enterprise level and eventually moving to the next stage of the DDAE development path.

\[
\Delta \text{Flow} \rightarrow \Delta \text{Cash Velocity} \rightarrow \Delta \left( \frac{\text{Net Profit}}{\text{Investment}} \right) \rightarrow \Delta \text{ROI}
\]

\[
\Delta \text{Cost} \rightarrow \Delta \text{Cash Velocity} \rightarrow \Delta \left( \frac{\text{Net Profit}}{\text{Investment}} \right) \rightarrow \Delta \text{ROI}
\]

**FIGURE 13-18** Flow versus cost perspectives and metrics
Stage 3: DDAE Level I

Stage 3 is the first level in which an organization can really begin to describe itself as "demand driven." Thus the name of the stage is DDAE Level I. This features a fully implemented Demand Driven Operating Model (DDMRP, demand driven capacity scheduling, and demand driven execution methods in use). The movement from DDAE Stage 2 to DDAE Stage 3 can take several years in larger organizations with multiple facilities and vertical integration. This represents an extensive (but significantly beneficial) overhaul of operating tactics impacting supply order generation, resource scheduling, operational execution, and metrics. This stage is thoroughly described in Demand Driven Performance: Using Smart Metrics (Smith and Smith, McGraw-Hill, 2013). A maturing Stage 3 company will eventually become constrained by a lack of alignment with other functions in the organization on flow.

Stage 4: DDAE Level II

Stage 4 describes the expansion of the demand driven concepts throughout the organization. A tactical reconciliation process is in place with DDS&OF, and the organization as a whole understands how to leverage the mature DDOM capability into the market and throughout the organization for better financial performance. Its personnel understand and see the company as a true system. Finance, engineering, IT, marketing, sales, and strategic planning understand how to use the DDOM as a competitive advantage and can communicate through a common flow-based language.

Stage 5: DDAE Level III

Stage 5 describes how the organization can become a valuable and strategic supply chain partner by facilitating flow with its suppliers and customers in mutually beneficial ways. Its personnel understand and see the supply chain as a complete interconnected network identifying opportunities for better flow creation and protection. Management has the capability to define current and impending strategic conflicts and reconcile them through adaptive and innovative solutions. These organizations are capable of mentoring new generations of management through the DDAE Model in order to sustain and even accelerate momentum.

A complete journey through these five stages can take several years. Indeed, the upper stages (4 and 5) may never be achieved as key personnel exit for other opportunities and acquisitions occur that slow the momentum or sponsorship of driving the DDAE Model implementation. At each stage, however, the ROI improves and accelerates.

Summary

The New Normal has radically altered what it takes to sustain and improve a company's competitive advantage. This alteration requires a new form of strategic, tactical, and operational management, one that allows a company to see, learn, and adapt its resources to the complexity and
volatility of the New Normal. The Demand Driven Adaptive Enterprise Model is first and foremost about visibility to what is relevant. It recognizes that the only way to effectively implement and foster flow is to enable a company to determine truly relevant information at the strategic, tactical, and operational levels. Through that visibility, companies can also eliminate what is irrelevant, distortive, and damaging.

What stands in the way of bringing significantly elevated performance is a series of common conventional practices and assumptions in both operations and finance that must be understood for what they really are—common nonsense. Optimizing these old and inappropriate rules in the current more complex and volatile set of circumstances will only push organizations further away from embracing flow and cause them to incur devastating amounts of waste resulting in eventual company failure.

The path to becoming a Demand Driven Adaptive Enterprise starts with DDMRP. The legacy tactics inherent in the conventional planning and execution systems as characterized by MRP and MPS are simply inappropriate for the circumstances that a company faces today. That inappropriateness translates directly to poor return on asset performance. It distorts and confuses the picture and makes strategic analysis and prediction extremely difficult. We are drowning in data and are simply starving for relevant information across and between relevant ranges (strategic, tactical, and operational).

The results of starting with DDMRP speak for themselves. Typical results include:

- Service level above 95 percent
- Inventory reductions of 30 to 50 percent
- Expedite-related expenses down significantly or eliminated

These results give the organization confidence and the insight to continue to challenge convention and move forward with the DDAE Model. There are many case studies available at www.demanddriveninstitute.com.

**Contribution by Dick Ling**

We would like to recognize Richard (Dick) Ling, the originator of S&OP, for his critical contribution to this chapter. Dick Ling has been helping companies large and small with their business planning processes for over 40 years. He has found that most companies can improve their business planning with some help and the right focus. Dick has a reputation as an excellent counselor and problem solver.

To learn more about Dick Ling and his enormous contribution to Sales and Operations Planning visit www.dickling.net.