

Lean Distribution

Applying Lean Manufacturing to
Distribution, Logistics, and Supply Chain

KIRK D. ZYLSTRA



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*To my clients, with whom I learn so much, and my consulting colleagues,
who help me see what I have yet to learn*



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Preface

The distribution function shoulders responsibility for successful customer service while continually being under pressure to reduce costs and inventory. It can be an awesome responsibility that only gets more difficult and complicated as the supply chain spans the globe. For products moved across great distances, say for ones sourced from China into the North American market, supply chains become “long,” making distribution more difficult than for products sourced or produced locally.

The “long” supply chain is here to stay as global sourcing has taken firm hold. Despite the long distances, time zones, and other hurdles involved, distribution is under pressure to reduce costs and inventory. There is a substantial amount of cost and inventory in Distribution, so it is a natural target for profitability improvement efforts. Any reduction in freight expense appears to go directly to improved profit, which encourages an ongoing emphasis to reduce freight costs.

Longer supply chains require more accurate forecasts to plan. Commitments must be made to suppliers or plants for long supply chains much farther into the future than for ones right next door. These long commitments require customer order forecasts farther into the future. But forecasts may not be sufficiently accurate to maintain a stable plan causing continual changes and updates. With the plan always in flux, it may be difficult to see how costs can be kept low.

For my clients, the forecast limitation to cost reduction came to light only through rigorous assessment of the overall product flow. Mapping and assessing product flow from source through internal manufacturing (if applicable) to distribution and finally to customers provided this new view. Assessments highlighted many of the policies that inhibited improvement due to the focus on cost reduction and forecast-based planning. By addressing the underling policies, it became clear that forecasts are essential

for overall and long-term planning, but that short-term execution required a different approach.

To break the forecast- and cost-driven approaches, Lean techniques were employed. Practices such as Pull replenishment showed dramatic benefits to improve service and maintain low inventories and costs. This seemed counterintuitive at first, but as the total product flows were modeled and changed, the benefits became clear. The problem all along was not just forecast accuracy, but all variability. Using Lean helped compartmentalize and reduce variability such that replenishment was easier and planning more effective. We came to call this transformation as taking a Lean approach to Distribution.

This book, *Lean Distribution*, is based on these successful Lean implementations I had the privilege to lead. The primary driver for these implementations was addressing today's challenges in customer service and distribution. This book provides a composite of the issues and drivers leading to the design for a Lean approach that simultaneously reduces costs and inventory while improving service. In this way, the *Lean Distribution* approach has been market tested and proven to deliver results by leveraging the Lean concepts of Pull, kanban, cycle time reduction, and buffer against variation.

Each client takes a different path on the Lean journey and develops a unique design, but typically addresses similar issues and challenges along the way. *Lean Distribution* provides a comprehensive framework for you to take this journey and design your own Lean approach. Each step is methodical and provides a link to both the last step and the ultimate goals for distribution. The transformation is driven by key distribution metrics such as order fill rates, warehouse costs, and inventory levels, to name just a few.

The *Lean Distribution* framework provides a comprehensive and cross-industry guide to the Lean journey. It starts with the business trends and drivers leading to the need for new approaches in distribution and then uses customer service expectations to initiate the Lean design. Readers may skim over some of the trends they already understand well, but covering all is important to ensure that perspectives are well understood prior to designing the Lean solution. For the typical company, these trends enable the entire executive team and organization to gain a common understanding of distribution challenges and solutions by seeing the perspectives and issues from all sides.

Viewing all sides of current distribution paradigms exposes the implications and limitations of forecasts to improve service and profitability. Forecasts and the planning processes to improve distribution have been improved as information technology matured, but cannot further improve results due to the inaccuracy of sales order forecasting. Forecast-based plans have added tremendous value to business growth, profitability, and customer service, but have reached the limit of their underlying accuracy. Forecast accuracy is limited by the pace of change and variation in sales, which are the new fundamental characteristics of markets. Forecasting algorithms and customer collaboration techniques may be seen as the “answer” to forecast inaccuracy, but are in conflict with the needs of customers to be flexible and respond as their customers or markets change.

Closely following and responding to customer demand enables companies to succeed without the buildup or dearth of inventory in distribution. Whenever inventory swings too high or too low, distribution costs increase. Usually these swings are caused by forecasts that have gone awry. Consider the difference in Dell Computer’s approach to the market: Produce to demand and do not stock finished goods internally or at retailers. Inventory swings are stabilized rather than magnified going back to internal operations and suppliers.

I assume that you have some understanding of Lean concepts and practices such as Pull, kaizen, lot size reduction, and their relationship with lead time reduction. Many excellent books can provide the background, approach, and practices for Lean so this book does not repeat these themes. Lean books provide an excellent foundation for the transformation, but do not provide effective solutions to the transportation and customer demand variation that are such key factors in distribution. Taking Lean into a distribution environment requires a customer service-based approach that builds change around total cost minimization rather than the more traditional Lean approach: value stream mapping and using kaizen to improve each area of the process.

The *Lean Distribution* approach is described using a number of analogies. Each analogy is meant to describe how and why Lean provides a solution to fairly knotty problems. Terms are defined when introduced and described in the relationship to distribution. You should be able to follow along with the framework and solution approach, but you may not fully appreciate what should occur in the plant or at your suppliers to enable

these distribution changes. At least you will see the distribution transformation, which should whet your appetite to understand more about Lean.

Lean Distribution may be read differently across the organization. Some executives may benefit most by just reading Chapter 1 to gain perspectives on the reasons to change. Other executives may also read the chapters associated with their functional responsibilities, such as customer service. Managers and professionals who are in the day-to-day operational processes may read the entire book with emphasis on sections most pertinent to their responsibilities. Project managers and leaders may take particular notes across all sections to best relate to each portion of their team and management group.

Implementing the *Lean Distribution* approach is enabled by addressing key paradigms in customer service and distribution to “pave the way” for change. For example, with customer service policies, these paradigms are critical elements for daily decision making and must be aligned with the Lean transformation. New capabilities may be discovered to serve customers better; in other cases policy will be aligned with capabilities and customer needs. The critical point is that paradigm shifts are essential to success in both the long term and across the organization.

A Lean journey can be a wonderful learning experience related to both Lean and how the organization really operates. In many cases assumptions have been made and built into the fabric of the organization and business processes without being fully challenged. A Lean transformation brings these assumptions to light and designs processes according to how growth, profits, and customer service can be optimized. It is a journey of discovery and adventure that leads to an aligned organization, relevant metrics, and enhanced results.

Kirk D. Zylstra
Redmond, Washington
April 2005



Acknowledgments

Many ideas and contributions were necessary to develop and successfully implement the Lean Distribution approach. Lean takes a different view than the typical Distribution model and requires a dedication to analyze and see the forest for the trees. Because the typical distribution approach chases cost savings for each transaction, organizations struggle to manage total costs and customer service. The Lean Distribution approach starts with the total and then works back to how individual transactions are processed requiring a more thorough viewpoint. Taking this view from the total to the detail required the dedication and contribution of many clients and co-workers of mine.

I am grateful for the opportunity to work with two wonderful clients in particular who have challenged and embraced these ideas and in so doing improved the approach and results. Especially, Fred Beightol and James Handley who stood with our team as their organizations embraced the shift from the current mindsets. These can be perilous journeys fraught with anxiety and doubt, but they held true to the new perspectives that we developed and tested. As these journeys unfolded, both Fred and Jim have become friends and colleagues in the pursuit of operating excellence and the demand-driven enterprise. Their contributions and encouragement have been critical to my enthusiasm to take on this book project to spread Lean practices further across the world of Distribution.

A number of consulting colleagues contributed to both my success and ability to develop the Lean Distribution approach. The teams for both of these clients, as well as many others, were instrumental in transforming ideas into successful implementations. The dedication and enthusiasm of these many bright colleagues helped take on the difficult task of enterprise change against the odds of current performance measures, limited financial systems, and organizational dynamics.

The quality and completeness of Lean Distribution was greatly enhanced by the contributions of my reviewers and confidants. I appreciate the efforts and insights brought by Patricia Bailey, Hank Barr, Fred Beightol, William Dettmer, James Handley, Michael Miksis, and Raffiq Rajabali. Each uniquely contributed to the contents and approach for the book. They endured reading the entire draft manuscript at a point that certainly took a certain amount of diligence to complete.

My Dad, Bud Ruby, has provided invaluable insights and guidance for my career over these many years. His successful business leadership in the apparel industry has been an inspiration to me during this writing and all through my career. He has also brought practical context and ideas, such as perspective on one of the earliest implementations of Vendor Managed Inventory (VMI) I have encountered. I am grateful to have had his influence, encouragement, and support all along the way.

Last, I am grateful for the support from my family to make the transition from Big 4 consulting partner to author, University of Washington Business School faculty member, and independent consultant. I wanted to write this book for several years now, and retiring from a full time consulting partner role was necessary to see it through. I have spent an enormous amount of time thinking and creating Lean Distribution. I could not have completed the book without making this transition, which opened up my time to reflect on past consulting successes and the approaches that succeed in changing the perspectives of others. My wife Mariann, son Alex, and daughter Ashton have supported my difficult transition with grace and humor. Their insights many times were refreshing and helpful as they commented on my ideas. They understood the quirks of my writing time and this lifestyle change. It has been a wild ride at times and I am sure they are glad my first book is behind me.



Taking the Lean Approach

Lean Distribution breaks the forecast accuracy barrier to improving customer service and profit with flawless execution of simplified operating processes

Competition is growing at an ever-increasing rate, and price tends to be the main battleground. Finding the lowest-cost source or manufacturing location has been the strategy with sourcing from China, the preeminent destination. Low cost sourcing is creating and extending supply chains across the globe making distributing products more challenging than ever. There is just no room for error when planning and moving products across complex, global supply chains.

Distribution in these price-sensitive times must evolve to meet the competitive threats and realities of global markets. In the past, distribution processes relied on customer order forecasts to find the most cost-effective plan, but forecast accuracy continues to be an elusive goal. Forecast-based plans are becoming less reliable, making cost reductions more elusive.

Some companies have been successful with new distribution processes and strategies that transcend the forecast accuracy barrier to lower costs. Dell Computer, Wal-Mart, Apple, and others are using advanced approaches combined with Lean principles to drive new levels of competition. The results are evident in any analysis of Dell's working capital: it is actually negative! With negative working capital, Dell's profit is increased by the leverage gained from current assets, a very uncommon effect. Can any other significant business boast similar results? Clearly, these companies are taking new approaches that their competitors cannot match.

Apple and Wal-Mart streamlined the global distribution model. Consider how some of the newest products are sourced, sold, and distributed without time moving through distribution centers in the United States. The model is to reduce contact, reduce time to consumer, and completely eliminate as much cost as possible. The ideal situation is direct from source to consumer.

Current operating paradigms, measures, and business processes that seek to forecast, plan, and optimize distribution into perfection stand in the way of the dramatic changes that Dell, Apple, and Wal-Mart are pursuing. Consumers and industrial markets are just moving too fast for forecasts to be sufficiently accurate to optimize and execute a plan. The alternative? A simplicity, flexibility, and market-driven approach built around Lean principles in distribution.

THE LEAN CHANGE IN DISTRIBUTION

Distribution operations are particularly susceptible to globalization trends due to the direct linkage to customer service, the limited value added, and the high levels of cost across distribution. Changes in plans quickly impact customer service and/or costs. Only well-optimized plans that are flawlessly executed meet distribution's exceedingly stringent standards for both service and low cost. Plan changes challenge distribution optimization and the organization's ability to meet performance objectives.

The Lean Distribution approach increases flexibility and simplicity and thus reduces the reliance on forecasts and optimized plans to achieve results. With Lean, process and performance improvement is focused on reducing lead time, reducing lot sizes, and increasing reliability, yielding the flexibility and simplicity required to achieve consistent results. Lean Distribution takes a very different approach from an optimization and planning approach that is based on fixed lead times and lot sizes. Forecast-based optimization seeks to reschedule the orders and inventory within the plan in order to reduce costs, whereas Lean seeks to create flexible distribution operations that respond to changing market needs.

THE RFID CHANGE DILEMMA

A customer-driven initiative to streamline supply chains and sourcing that is currently impacting distribution is radio frequency identification (RFID).

RFID is the latest initiative by Wal-Mart, the United States Department of Defense (DoD), and others to improve the flow of incoming products. These customer requests to tag pallets or cases with an RFID tag as well as the current bar code appear to add cost and time to each supplier's distribution process. The benefits are most evident in the customer's operations (Wal-Mart, etc.), yet these customers are not willing to pay increased prices that account for the tags and additional work suppliers must perform to transmit RFID data. As a result, suppliers are making limited efforts to comply, and distribution is where most of the added costs and time reside.

The majority of professional conversation around RFID tends to relate to technical standards or RFID costs rather than specific distribution transformation capabilities. Like the bar code transition of 30 years ago, the RFID movement will continue to raise cost-related objections until the technology becomes ingrained across nearly all supply chains and is nearly "invisible" to cost measurement. The benefit question remains focused on how the customer gains value and not how suppliers and their customers will transform supply chains and distribution.

This missing link to RFID benefits for suppliers is the fundamental disconnect for distribution processes. The operations paradigm is to reduce the most observable and measurable costs, such as transportation and warehouse labor. RFID technologies provide transformational capabilities, but ones that have not been sufficiently explored. The customers seek continual cost and service improvement, but how the supply chain will be operated differently has not been defined. With Lean Distribution, approaches to leverage RFID signals for replenishment can be identified.

THE FORECAST BARRIER

Customer order forecasts are the starting point for nearly all business, operational, and financial planning. It is very difficult to get around it: forecasts are the best estimates for the market directions, volumes, and pricing necessary to make many decisions across any business. Commitments to suppliers, setting operating levels, and projecting financial results are all driven from the forecast. These many decisions require review, revision, and change as forecasts are updated and revised, an almost daily process to keep pace with the market. So forecasts are absolutely necessary, but also have

the unintended consequence of producing continuous disruption as organizations strive to hit plans driven by forecasts that are moving targets.

Forecasts change frequently as customers change plans to adjust to market conditions. So why do companies spend so much time and place so much importance on demand forecasts that change frequently and at times change dramatically? The answer lies in the forecast as the foundation for all business, operational, and financial planning. The forecast initiates and dominates these business processes as the organization diligently works to ensure excellent customer service and low costs by planning from the forecast.

Distribution tends to be a lightning rod for forecasting issues and inaccuracy, because excess or inadequate inventory is highly visible in a distribution center. There are immediate impacts to service in distribution for inventory imbalances, many of which are “blamed” on poor forecasts. So the success of forecasting and the subsequent planning processes can be assessed with distribution service levels, inventories, resources, and costs. The effectiveness of these distribution measures typically is tied back to planning processes and in many ways is limited by the effectiveness of forecasting.

THE BALANCING ACT

The inevitability of forecast change builds contention into the relationship between supplier and customer. Suppliers desire certainty with fixed purchase schedules, and customers desire flexibility to change with their market. This contention is shown in Figure 1.1 as the difference in interests between customer and supplier. From a customer’s perspective, the flexibility to change on short notice is preferred over firm plans that cannot change as the market or competition changes. However, suppliers seek certainty, long lead times, and limited forecast changes. Clearly, customer and supplier interests may not be fully aligned. The root of their differences can be a supplier’s focus on controlling costs with stable plans and lead time, while the customer may have the “luxury” of making changes to forecasts without concerns that prices will increase.

Depending on their relative negotiating positions and strengths, this balancing act may shift toward one or the other party. Tilting toward the customer tends to focus more on maximizing the total sales through the

FIGURE 1.1 PLANNING BALANCING ACT

Lean Distribution

- Flexibility to avoid trade-offs
- Simple, cost-effective operations
- Reliability for flawless execution

***Customers Desire Flexibility***

- Minimal ownership of finished inventory
- Easy forecast changes
- Short lead time

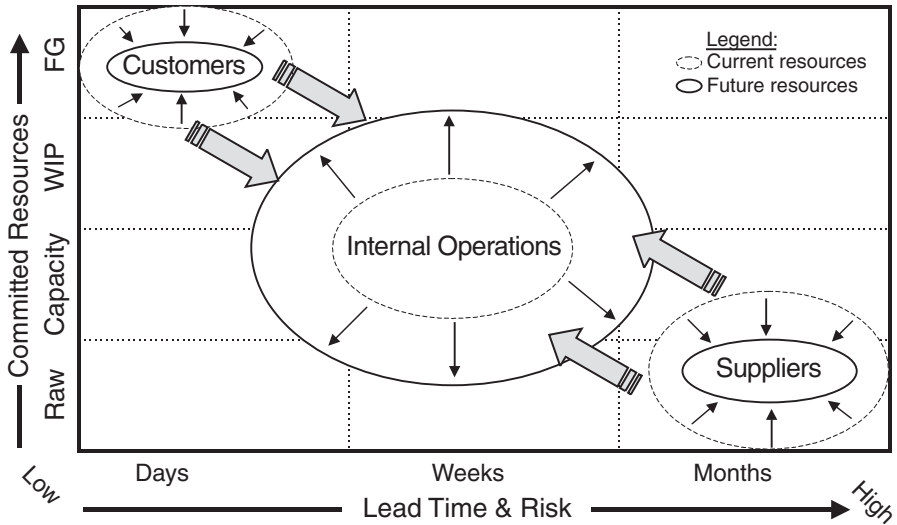
Suppliers Seek Certainty

- Customer commits to inventory in process
- Limited forecast changes
- Long lead time

supply chain with quick responses to market changes, despite concerns over cost implications at the supplier. Conversely, strong suppliers will receive more assurances and control over forecast changes that may impact their costs or profitability. Frequently the struggle is really within the supplier as Marketing seeks to maximize sales while Operations and Finance struggle to maintain profitability. In a “sales”-driven organization, the internal struggle may not be pronounced, because the operators know the changes must be accommodated and they may have some level of inefficiency budgeted to compensate.

Another view of the flexibility dynamic can be found by assessing the risks and resources across the supply chain. Figure 1.2 has circles representing the amount of inventory, resources, and risk across the supply chain. Customers typically desire to push inventory responsibility back to their suppliers, displayed with arrows toward Internal Operations. On the other side, a supplier’s supplier will likewise seek to receive commitments and push inventory and commitment toward the Internal Operations of their customer. The longer the lead times and higher the inventories are, the more risk across the supply chain. The only question becomes which parties carry the risk.

FIGURE 1.2 THE RESOURCE COMMITMENT AND RISK SQUEEZE



Mapping the extent of resource commitment for each party can assess the risk inherent in a specific supply chain and across distribution operations. Contract and business relationship negotiations tend to move these commitments around rather than reduce or even eliminate them. The key to successful relationships across the entire supply chain lies in reducing risk and eliminating resource commitments, the fundamental tenets of Lean.

With Lean Distribution, the approach is to clarify how risks can be mitigated, total supply chain costs reduced, and service improved, while increasing focus on maximizing total sales and volume throughput. The Lean approach requires a thorough reevaluation of current processes and practices to break the trade-offs inherent in most forecast-based planning and optimization processes.

BUSINESS AND OPERATIONAL PLANS

Business planning may seem like a “necessary evil” to meet customer orders, reach financial results, and optimize performance. Planning requires detailed customer demand forecasting, which can be time consuming, con-

tentious, second-guessed, and frequently inaccurate. Executives' time and energy can be sapped by these processes due to the need to synchronize business plans to meet financial objectives. In the end, the business plan may be less a true reflection of the market and more a set of plans and objectives necessary to meet the financial performance required by shareholders and financial markets.

Planning processes are focused on these important objectives because of the pressure executives are under to perform. Due to the difficulty of meeting ever-increasing objectives, the tendency may be to increase the detail of plans to improve execution, ownership, and accountability across the organization.

What may be curious is the inaccuracy of the underlying assumptions for these increasingly detailed and complicated plans. Market forecasts are the starting point and the data with the greatest degree of error and change. Forecasting customer demand may range from highly sophisticated analytics to rudimentary estimates, but ultimately it requires frequent updates. Markets move fast, and organizations devote an extensive amount of time and effort to forecasting and planning in a quest for accuracy.

As forecasts are revised and business plans updated, problems are created in the form of changing schedules across and down through the organization. The revised plans require many reactions to change all of the inputs to business planning: purchase orders, production schedules, transportation plans, and many others. Planning today creates numerous "ripple effects" in nearly all functions of the organization. These ripple effects can be frustrating for the organization as more and more details are created and then changed with every new revision of the forecast.

FORECAST ACCURACY

How accurate are forecasts? Have they ever been sufficiently accurate for the planning, sourcing, operations, distribution, and logistics users? Are there complaints about inaccuracy? This may seem like an odd question, since logic dictates that forecasts are not correct, yet nearly all daily schedules are driven by detailed forecasts and commit large portions of resources based on them. In fact, these plans are the cornerstone for nearly all operational performance and cost reduction efforts despite the fact that forecasts are rarely accurate, except in total sales dollars or an aggregate volume measure.

But accuracy in aggregate units does not support operational planning and cost reduction efforts. If a product-level forecast does not exist, Operations Planning must create another forecast by product, which may need more work to make it accurate and consistent with the business plan forecast. Any planning based on the “operations forecast” may be called into question due to differences with the real forecast that has proven to be accurate for business and financial planning.

Collaborating with customers to improve forecasting may be a worthwhile initiative, but does not guarantee accurate forecasts. Collaborating should improve forecasts by tightening the communications of market changes. Faster and better communications means being more responsive to changes in the customer’s market rather than creating a “fixed” forecast for the supplier. Is it in customers’ best interests to stick by their input to the forecast despite the market changing? Since customers must respond to changes in their markets, having their suppliers respond in kind is more beneficial than having their suppliers demand frozen schedules. Collaboration in actual practice creates more changes to a forecast rather than less.

In the final analysis, forecasts are the best attempts to tell the future and by their very nature will always require revision and be challenged over accuracy. Detailed plans driven from forecasts are the first cause of instability in daily operational schedules that are well intended but are based on hitting a moving “target,” the forecast. A cycle is created starting with forecasting, then planning, and then revising the forecasts to keep the plans current and accurate. For the folks down the line, the daily schedules are either a moving target or artificially “fixed” to appease suppliers, operations, and distribution. Hence, today’s planning driven by an inaccurate market forecast creates tomorrow’s operational problems, as schedules must be continually revised.

ANOTHER APPROACH

But is there another way to plan and manage? This is not obvious, because optimizing distribution requires some method to plan and take actions in advance that reduce costs, such as scheduling carriers with the most cost-effective rates. Unfortunately, these plans are subject to change as forecasts change, which happens frequently. Forecast changes create a ripple effect of increases to other costs, such as inventory, as attempts are made to retain

the cost reduction obtained in freight. A conflict exists between attempts to reduce costs using the forecast and daily efforts to serve customers and revise the forecast as business conditions change.

An alternate approach to planning and optimizing must accommodate the variation that creates instability in forecast-driven plans. Variation comes in many forms: customers demand changes, operations have good days and bad ones, suppliers may not deliver, and many other factors affect the daily plan or forecast. An approach to optimization that embraces variation rather than being whipsawed by it could greatly improve performance and total cost across the business.

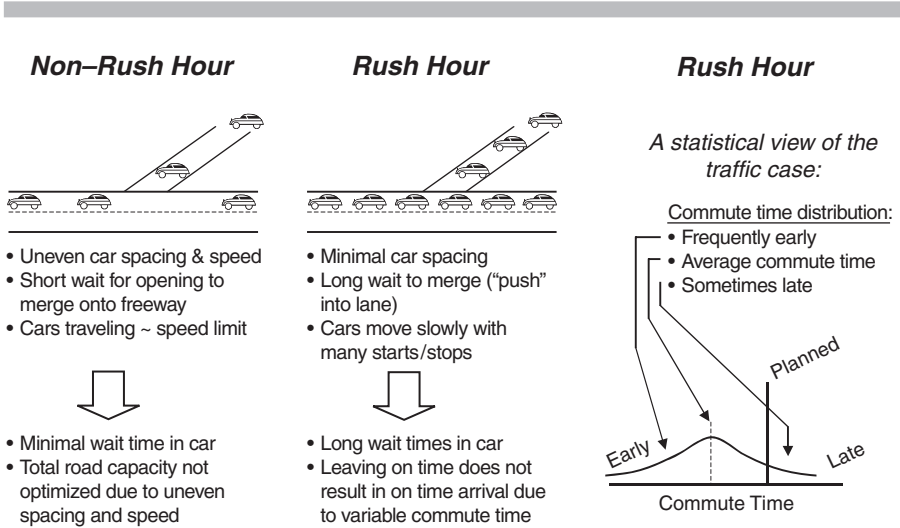
The roadblocks to a new approach are the planning processes and optimization mind-set. Organizations “teach” and measure their people based on the assumption that forecasts provide sufficiently reliable plans and productivity follows solid planning. Variability has only recently become a topic as quality improvement initiatives such as Six Sigma challenge traditional “inspect in” quality approaches. It is becoming accepted that variation in the production process is the cause of quality problems, but this concept has not moved into forecasting, planning, and scheduling.

THE TRAFFIC ANALOGY

Consider the dilemma of answering the question “How long does it take to drive downtown?” For anyone in a major city the typical answer is “It depends.” There are many qualifications related to time of day, weather, carpool status, and other factors necessary to provide even a rough estimate. Answering the question may end up as a range of the best-case to worst-case scenarios, to ensure the driver allows sufficient time.

The dilemma for this driver is not unique; it involves many factors to ensure on time arrival, as shown in Figure 1.3. For the non-rush-hour case, getting to and merging onto the freeway does not encounter lines or a wait. Once on the freeway, cars move at the speed limit, allowing a predictable commute time and on-time arrival based on the distance to be covered. For the rush-hour case, there is a wait to merge onto the freeway and many starts and stops once on the freeway, causing a highly variable amount of time commuting. During rush hour or any other high-traffic-volume time, the commute time varies greatly, requiring the driver to allow “more than enough” time in order to rarely be late. The variation in

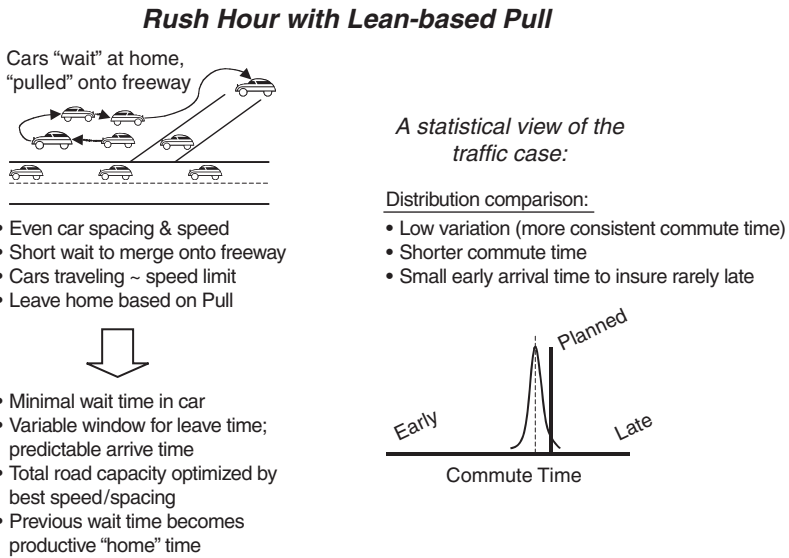
FIGURE 1.3 THE TRAFFIC ANALOGY



commute time is represented by the statistical curve on the right side of Figure 1.3. A wide and low profile indicates a highly variable commute time, which requires allowing more time to ensure on-time arrival. The more time allowed, the higher the chance that arrival will be very early. An on-time arrival is purely chance rather than good planning or driving. Unless the arrival time really does not matter, the statistics show that very early arrival must occur much more frequently than on-time arrival

Solving the traffic case requires reducing the variability for the commute time and maximizing the total volume. This can be addressed for all cars by maximizing the total flow of cars by moving from push to Lean Pull. During rush hour, speed and spacing between cars deteriorate as cars “push” their way onto the freeway, reducing the total flow. Once on the freeway, the variability of each driver’s speed reduces spacing, causing the average speed and volume for all cars to deteriorate. Because the flow of cars is dependent on the speed and spacing of cars, an optimal combination must be enforced for all cars to maximize flow. Improved speed and spacing could be accomplished by using Lean-based Pull to bring cars onto the freeway up to the point where optimal speed and spacing start to deteriorate. Then maintain that level of Pull (number of cars allowed on at each entrance) during rush hour. This Pull approach to the traffic analogy is shown in Fig-

FIGURE 1.4 LEAN PULL-BASED COMMUTE TIME



ure 1.4. For the Lean Pull approach to work, each driver must be ready to depart home on fairly short notice (the Pull signal) and able to maintain a constant spacing for the given speed (imaginary linkage to the next car).

These two principles of Lean—Pull and linkage across operations—improve total flows across distribution. The Pull signal (time to leave home for the freeway) moves the current wait time in a commute to the beginning, and the linkage (maintaining the proper speed and spacing) maximizes how much gets through existing capacity (the freeways). As Pull and linkage are combined, the right products (cars) get to their destinations fastest (commute time).

How does this apply to distribution? Consider the similarities between inventory and the cars during rush hour: both must endure long transit time and arrive early to avoid being late. For inventory arriving late, customer service is impacted, which must be avoided at nearly all costs. So inventory arrives early, increasing the requirements for capital, warehouse space, handling, and tracking. The time for inventory to move may seem small for any one rushed shipment, but overall is long due to time taken to maximize shipments (freight) and operate efficiently (labor). If inventory

can be moved faster and more reliably, then it could arrive closer to actual customer need and reduce many distribution costs and resources.

But what if the planned arrival time varied as well as the commute time? This does not happen for people heading to a sporting event or the symphony, because the event's starting time is fairly well fixed; although an event may start a little late, it would never start early. For the event attendee, arriving late may not be an option, making early arrival mandatory. But what if the event's start time changed during the commute? A variable expected arrival time makes trip planning even more complex and risky.

The uncertain length of the commute time represents a company's lead times to respond to customer needs. These times are not easily estimated and are subject to the conditions at the time, hence they are highly variable. Unlike the typical commuter, customer needs are highly variable. So there is a variable time to respond and uncertain arrival time. Planning can only come up with the best estimate (forecast) of the needed arrival time and allow plenty of commute time (lead time), resulting in lots of excess time, except for the rare occasion when start time is early and drive time is long.

Planning becomes difficult for this commuter, who eventually decides to move downtown. By living in the city, the commute time is low and responding to a variable arrival time is easier. Relocating to a downtown home is like setting up a local warehouse for a customer; it decreases lead time to respond. The downside is that if the customer moves or the mix of customer requirements change, the warehouse location may become obsolete or at least suboptimal. This is why many workers choose long commutes over relocating their residence: The commute may change, requiring another move anyway, and living outside the city is less expensive. Moving can be expensive as well and would limit other opportunities; for example, moving to the south end of town might limit taking a new job on the north end because it would require yet another move.

The moral of the commuter's tale is that estimating an exact departure time is near impossible due to the variable time to drive downtown. An estimated time to depart is the best case, using an assumed commute time and whatever amount of safety time the particular driver is comfortable with, but in no case does a driver realistically expect to know exactly when to leave to arrive exactly on time.

For a business with physical distribution of products, lead times vary and have many of the same patterns as the commuter. Unfortunately, businesses

attempt to obtain an exact expected arrival time from customers (a forecast) and then calculate an exact start time for operations and suppliers (a schedule or purchase order). A major difference with companies is the propensity to establish a local distribution center or warehouse to serve the customer, which is difficult to change as customer demand patterns change. Unlike the commuter, companies frequently err on the side of the added cost of warehousing facilities and operations close to customers rather than the long commute (being more flexible) to respond to the changing arrival times.

IMPROVING DISTRIBUTION OPERATIONS

As initiatives to reduce cost are implemented, other areas across the distribution chain may be impacted that are described in Chapter 8 as the Distribution Cost Waterbed. The analogy represents that pushing down costs in one area may actually increase costs in another, as reducing freight can increase inventory and handling costs. This identifies a conundrum: Do all cost reductions reduce total cost? Some of the initiatives distribution operations have employed are shown in Figure 1.5 along with common downsides.

The question may arise whether the improvements for one year are enough or are the best that can be achieved. Is this question answered with the pound-of-flesh approach? Or pushing for “cuts” until the organization nearly breaks?

Another approach requires a better understanding of the levers that can be “pulled” to consistently and productively reduce total costs in all distribution and logistics operations. But another approach also means focusing on flows and customer service rather than individual departmental budgets and isolated areas of spending.

LEAN PARADIGM SHIFTS

Lean Manufacturing started as the Toyota Production System (TPS) in Japan and later caught on in the United States as companies studied Japanese methods. As the domestic automotive industry embraced TPS practices, such as kanban, the movement became known as just-in-time (JIT). Subsequently, the JIT movement transitioned into Lean Manufacturing as a more holistic approach to enterprise productivity was taken. So Lean

FIGURE 1.5 DISTRIBUTION IMPROVEMENT INITIATIVES

| Initiative | Description | Downsides |
|--------------------------------|--|--|
| Improve forecasting | Collaborate with customers and work with Sales to make product-level forecasts more accurate to reflect the customer orders expected over the near-term planning time frame. | All forecasts are wrong, requiring significant time to revise and then re-plan. Lower-level operating schedules are not stable or are fixed and not responsive to customer demand. |
| Reduce freight | Ship full truckloads, eliminate expedited delivery, and negotiate favorable rates with carriers. | Freight flexibility may become limited, which can be critical to reducing total supply chain costs. |
| Automate warehouse labor | Install material-handling equipment and information technologies to speed material flow and reduce put away/pick times. | As capital investments are made, the distribution network becomes more difficult to change as market and operating conditions change. |
| Automate data entry | Implement bar code, wireless terminals, and RFID to automate and increase the accuracy of data capture. | Increased tracking requires more controls to validate accuracy and complicates planning processes. |
| Maintain inventory for service | Place inventory in warehouses (public or owned) close to customers to enable quick response and readily available inventory for customer orders. | Inventory and planning complexity dramatically increase as locations are added, which actually slows response to major market shifts. |

Distribution is the natural extension for companies using Lean practices within their own operations or that have customers that embrace Lean.

Lean works to systematically improve the parameters that drive performance across the entire supply chain rather than to take independent actions seeking to improve departmental costs, service levels, and inventory. The main levers of a Lean Distribution approach are cycle time, variation, and flexibility. These parameters become the drivers for inventory levels, cost profiles, and other aspects of the distribution chain so the relationships and interactions are readily apparent.

Lean takes the approach that markets move and the supply must move quickly with them; it is not a forecast- and plan-based approach that attempts to optimize and execute a “frozen” plan. With Lean, market shifts

FIGURE 1.6 LEAN DISTRIBUTION PARADIGM SHIFTS

| Paradigm | Traditional Approach | Lean Distribution |
|------------------|--|---|
| Customer service | Collaborate to forecast, then ship to firm orders/releases. | Manage flow as customer consumes, “owns” replenishment. |
| Forecasts | Are accurate enough, but should strive to make more accurate. | Limited accuracy, use for longer-term and aggregate planning only. |
| Inventory | Is an asset and should be close to the customer to meet lead time demands. | Consolidate at the source and redirect flow quickly for changing replenishment needs. |
| Variability | Not explicitly used in planning, but measured in operations if Lean and Six Sigma are embraced. | Operational, customer demand, and supply chain variability factors used in Lean processes. |
| Transportation | Changes with forecasts and orders; seek to reduce. | Replenishment cycle driven; stabilize lanes to reduce. |
| Optimization | Reduce each component of cost while filling forecasted demand. | Streamline distribution total cost to replenish actual demand. |
| Assumptions | Forecasts are sufficiently accurate and stable for planning. All cost reductions add to net profit. Inventory costs less than labor. | Pull reduces variation and improves service. Only <i>total</i> cost reduction adds to profit. Inventory, handling, and storage costs are understated. |

are expected and taken in stride because variability and flexibility are built in. A forecast and plan approach resists market changes, because changes upset the plan and all of the actions being taken to optimize and execute. A more complete comparison of the traditional forecast and plan approach and Lean is provided in Figure 1.6, which tackles each of the main paradigms related to managing distribution.

The Lean paradigm is to work with the realities of the market and improve “internal” flexibility and cycle time. These two components of distribution and operations are within the control of all businesses, whereas market fluctuations may not be within anyone’s control. The beauty of taking the tack to control what can be controlled and be flexible is that market variation frequently can be reduced with Lean replenishment. The

faster and better a supplier responds, the less customers induce variation into the market shifts they experience, because they will “hedge” market shifts less. Customers hedge market shifts by ordering more than needed for an uptick in the market and then later ordering less to compensate for the overordering, causing an ever-increasing seesaw effect. This trend has been called the bullwhip effect to illustrate the reactions to market change become larger for suppliers.

BOOK APPROACH AND CONTENTS

Lean Distribution is a guide to assessing current distribution practices and paradigms to enable greater flexibility and lower costs. It takes a general approach based on Lean Manufacturing to streamline and optimize product flows, enabling a simpler customer service and inventory replenishment model. The general theme is that forecasts are not sufficiently accurate to plan and execute short-term customer service requirements. A Lean Pull replenishment model delivers lower total costs while maximizing customer service.

Chapter 1 sets the stage by describing the overall approach and serves as an executive overview to align the leaders of the organization on transformation. In many cases, executives may need to read only Chapter 1 and perhaps one or two other chapters or chapter summaries to appreciate the implications of a Lean model to their portion of the business. For example, Sales and Marketing executives may read Chapter 1 and then focus primarily on Chapter 6, “Customer Service Policy.”

Lean Distribution starts in Chapter 2, “Distribution Challenges,” with perspectives on the business and competitive drivers that have led to today’s intense pressure to reduce each element of distribution cost. The short historical discussion enables a common view of business issues that have impacted various industry segments at different times over the past decade, resulting in today’s distribution focus and challenges.

The underlying structure and configuration of distribution networks is addressed in Chapter 3, “Optimizing Distribution.” This chapter describes how organizations responded to the profitability pressures with the design of distribution facilities and operations in order to optimize total distribution costs while still meeting customer service requirements. The various optimization techniques are presented and contrasted to link the decisions

for physical layout and location of distribution assets to the quest to lower overall costs.

As information technology (IT) developed over the past decade, applications in distribution have multiplied. Chapter 4, “IT Transforms Distribution Processes,” addresses how IT has been employed to automate many distribution processes and to enable forecast-based optimization. Freight, labor, and warehouse expenses have been prime targets for automation with IT by cost cutters and operators seeking to excel. IT has transformed distribution in a number of ways and delivered many benefits, but also has created complexity and a set of processes that stymies improvement past the limits of forecast accuracy.

An overview of the content and concepts in Chapters 1, 2, 3, and 4 is provided in Figure 1.7. These first chapters form the basis for the background on distribution that has led to the relevance of Lean practices. Themes for each chapter indicate the concluding ideas being presented that challenge existing norms and paradigms.

The IT transformation has been beneficial in many ways, but has tended to focus performance improvement on planning-based optimization and automation. This future focus places too much emphasis on data for forecasts, customer orders, and operating schedules that are all changing more rapidly than ever before. It is an attempt to plan based on a number of moving targets that can be most successful only over the longer term. The organization can balance the “futures”-based plans with Lean-driven execution to be more flexible and responsive to day-to-day customer needs.

LEAN DISTRIBUTION FRAMEWORK

The Lean Distribution approach is shown in Figure 1.8. The five elements of the framework form the solution to a Lean transformation. The top and most critical element is customer service policy, defining the lead times, order parameters, and service levels for specific customers, groups of customers, and/or products. All aspects of the Lean approach must be focused on these policies, which are frequently not formalized or well communicated. On the bottom, operational capabilities are the foundation for the approach to ensure the Lean processes can be successfully executed. Operational capabilities can be defined to drive a Lean Distribution approach,

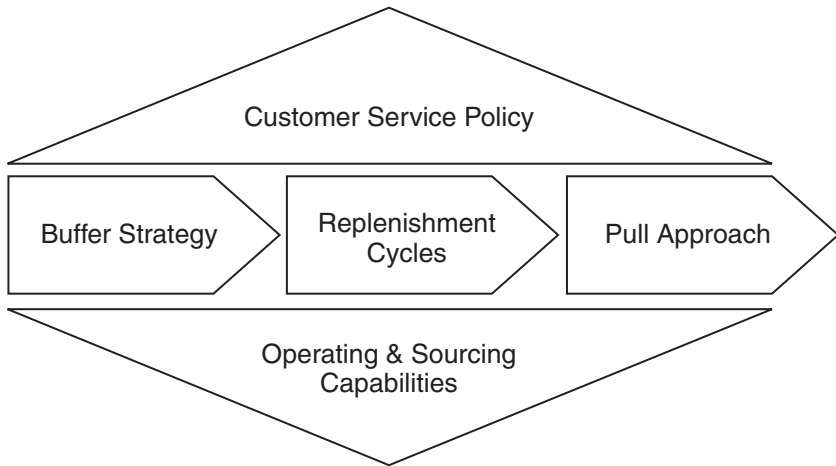
FIGURE 1.7 DISTRIBUTION TRENDS LEADING TO LEAN

| | Chapter 1 Lean Distribution | Chapter 2 Distribution Challenges | Chapter 3 Optimizing Distribution | Chapter 4 IT Transformation |
|-----------------|--|---|---|---|
| Theme | <i>Lean simplifies distribution to flawlessly execute and break the forecast accuracy barrier to service and profit.</i> | <i>Distribution: from silos to streams.</i> | <i>Networks are like people: they grow and mature but are difficult to change.</i> | <i>Technology implies accurate planning, when businesses must concentrate on flawless execution.</i> |
| Overview | Customer order forecasts are the basis for business planning and optimization, yet forecasts are always wrong and create as many problems as they solve. | The pressure on distribution has been increasing as customers streamline their supply chains, as companies globalize, and as cost scrutiny intensifies. | The distribution optimization cycle has been broken as fewer networks are modified to demand changes resulting in excessive cost reduction investments. | Information technology has taken a large role in distribution success as processes have become highly automated, but difficult to manage. |
| Concepts | Forecasts are inaccurate. Variability stymies cost reduction. Lean enables execution and reduces reliance on forecasts. | Organization silos. Customer-driven streamlining. | Optimization framework. Technology-enabling capabilities. Asset structure alternatives. Inventory tracking points. | Planning process maturity levels. Forecast usage tug-of-war. Snowball effect. Forecast confidence over time. |

even if the current operations are not Lean Manufacturing enabled, but the benefits will not be as substantial.

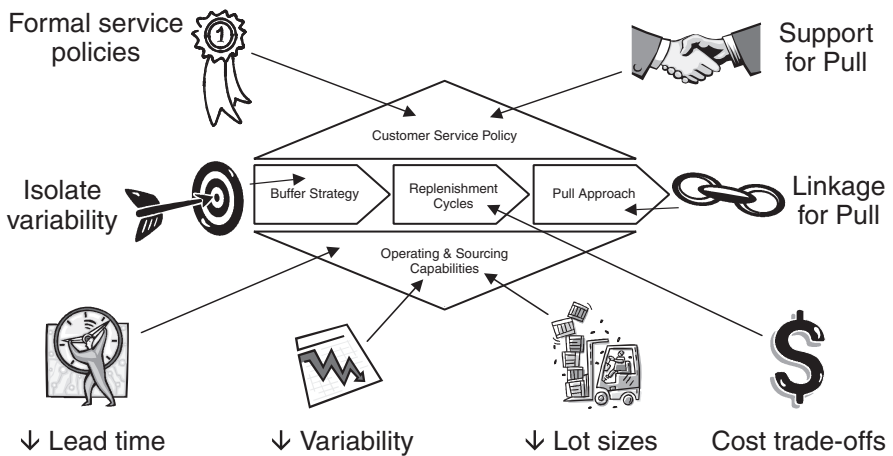
These five elements of the Lean Distribution framework contain the paradigm-shifting enablers necessary to break the forecasting barrier to customer service and profits. Figure 1.9 displays the critical enablers in each element. These eight enablers come from Lean Manufacturing and supply chain practices as tailored to the distribution environment:

FIGURE 1.8 LEAN DISTRIBUTION FRAMEWORK



- Formal service policies.* All organizations have some established “norms” and guidelines for customer service, but few examine and formalize policies to optimize the entire supply chain. The formal policies required for Lean Distribution revolve around articulated customer needs and key internal capabilities.

FIGURE 1.9 LEAN DISTRIBUTION ENABLERS



- *Support for Pull.* Customers seek dependable service and generally are willing to allow suppliers more latitude and responsibility to deliver. Support for Pull signifies that the customer recognizes the advantages and allows requirements to flow to the supplier without undue modification or hedging.
- *Isolate variability.* Variability exists in all environments and requires at least some buffer to isolate both customers and internal operations from daily gyrations in forecasts and orders. The trick is to have buffers in the most advantageous places rather than in many or all places customer demand occurs. Strategically placing and managing buffers enables Operations and Sourcing to hit more stationary targets rather than the ever-changing and moving target of a forecast-based plan.
- *Cost trade-offs.* Assess and decide cost trade-offs on a structural level rather than obsess on cost trade-offs for specific transactions every day. It may seem counterintuitive to increase profit by cost optimization of the distribution paths rather than individual replenishment shipments. This more structural approach addresses the variability that is a major barrier to most forecast- and order-driven cost reduction.
- *Linkage for Pull.* Making the links between customer usage or consumption and distribution replenishment processes is the tactical connection required to synchronize the supply chain to consistently meet customer requirements. Pull is more than a kanban or an “ordering” signal; Pull is the philosophy for replenishment and customer service excellence.
- *Reduced lead times.* Lead times are generally too long. Lead times for internal operations and from suppliers include a high level of safety time to accommodate unforeseen events. Lean helps reduce lead times, improving flexibility and responsiveness. Short lead times enable many wonderful cost and service improvements in distribution, particularly when paired with Pull.
- *Reduced variability.* Despite variability existing in all processes, few organizations focus on quantifying and reducing variation in the supply chain. The typical focus is product quality. The first step is to quantify the current variation in order to operate distribution processes based on the limits of current capabilities. For example, distribution center replenishment times may vary, causing Planning to use a “high-end”

time for all planned shipments “just to be safe.” This longer lead time results in excess inventories and a realization that not all orders must be shipped on the day planned, requiring expediting and overrides to ensure priority orders are shipped when needed.

- *Reduced lot sizes.* The quantity produced or sourced at one time or lot size has a direct relationship to flexibility and total costs. Larger lot sizes appear to lower costs in sourcing or production but can increase cost and reduce service across the rest of the supply chain. Lean Manufacturing practices help reduce lot sizes while eliminating waste, thereby enabling both low product and supply chain costs.

The eight enablers combine to form a cohesive system to improve distribution costs, asset utilization, and customer service. These enablers must be linked and implemented to leverage the overall approach and not as a series of disjoint cost reduction initiatives. The approach is tied together by the Lean waste reduction philosophy and the transition away from forecasts to serve daily customer needs. The end result is a new paradigm to view profitability and customer relationships, shown in Figure 1.10. As lead time, variation, and lot sizes decrease, profit approaches gross margin (excluding other general expense items). When these factors decrease sufficiently, there is a net addition to profit above gross margin from the effect of negative working capital, an example being Dell Computer (where accounts payable is three times the amount of inventory and accounts receivable combined).

FIGURE 1.10 PROFITABILITY AND TOTAL DISTRIBUTION COSTS

Profit $\cong f$ [Gross Margin – (Lead Time – Service Policy) – Variability – Lot Size]

The problem:

- All of these factors currently result in costs > 0 , reducing profit!

Consider the possibilities:

- Short lead time; therefore: Lead Time – Service Policy $\cong 0$
- Minimal variation; therefore: Variability $\cong 0$
- Lot sizes $<$ customer order quantity; therefore: Lot Size $\cong 0$

The result:

Profit $\cong f$ [Gross Margin – (1 – 1) – 0 – 0] = Gross Margin

This total cost paradigm is more than just adding up all the usual department budgets into a total. It is a view of the *drivers* of cost rather than the results. Results are the freight, labor, inventory, overhead, and other costs included in financial reports and departmental budgets. These results are driven by other factors, such as lead times and lot sizes. It is these drivers that require the cost-reducing focus; budgets and financial reports are the measures of results.

LEAN DISTRIBUTION TRANSFORMATION

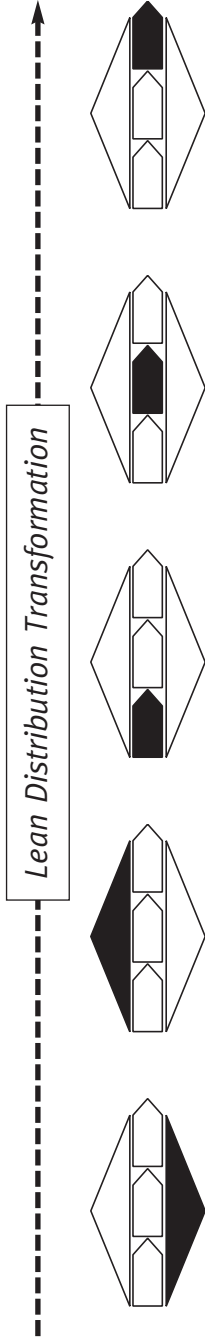
The Lean Transformation is built on the eight enablers to achieve new operating and customer service paradigms that leverage inherent capabilities. The enablers in Figure 1.9 and paradigm shifts in Figure 1.6 provide the flexibility required for short-term customer requirements with simpler distribution planning and replenishment processes, transforming the forecast into a longer-term and more aggregate focus. But to make this transition, an organization must thoroughly and critically reevaluate current processes and ensure that the paradigm shifts are well understood and articulated. The Lean Distribution Transformation is summarized in Figure 1.11 to show the major themes, steps, and concepts involved in moving to Lean-enabled operations.

To initiate the transformation, Chapter 5, “Lean Operating Capabilities,” describes the differences between traditional planning-based processes called distribution requirements planning (DRP) and Lean. The emphasis is on responding to actual short-term customer needs rather than planning far into the future. The Lean processes are described and contrasted to DRP. Pull is defined and contrasted to Push-based replenishment within DRP. Pull is shown as the key ingredient for the Lean Distribution approach to responding faster to shifts in market demands, product life cycles, and customer relationships.

The implications and need for customer service policies is presented in Chapter 6, “Customer Service Policy.” These policies can be taken for granted, just assumed, or possibly not communicated, but are fundamental drivers for all Lean Distribution process design. Meeting customer needs is paramount and the primary driving force for Lean Distribution.

Making the transition from a forecast-driven process to Lean-based Pull is accomplished with a combination of buffer inventory, replenishment

FIGURE 1.11 LEAN DISTRIBUTION TRANSFORMATION



| Theme | Chapter 5 Lean Capabilities | Chapter 6 Customer Service | Chapter 7 Buffer Strategy | Chapter 8 Replenishment | Chapter 9 Pull Approach |
|----------|--|--|---|---|--|
| Overview | <p><i>Pull Ship one, replenish one, and make one is Pull perfection.</i></p> <p>Lean Manufacturing practices provide the underlying capability to transform distribution from planning to executing.</p> | <p><i>Service excellence builds sales confidence.</i></p> <p>Customer needs and value must be aligned and improved with the distribution transformation.</p> | <p><i>Murphy says: Variation happens, so don't self-inflict it.</i></p> <p>Buffers are necessary due to demand or other variation with a strategy that supports excellent customer service.</p> | <p><i>Create distribution pipes and let replenishments flow.</i></p> <p>Replenishment processes are the structure enabling reduction of total distribution and logistics costs.</p> | <p><i>Customer orders may not be Pull demand.</i></p> <p>Pull creates the actual link with customers to ensure the supply of product and respond quickly to changes in demand.</p> |
| Concepts | <p>DRP versus Lean. Summing demand.</p> | <p>Segmentation. Service strategies.</p> | <p>Service buffers. Demand patterns. Service policies. Variation and lead time.</p> | <p>Distribution cost waterbed. Delivered cost analysis. Distribution pipes.</p> | <p>Replenishment triggers. Replenishment process. Inventory graphs. Inventory zones.</p> |

processes, and Pull-based execution. These elements of the Lean Distribution framework are described in Chapters 7, 8, and 9. The general principles are presented and then applied to specific environments. Each principle must be tailored to meet the unique aspects of an organization's environment.

Last, Chapter 10 provides some perspectives on implementation and how to view the dynamics of a Lean Distribution transformation. Lean Distribution provides a transformed view of the organization and operating dynamics. The paradigm shifts shown in Figure 1.6 are the visible indicators of change, but a much deeper principle must be embraced: an organization's flexibility is the key to customer relationships, profitability, and performance improvement.

ROLE OF INFORMATION TECHNOLOGY

Information technology plays a pivotal role in optimizing distribution and executing Lean processes. The Lean approach is to simplify processes, especially replenishment and inventory targets, but they still should be automated to leverage the time of people and provide fast response to customers. Some of the technology investments that leverage the Lean Distribution approach can include:

- *Delivered cost.* Delivered cost calculates the total of all costs to source/produce, inventory, sell, and deliver to each customer or similar group of customers. This delivered cost concept is critical in developing customer service policies and distribution processes that maximize profit potential for each customer or group.
- *Delivered profit ratio (DPR).* This is a comparison of the revenues to the number of products and locations providing a summary level assessment of the difficulty to operate the network and serve all customers, a group of customers, or an individual customer. Typically it is calculated manually, but for more complex environments it may require specific reports and analytics.
- *Total cost view.* This view combines all departmental budgets and costs into a total supply chain cost picture. It uses activity drivers, such as orders picked and shipped, to identify trends affecting the cost picture, especially variable costs.

- *Replenishment order triggers.* These triggers obtain customer daily demand (point of sale [POS] for retail, consumption for other customer industries) and processes against inventory targets to identify replenishment quantities and timing. They generate replenishment orders and communicate back to the customer status for their planning system. These processes may also be called electronic kanbans.
- *Variation and cycle time analysis.* These two key drivers of the replenishment process must be tracked and quantified in order to drive the entire Lean transformation. The inventory levels and replenishment cycles are determined based on these two parameters, which should be quantified and tracked, even though they may initially only be estimated. Variation can be split into multiple components, such as demand, supply, and lead time, each of which requires different actions to improve.
- *Buffer management.* This tracks and monitors inventories across the three zones: green, yellow, and red. It calculates the buffer inventory target levels, establishes the three zones, flags items based on time in zone, and reports aggregate statistics.
- *Forecast confidence.* This establishes the level of confidence in forecasts across the planning horizon to drive the planning system. Forecasts are more accurate in the near term, but also change frequently, creating ripple effects.
- *Network modeling.* This uses the forecast to simulate changes to the network and make changes over the long range. It uses modeling capabilities to determine the trade-offs for freight, warehouse size/location, inventory, and other costs to best meet customer delivery requirements.

Technology investments are critical for fast response to customer demand and effective Lean Distribution. Technology serves to automate replenishment processes, provide the consumption signals, and measure the entire supply chain. The Lean measures can be new views of the supply chain that are holistic and cut across current departments.

APPLICATIONS FOR LEAN DISTRIBUTION

Lean Distribution provides capabilities that address a variety of business situations and challenges. Lean Distribution is not necessarily a “solution” to

these business issues, but it can provide the necessary responsiveness and cost reduction to address the underlying issues driving many current topics on executive agendas. From customer-driven cost reduction to considering the implementation of new technologies, Lean can provide a framework to assess the benefits and construct approaches for success. Lean Distribution practices link the operational cycle times and variability to all aspects of process, enabling a clearer link between operations and results. As various initiatives alter operations or customer demand characteristics, the benefits and implications become more readily apparent and easier to deliver.

Customer Service

Customer service is the top priority for most distribution operations. It can be measured in order fill rates and inventory stock-outs to identify when customers are not receiving products when needed. If these measures fall, the typical reaction is to increase inventory levels. The difficulty can be that service level is a function of a number of parameters, and increasing inventory tends to mask the parameter causing the problem rather than to address the root cause.

With the Lean approach, customer service levels are well defined and communicated prior to designing service processes. Defining service helps to minimize differences in expectations or communications such that the main parameters required are documented and quantified. With the service policy, actual levels that depart from expectations can be addressed with root cause analysis to seek out and address the real underlying problem.

Vendor-Managed Inventory

Inventory at a customer's or distributor's location such as vendor-managed inventory (VMI), supplier-managed inventory (SMI), or consignment inventory is intended to provide better customer service with inventory "always available." Although service may be improved, it may present challenges to controlling costs and inventory. The customer's demand variation and desire to control inventory may be obstacles to managing this relationship effectively.

Using the retail industry as an example, point of sale (POS) data provided to suppliers enabled the transition of responsibility for replenishment from the retailer to supplier. As suppliers receive POS data, they can produce and ship to actual sales rather than to a series of purchase orders from the retailer.

For other industries, there may be a parallel to manage VMI using a Lean Distribution approach. The starting point is actual demand from the customer that drives replenishment processes geared to Pull rather than customer-order-based Push. The trick to effectively managing the relationship is designing the replenishment process on operational and demand statistics rather than gut feel and intuition. Inventory can be managed and service maintained while keeping costs in line using the Pull-based approach in Lean Distribution.

Radio Frequency Identification

Collecting data as inventory moves through the supply chain has been increasing since the introduction of bar codes and POS data collection. As technology progressed, radio frequency identification (RFID) has become the latest capability to collecting data by attaching a tag to the product, case, or pallet that can be “read” remotely via radio waves. The cost of tags and commercial standards has been the main obstacle to broad application, but as they continue to improve, applying RFID tags will be less expensive and adoption will increase.

Wal-Mart, the Department of Defense, and others have successfully piloted RFID applications and require some level of support from major suppliers. For suppliers, RFID efforts appear to increase their costs as tags and radio frequency devices must be purchased and implemented. The debate for suppliers relates to finding the benefits for RFID, because customers are not willing to pay extra to receive products that are RFID tagged.

A Lean Distribution viewpoint on RFID is to determine whether a more effective trigger for replenishment can be obtained. For the retail industry, this may be product movement from the backroom to the sales floor. These moves are not tracked by the retailer’s inventory system, but are crucial to maintaining sufficient inventory at the store. Store backroom space is limited, making a quick response to an empty backroom shelf critical.

Using POS data can be a proxy, but includes assumptions about backroom inventory and movement to the shelf rather than positive tracking.

Cost Reduction

The pressure to reduce costs across the entire supply chain comes from nearly all directions: customers, executives, and channel partners. What is driving the demands and expectations for cost reduction? Increasing profitability is the most likely answer, but could some derive from the perspective that applying pressure will produce at least some results?

In distribution, the challenge for cost reduction efforts is to ensure that customer service or other cost reduction efforts do not suffer. As one cost reduction idea is contemplated, can all of the other “balls in the air” be maintained? For example, it can be complex to assess freight savings opportunities when shipping schedules continually change.

A Lean Distribution approach to cost reduction is to clarify the factors driving the existing cost structure. Each parameter for the Lean design can be assessed to determine cost reduction opportunities that can be implemented with fewer impacts to other portions of the distribution processes. Customer service policy, variability, and supply lead time are the three primary examples of these parameters. With a Lean approach, changes to any one can easily be translated into savings potential. In this way, cost reduction efforts are focused on sustainable and measurable change.

Other Business Situations

Consider a water pipeline analogy: The utility can “push” water into the pipeline, creating the pressure that enables immediate flow to each point of use, the faucet. The pipeline has a fixed volume that allows pressure to build. Unlike the pipeline, supply chains allow materials to build up at numerous points prior to the consumption point; therefore, pushing materials into a supply chain creates excess cost and inventories. So the trick is to find material movement and consumption data that limits inventory build-ups to further synchronize the entire supply chain, improve service and reduce total cost.

As information technologies and Lean practices make further inroads across all industries, additional opportunities to apply Lean Distribution will

be presented. The transformation seeks to synchronize the supply chain by using actual sales and material movement data rather than various “orders” that are processed from forecasts by planning systems.

SUMMARY

The traditional forecast, plan, and then execute approach to managing Distribution has a lot of appeal and momentum for serving customers and achieving profitability objectives. It developed from the progression of information technology applications that translated detailed customer order forecasts into operational plans with a high degree of precision. Organizations assumed these detailed plans would improve execution, ownership, and measurement. This is a logical approach, but was built on a shaky foundation, as a forecast will always be inaccurate, resulting in higher than necessary inventories and complex business processes.

Improving forecast accuracy can be a tough task, even with customers willing to collaborate. The resulting “consensus forecast” may have significant customer input, but not much commitment to meet the numbers. For organizations seeking to maximize market share and meet all customer commitments, there is a tendency to plan high. Optimistic planning can create a frustrating cycle with a risk of obsolescence for forecasts that are high and expediting cost incurred to react to forecasts that are low.

Despite long sourcing and production lead times, a Lean Distribution approach can improve response to shifting markets without relying on more accurate forecasts or higher distribution costs. This paradigm shift can be tough to believe, because the forecast presumption is so strong. Evidence can be found in the difference between attempting to plan with an inaccurate forecast and then control variability to flawlessly execute versus the Lean approach to operate to actual customer demand and operate around variation inherent in all processes. With Lean, the focus is on flawless execution based on the realities of current operational processes rather than on assuming a forecast is correct and then hoping execution can be flawless.

Lean Distribution also delivers lowest total costs with a flawless execution and demand-driven approach. In the traditional plan and execute approach, variation from suppliers, operations, or customer orders may lead to some portion of the plan being off. As the plan is adjusted and changes

made, costs can easily be impacted. With Lean, variation is expected and built into the total cost picture rather than being a surprise that upsets the plan. With the focus on customer demand, Lean consistently delivers to customers while streamlining total distribution costs.



Distribution Challenges

Distribution: from silos to streams

At one time, the distribution function was primarily focused on storing bulk, pallet load, and case pack inventory for shipment on individual customer orders. It played a straightforward role as an inventory and time buffer between the large quantities and long production runs at the plant and the smaller quantities ordered by customers. Distribution strategies, warehouse locations, service levels, and operations were built around this role, resulting in many of the facilities, business processes, technologies, and policies that are utilized today.

Traditional distribution functions have fallen under attack as the business environment and competition are changing. Sales channels have expanded with the addition of online merchants, and other direct ship channels have increased order rates, reduced quantities per order, and changed the mix of outbound transportation. Competition is changing the traditional role of distribution as customers are having more success reducing prices and obtaining more stringent service policies. Information technology (IT) is providing new avenues to improve operations, especially for customers as they provide and demand more IT investment and support. In each of these trends, the traditional store, hold, and ship mantra for distribution is rapidly changing in favor of faster, cheaper, and more customized service.

CUSTOMER DIRECTIONS

Some of the methods customers employ to drive down costs may be less than totally cooperative in nature. In many cases large customers have

become very proficient at playing one supplier off another in bidding wars or skirmishes. These negotiations are about driving down prices, and the winner may seem more like the loser. No matter how it is accomplished, suppliers need to look for every opportunity to improve and eliminate as much cost as possible.

Total distribution and logistics costs seem like a good target for some of these cost reduction efforts. These costs vary by industry, but can range from 2 to 8 percent or more of sales dollars. With this amount of cost tied up in transportation, inventory, and distribution, customers and suppliers have sensed that this area was a tempting target. For companies making as little as 5 percent profit on sales, it does not take much improvement in distribution to make a difference.

Suppliers may view these customer “streamlining” efforts as pushing costs back in order to improve the customer’s profit. For many customers, this may in fact be the case; for others, the cost savings are being passed on to consumers in order to compete more effectively. In either case, the pressures from customers are real and must be addressed, or some portion of the business may be at risk. The trick for suppliers is to find ways to improve their supply chains while complying with customer demands.

Lean Manufacturing as an overall program to drive out waste can help address these customer pressures. Elimination of waste was the starting point for development of Lean principles. Cost reduction directly connects with elimination of wastes, even in distribution. There certainly are differences, but the ideas and principles behind the Lean focus on the flow product can be applied to distribution as well.

Sales channels also are a driver for change with the current increase in direct and drop ship sales. Retailers such as Amazon.com and many others sell products they never inventory by having their suppliers ship directly to the consumer. The suppliers’ distribution function may have been configured for shipments to retailers’ distribution centers, not end consumers. For others, this added sales channel may just have expanded existing shipments direct to consumers, but either way, the trend is clearly moving toward less handling by many retailers.

Retailers continue to struggle to maintain full shelves. As mystifying as it sounds, experience demonstrates that few retailers are able to maintain near 100 percent in stock status. There are just too many stock-keeping units (SKUs), too many promotions, and too many suppliers to reach the

perfection they all strive for. Stock-out percentages range from 1 to 3 percent or more, indicating lost sales and consumer frustration. It can be a key theme for retailers who are competing for customer satisfaction. It is definitely frustrating to customers when the item they are looking for is out of stock. In many cases, consumers do not have the time for store employees to search for something where the shelf is clearly empty. These consumers may just keep quiet and move on so no more of their time is wasted, so it is clear that a stock-out is much more than just a lost sale.

GLOBAL SOURCING

An outgrowth of customer pressure on cost has been moving manufacturing and sourcing further offshore into lower-cost locations. With this globalization trend, distribution is becoming more critical to business success. For offshore production or sourcing, the supply chain can be very long, stretching halfway around the world, with lead time to forecast and plan production or sourcing increased accordingly. Distribution inventory and flexibility must accommodate the variation in demand and also the large inflows from overseas occurring due to seasonality and container-size ocean shipments.

A long supply chain may be just one implication of the global sourcing trend. The single-minded focus to reduce acquisition cost is the main driver for this trend, and the savings can appear extremely attractive. But one result can be higher distribution costs, which may be part of the initial project cost reduction estimate, but may include some rosy assumptions for ocean versus air freight and Customs. Once the sourcing commitments are made and market demand starts its inevitable shift above or below the forecast, the distribution scenarios will change. Meeting higher than expected demand may incur expedited freight. When demand is below expectations, warehousing and storage costs increase. Either way, the market will seldom precisely match the forecast, so some flexibility and adjustments in distribution will be required.

COST REDUCTION

The distribution mantra to continuously reduce the cost of operations has taken new meaning as customers drive down prices and increase service

requirements. There is tremendous pressure on all parts of the business to do more with less, and distribution is no exception. Freight, labor, warehouse expenses, and other costs have been highly visible and are under increased scrutiny as targets for reduction. The budgets for these areas may be subject to numerous cost reduction projects and initiatives.

Distribution cost reduction or cost avoidance has even come into play with acquisitions, particularly for consumer products companies. These companies, faced with the prospect of growing or maintaining a distribution channel primarily to retailers, found that combining with others can be more cost effective and can justify the acquisition. Despite being only 2 to 8 percent of total costs, distribution can make a major difference in profitability such that overall company strategies are modified to serve customers most effectively.

The traditional approach to improving the cost of distribution operations revolved around technology-enabled optimization and automation to reduce costs. These cost strategies have applied technologies to each “piece” of the total distribution cost, such as warehouse management systems (WMS), transportation management systems (TMS), route planning, automated storage and retrieval systems (AS/RS), and wireless data collection, to name a few. The warehouse has truly become high tech as companies diligently work to speed flows and eliminate costs.

The downside is the significant capital investment required and its implication to fixed costs. Automation may reduce some warehouse labor and other costs, but may be beyond the reach of many companies. Further, increasing the investment in distribution assets can go beyond already tight capital expenditure budgets. While automation may provide many benefits, some companies may not have the cash flow or financing to make the investment.

An alternative to large capital investments has been outsourcing some or all distribution and logistics functions. Going to a third-party logistics (3PL) provider has many benefits, not the least of which is being able to utilize the logistics supplier’s existing distribution infrastructure rather than investing in one. The 3PLs also should provide more expertise and cost efficiency than most companies can achieve on their own. Also, some companies have started viewing distribution as not a “core competency.” Most of the outsourcing arrangements started as cost reduction efforts in order to leverage the outsourcer’s volumes, expertise, and capacity to lower

costs. There may even be multiple outsource partners as specialist firms in each area are contracted to provide an end-to-end solution.

Although many outsourcing arrangements may successfully reduce some costs, questions may arise about integration. Adding a “third party” between a company and its customers can raise concerns related to bridging yet another organizational gap between operations, planning, service, and sales. The outsourcer can become an even more pronounced functional silo than what existed while the distribution function was in-house. This is difficult to avoid: The outsourced firms are paid on transactions and service levels and would quite rightly seek to protect their results. So one has to hope and trust that the added expertise from the outsourced firm outweighs any added complications resulting from silo behaviors and incentives. For example, does an outsourced transportation provider really have as much incentive to wait for that rush shipment and still keep the cost as low as for a shipment with adequate lead time and planning? This may be a situation where the contract language is a little sticky, due to a range of situations that might fall outside the norm.

LEAN STREAMLINING

Lean Manufacturing principles are changing the characteristics of plant production output to distribution. As Lean has taken hold in production operations, many of the previous assumptions regarding production run volumes, quality, and flexibility are changing. The paradigm in operations of long production runs due to high setup costs and quality are dissipating in favor of developing capabilities for shorter runs and more flexibility. The more that Lean has taken hold, the more inventories are being reduced, scheduling is simplified, and quality is improved. With these dramatic changes in the plant, companies should be better prepared to serve customers and drive out waste across the entire supply chain.

But the world has also changed from customers’ perspectives. They are making demands to streamline supply chains and their own internal operations. Gone are the days of cost-based trade-offs for purchase order decisions. Customers now demand more service at the same or lower cost. In the past, customers would review purchase decisions and identify the most economical quantity and time to order, especially for retailers that viewed buying as their key strength. Now fewer purchase decisions take this time

value of money and discount approach. For example, with Wal-Mart, the trend has been to Everyday Low Prices™ driven by everyday low purchasing. This change is based on a lower-cost supply infrastructure rather than periodic special deals or one-time purchases.

Wal-Mart's focus is on taking all waste out of the supply chain. The large firms are very good at obtaining cooperation from suppliers, whether it is viewed as win-win or not. Whether the customer is in retail or industrial manufacturing, the large customers are using clout to drive change. Their assumption is that whatever helps streamline the supply chain "helps" the supplier and is cost justified. Or in some cases, survival and international competitive themes are "justifying" change.

NEW CHALLENGES?

Does any of this really sound new? It seems like customer service has been a priority for decades, and customers have pushed on pricing since the last recession. But yes, there are new trends related to how systematically these changes are occurring and what the implications are for distribution operations. Supply chain innovators are working to instill an ongoing process of change and improvement rather than just incremental steps to lower costs, change policies, and get a better deal. The steps are leading to end-to-end visions for supply chain optimization rather than a view limited to each organization's four walls.

The suppliers who "win" at this new optimization game are ones who can anticipate and best support rather than just react to a customer's next demand. Being able to anticipate relates to identifying the next opportunity to take waste out of the supply chain, at least that portion a customer can "see." The remaining portions not typically "seen" by the customer are still important from an overall cost and service perspective, but at a minimum customers' views enable them to plot out next steps and actions that naturally involve suppliers.

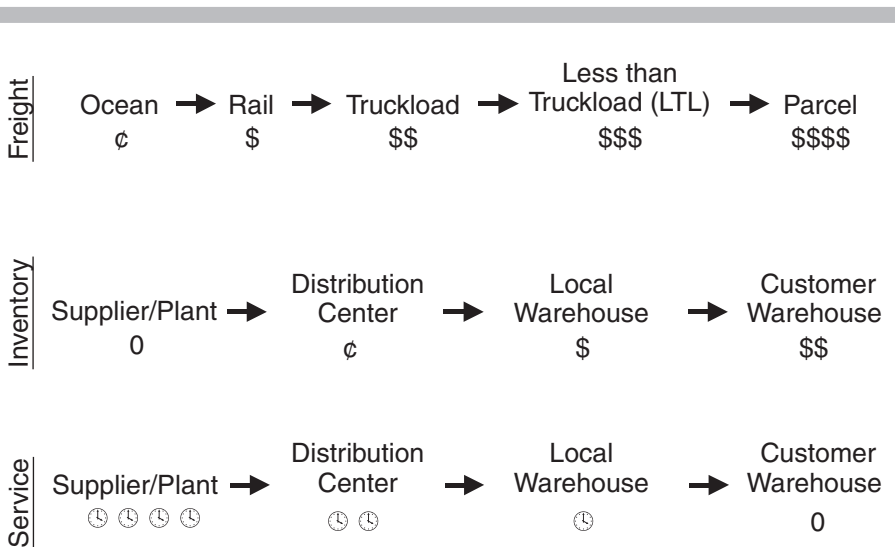
Optimizing the supply chain means addressing distribution's historical role as the buffer between customer demand and the internal and external capabilities to produce and deliver. The buffer was required primarily due to production limitations of suppliers and the plant. If production could make and ship every product ordered every day, would distribution be necessary? In some cases, yes: where the delivery time is much longer than

the customer’s tolerance to wait. For those cases, the company places distribution warehouses or another plant near the customer to reduce final transit time. Since a warehouse and inventory are usually less investment than a plant, the choice is clear: build out a distribution network. In many other cases, immediate response and shipment by the plant would negate or severely downsize any requirement for distribution facilities and processes.

To optimize the placement of inventory and the build out of a distribution network, the network should optimize costs while meeting customer service objectives. A general optimization paradigm is shown in Figure 2.1 to illustrate that lowering costs (moving from the right to left for freight and inventory) has customer service implications (more “clocks” representing longer response time). While an “optimum” trade-off of costs and inventory versus service is sought, products, forecasts, and many other inputs to the optimization evaluation are changing.

Distribution’s primary role has also been changing as customer requirements expand beyond just meeting the delivery timing. Customers are demanding more customization, more labeling, and more specialized handling in order to streamline their supply chains and operations. Customers have been driving change to their suppliers such that products arrive ready

FIGURE 2.1 DISTRIBUTION OPTIMIZATION PARADIGM



for use or sale and flow easily through their distribution center operations. This is a fundamental transformation of product flow and presentation from a manufacturer's product sold to all customers in basically the same packaging to major customers only accepting unique variations of the product. Blister packs, variable-size containers, and other methods are used to make the Wal-Mart, Target, and Costco unique SKUs for the same "product" different.

The complexity of modifying products to meet these customer requirements frequently falls to the warehouse. Creating blister packs or applying customized labels creates a multipronged divergence of flow for a product, which should be placed at a point to maximize simplicity and flexibility. By placing these operations closer to the customer, a single inventory of product serves multiple customers rather than having the many different packaged configurations stocked at the same distribution point.

FUNCTIONAL SILOS

Crossing an organization's functional silos is an area where Lean Manufacturing approach excels. Lean takes a total flow view and addresses the underlying causes of service issues and constraints. Shipments not available when scheduled are just one example. Lean seeks to identify where the trigger for production was missed or was insufficient to meet the demand condition and correct it for the next time. A Lean approach entails building the view of product flow and dissecting components and attributes in order to continually eliminate those steps considered waste and to improve the value added processes. With movement and storage high on the list of Lean wastes, distribution should be a worthwhile area to link improvements with the shop floor and suppliers.

Distribution and logistics operations have long been operated to minimize cost and maximize customer service. These were well known and understood objectives for everyone in these functions. Cost includes many aspects of the end-to-end logistics function: transportation, warehouse labor, expenses, and overhead. It is not too surprising that transportation and labor seem to receive the most day-to-day attention: they are viewed as the most variable and controllable. Expenses and overhead may receive more focus in environments requiring cold storage, packaging/repacking,

or other special handling. In any case, the cost side of the ledger gets the most attention and focus.

Customer service objectives seem less about the degree of performance and more about absolute compliance. This means that there is a focus on “missed” shipments rather than on how many additional shipments were made. The expectation is to hit 100 percent of shipments on time, no backorders and no excuses. Across a broad range of industries, expectations near 100 percent are common and indeed expected by customers. With service measured against perfection, the real discussion is how we measure against shifting customer requirements, unexpected demands, or defining the real service need. These discussions are driven by the sincere concern that distribution is being measured against an objective with limited relevance, but lots of emotion: we never, ever want to lose an order! With a 100 percent service objective, the natural concern from distribution is the high level of resources necessary and the possibility for excess expenses, inventory, and effort being applied against unnecessarily high goals.

It is important not to confuse service with volumes. Logistics operators seek to ship more volumes: cases, orders, and/or dollars. Volume increases typically makes hitting cost targets easier: many “variable” costs are really closer to being fixed, and a higher volume makes cost targets easier to attain. But the expectation is that expenses generally rise and fall with volume. Only a small portion of distribution costs are truly variable expenses, so distribution has significant incentives to maximize volumes in order to hit cost targets.

Many distribution initiatives to reduce costs and improve service are similar to those pursued in operations prior to Lean Manufacturing. An incentive to increase volume is one example that leads to higher inventory and space by seeking to optimize transportation costs.

SUMMARY

The customer-driven pace of change is accelerating due to technology and pressure on costs. The pace is beyond the point of being relentless and is transforming the business landscape into a battlefield. Business is being won or lost as customers drive difficult bargains and force technology and other streamlining efforts back down their supply chains. When these pressures

meet up with functional organizations, the focus can be reducing each component of cost: freight, warehouse labor, expense, and inventory within the allowable expectations for customer service lead time.

At the same time, supply chains have become more global and complex. Executives sought and found more global sourcing options and lower costs that resulted in supply chains that span long distances, time zones, and lead time. The complexity to manage these extended supply chains has increased in tandem with expectations to reduce cost. The optimization paradigm for distribution shows that times to respond to customer, inventory levels, and freight are in conflict and can result in difficult choices.

Distribution is experiencing change, similar to the long history of cost and service focus, but with more options and heavier investment choices. Some companies outsource while others bite the investment bullet. However, some organizations have approached these challenges with a Lean tool set with great results. They have applied Lean to distribution operations to streamline, increase flexibility, and reduce cost simultaneously.



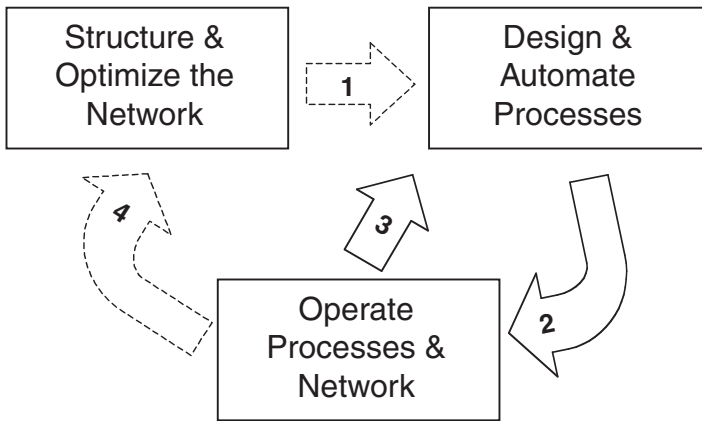
Optimizing Distribution

*Networks are like people: they grow and mature,
but are difficult to change*

Distribution must achieve multiple and sometimes conflicting objectives. Customer service, inventory management, and cost reduction are paramount objectives for anyone in distribution. The problem is they seem to be conflicting objectives. If we reduce inventory, customer service suffers. When costs are controlled too tightly, special customer service requests may be avoided. Meeting the objectives for all three simultaneously is in conflict.

The approach to achieving the diverse distribution goals includes structuring network assets, applying automation technologies, and operating the business processes well every day. These three components are interrelated and yet very different. Consider the connections between the optimization steps shown in Figure 3.1. They appear related or even sequenced, but most often this is not the case. An existing facility or two may be the starting point in a network structure, and the past decisions regarding placement and structure may be lost in the years gone by. Over time, the network may have been expanded or patched without reassessing the whole. Similarly, during the course of daily operations, ideas to add or extend automation may be implemented. The tendency is to continue the loop between steps 2 and 3 to automate the problems of the current operations with little “stepping back” to reassess the entire structure, steps 4 and 1.

FIGURE 3.1 OPTIMIZATION FRAMEWORK



It can be difficult to identify when it is appropriate to take step 4 to reassess the network. Small changes, such as adding customers or products, can creep up and not be noticed as they accumulate. Some of the inputs to network structure, such as transportation cost, may change, but it is not clear how much is necessary before reassessing the structure is warranted. Prior to actually structuring, there may be limited clarity of the warning signals; therefore, most organizations perform network assessments only infrequently.

DISTRIBUTION SPORTS FRANCHISE ANALOGY

If we use a sports analogy, structuring assets is the definition of which players are recruited and signed, automation is developing and calling each play, and operations is how each play is executed. In recruiting, the desired characteristics of the players include how well they fit the needs of the team, not just their individual skills. Players must work together well and be a team, because a group of superstars does not necessarily mean a winning team. The plays must fit the team and the competition for that specific game, because the same plays in the same order would not be used against every opponent. During each game, plays must be executed flaw-

lessly. Winning requires the right combination of all three factors, any one not being sufficient.

In the sports world, each of these three components occurs under different timing with different implications. Players are recruited and signed once a year, with trades occurring infrequently during any one season. This clearly makes sense, because the coach works hard to train and build the players into a team, teaching them plays and honing their ability to work together. Changing players during the season can disrupt some of the long preseason training. The playbook may be developed annually as well, with additional plays added or revised easily during the season. Plays and their sequence must be changed based on competition, and revisions may even be sketched out during a game. However, it is tough to change all of the plays in the book every week: it would just take too much time to practice them, and the odds of errors in execution would be high. Last, each play is another chance to execute well or to spoil an opportunity created by having the right play, called against the right team, at the right time. All three components must be orchestrated by the coach and head office for the franchise to win.

Despite being the last step, execution is where the game and season can be won or lost for our sports franchise. Teams may improvise successfully on a poorly called play. Unknown players may step in for superstars and exceed everyone's expectations. But if the team cannot execute each play, then it will look like a sand lot team and not professionals. So what must be considered first and foremost in the strategies for all team building and play creating strategies? The ability to execute and the requirement for simplicity are paramount. How many times is a reverse seen in football? Not many, because it is a complex play and fraught with the danger of poor execution. Successful coaches and managers find the right balance of all three components in their strategies for each season. In fact, some winning franchises have been built on little more than the best execution of basic plays by a solid team: the fundamentals.

OPTIMIZING DISTRIBUTION

Back to the world of distribution, how does one develop the right balance of the three components: network structure, automation, and operations? The decisions must be based on a specific set of conditions and assumptions.

The steps to maintain optimized distribution with the three components from Figure 3.1 include key decisions and assumptions:

1. *Structure and optimize the network.* Determine how many locations, where, and how much space is required to deliver to customers: assume a forecast, key parameters about each product and demographics.
2. *Design and automate processes.* Design and simplify processes, and implement information- and material-handling technologies to automate activities occurring in the warehouse: assume definition of the needs for automation.
3. *Operate processes and network.* Develop and manage the business processes and physical operations of the distribution centers and logistics.

Guidelines or policies are required to design the optimum network for customer service, pricing, and production/sourcing. Sometimes these “policies” are informal and possibly not well understood across the organization. Other times they are blanket statements, such as shipping within the same day for orders received by 3 P.M. Informal policies primarily are verbal, and tracking actual compliance may be difficult or not done. Formal policies tend to be documented and more closely followed. In either case, policies for lead time commitments, inventory availability, and many other aspects of service are necessary for each customer or group of customers.

Once structured, the supply chain processes should be simplified and automated to improve customer response and reduce costs. Simplification is the first order of business to ensure that complicated processes are not automated. Numerous technologies are employed, such as warehouse management systems (WMS), automated storage and retrieval systems (AS/RS), conveyor systems, bar coding, transportation/route planning, and a host of others. The point is to reduce errors, minimize handling costs, and increase the speed of product flow. All of this must align well with the objectives for distribution.

Technology must be steered through the minefield of too much automation. It is clear that without automation, repetitive tasks would require too much elapsed time, cost too much, and be highly error prone, so some level of automation is necessary. The questions become: How much and

what tasks? Therefore, automation should follow process design and alignment of the structure to strategies, rather than taking existing business processes and networks to automate tasks that cause the users the most pain. The risk of technology for automation's sake is a downward spiral of the investment/benefit equation. Chapter 4 presents more on technology approach and returns.

Operating the assets effectively every day should execute the strategies developed based on how the supply chain was structured and automated. Here the realities of getting the right products to the right warehouses and the right customers at the right time each day settle in. There is little margin for error when customer service expectations are 100 percent. Inventory must always be in the correct place at the right time, each day, without fail. Without the right inventory, the rest of the distribution processes cannot operate. For some companies, express shipping can substitute for inventory outages, but that increases costs, so it should be a very rare exception. The bottom line is that to operate every day, inventory must always be in the right place at the right time.

Structuring Assets

Decisions on structure are episodic: every several years, when a significant event occurs, or even less. If an acquisition or divestiture is in the wings, structure may be analyzed or just reassessed. These and other significant decision points are opportune times to review the structure of all supply chain assets and determine which stay, go, are expanded, or reconfigured.

Structure of supply chain assets can be thought of as a continuum from fixed (high ownership of assets) to variable (low ownership or outsourced) and from single location to many. Figure 3.2 shows this continuum indicating some of the inherent trade-offs. The relevance of these asset structure designations include:

- *Outsourcers.* Have the flexibility to align assets with changing needs, primarily through the use of third parties.
- *Owners.* Seek to optimize the long-term cost of distribution ownership because their needs vary little.
- *Concentrators.* Need to maximize plant operational assets much more than distribution.

FIGURE 3.2 SUPPLY CHAIN ASSET STRUCTURE

| | | | |
|----------------------------|-------------|--|---|
| Number of Locations | High | <ul style="list-style-type: none"> • Customer locations variable and fragmented • Ship \$ >> product \$ <p style="text-align: center;">OUTSOURCERS</p> | <ul style="list-style-type: none"> • Stable customer locations • Ship \$ >> product \$ • DC \$ << Shipment \$ <p style="text-align: center;">OWNERS</p> |
| | Low | <ul style="list-style-type: none"> • High plant asset base • Few customers with large shipments • Direct ship capability • Product \$ >> ship \$ <p style="text-align: center;">CONCENTRATORS</p> | <ul style="list-style-type: none"> • Plant direct ships to customers • High plant asset base <p style="text-align: center;">OPERATORS</p> |
| | | Low | High |
| | | Ownership | |

- *Operators.* Leverage their plant locations for distribution and have little incentive to build out distribution due to high transportation costs after manufacture.

Optimization Assumptions

This is where the underlying assumptions for the structuring and automating activities come in. It is obvious that assumptions, estimates, and forecasts were used to determine the optimum supply chain structure and automation technologies, but frequently these assumptions are then forgotten or neglected. Why are the assumptions important for everyday operations? Because costs are measured and profits are expected to be maximized with everyday operations, and many actions are taken to that effect. When push comes to shove, it is the express freight for an urgent order, the less-than-truckload (LTL) shipment, or labor overtime that gets management excited that something is amiss, reducing profit. These are “problems” that must be eliminated.

How to eliminate these profit-reducing events? The first step may be an edict, otherwise called policy, such as: only ship full truckloads to replenish the warehouse (or something close to that). These are based on good intentions, but will fall by the wayside whenever unmet customer requirements arise. A second step usually is to increase inventory levels to compensate for the cause of the emergency: an urgent unmet customer requirement (probably caused by an inventory stock-out). The third and final step may be to examine the forecasts and assess whether accuracy can be improved (the cause of stock-outs). The thinking being more accurate forecasts, higher inventory and forcing lower-cost modes of transportation will lead to more efficient operations.

Optimization Foundation: Shifting Sand?

The fallacy with this approach is the undue reliance on accurate forecasts and the short-term planning process. Consider the difficulty to forecast (guess) what customers will order in the next two to three months in order to have the exact inventory at the distribution center (DC). That requires having accurate data for the customer's inventory, build schedule, and planning parameters. Even with a complete duplication of the customer's planning system, the customer's purchase orders will still move as orders and forecasts change. There is no getting around it: the customer's orders and build schedule are changing, possibly during each day. With each change occurring at the customer, the planning system is moving or suggesting changes to purchase orders for suppliers. It is a moving target: every day brings changes that ripple down through the supply base.

This is where typical distribution requirements planning (DRP) and other planning approaches become "nervous" and change orders and plans too frequently, to the point where operations seems to be shooting at moving targets. An analogy may be the arcade shooting gallery: one must aim ahead of the target to hit it. Of course, we recognize those arcade targets are moving predictably, so we should be able hit the moving target. But now try a shooting gallery where the targets move erratically: How should one aim? A person whose reactions are fast enough should shoot as each target pops up. If a person's reactions are not fast enough, then all is lost, or he is shooting wildly just hoping to hit anything. In distribution, lead times are just too long to shoot as targets (customer orders) pop up.

How do we best manage in an environment with variability all around? Piling up inventory at the warehouse is the typical approach. Each pile is designed to protect shipments from stock-outs and is replenished according to lead times, planning factors, and forecasts.

Technology has been instrumental in helping distribution to plan and manage inventories. Consider the “old” manual methods to process orders, pick, move, and ship. Now compare those steps to today’s forecast and collaboration portals, vendor-managed inventory (VMI) order entry, wireless warehouse management system (WMS) picking, bar-code-driven conveyor systems, and much more. All this technology speeds the cycle for materials to move through the warehouse, reduces labor, and dramatically increases accuracy. And the pace of technology innovation seems to be quickening, providing more options to further improve operations and track inventory.

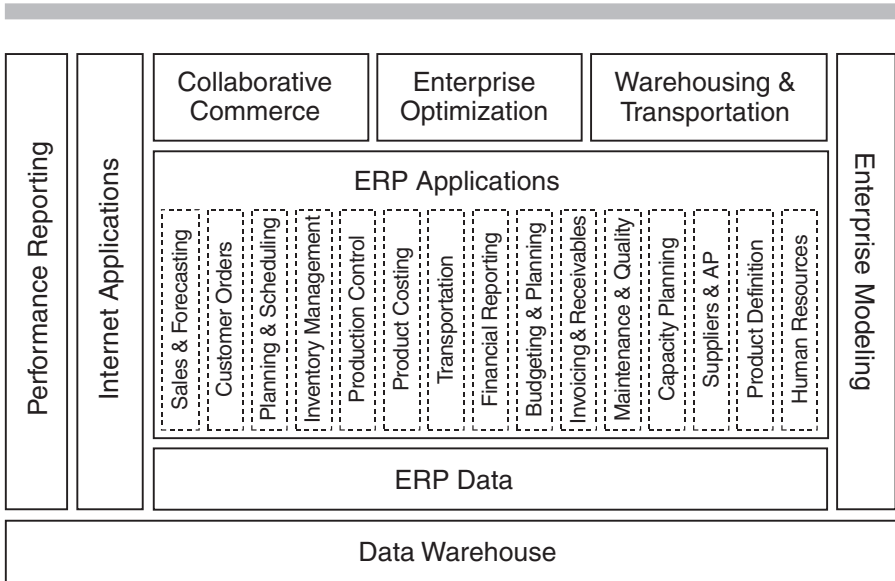
Why should technology changes be a consideration in a Lean supply chain? Technologies are developed and implemented to achieve many of the same objectives as Lean; however, the approaches between the two may or may not align well. Considering that the Lean mantra is the elimination of waste, almost all technologies would appear to fit well, but in practice a Lean simplification approach may be at odds with some technologies or how the technologies were implemented. It is the way that waste is eliminated that may cause concerns, so the technology angle to be considered is how it optimizes each of the various dimensions of distribution and where that aligns with a Lean approach to eliminating waste.

TECHNOLOGY INFRASTRUCTURE

Technology solutions span many types of systems, from material handling to business process automation to sophisticated optimization. For a distribution operation, each type of technology needs to work together to speed the flow of product and maintain low costs. How each of these systems is implemented and integrated forms a critical aspect of the success for distribution. An initial important view is to understand that the linkages between technology and Lean are the foundation and implementation of these systems.

These technologies are primarily built on an enterprise resources planning (ERP) systems foundation. Systems from Oracle, SAP, Microsoft,

FIGURE 3.3 TECHNOLOGY FRAMEWORK



and others provide the data foundation for advanced technologies in customer service, the warehouse, and across the myriad of business processes supporting distribution. ERP is a critical technology step to capture, process, and maintain data. The typical ERP system defines products, maintains customer data, enters orders, and performs billing to mention just a few functions. There are key linkages back and forth with third-party distribution systems or the distribution modules of these ERP applications.

Extended from the core applications or expanded with third-party packages, an entire suite of technology solutions is deployed. Figure 3.3 shows a logical relationship among the applications many companies deploy. ERP is the entry point for most static data (master data, such as customer addresses) and dynamic data (transaction data, such as customer orders) that is used by each of the extended applications. This sharing of data is important to understand and recognize in order to prevent timing, sequencing, and integrity problems.

A key result of ERP automation has been data integrity and the ability to enter data just once. This should be a reality for nearly every company today, considering the availability of systems across many price points and technologies. Even small distributors can find standard cross-industry

applications or possibly applications specialized in their industry vertical that performs a solid job of data entry, validation, retrieval, and reporting. Although few systems ever seem to be implemented with only the standard reports available from the vendor, most companies can download, export to Excel, or develop custom reports.

With data integrity and integration across the organization, ERP has banished the functional systems and disjoint point solutions commonly referred to as “islands of automation.” These islands restricted supply chain operations and distribution due to the rekeying and delay of data across each. The access to real-time data provided with ERP provides distribution planners more control over the movement of goods.

Technology-Optimized Distribution

How do some of the typical distribution technologies improve many of the dimensions of distribution optimization? The approach for technology optimization can be important to the connection with Lean in the plant, at suppliers, and with customers. There are six main dimensions of distribution optimization:

1. *Customer service.* The lead time, special handling, and fill rate commitments for customer orders.
2. *Operating costs.* The freight, labor, warehouse expenses, and all other costs to move products across the distribution network to customers.
3. *Production/sourcing costs.* The total cost for products coming into the distribution function from internal production operations or suppliers.
4. *Inventory management.* The physical and monetary levels of inventory.
5. *Asset utilization.* The degree to which property, plant, and equipment (PPE) for distribution is actively “busy.”
6. *Flexibility.* The extent of change in operating levels, customer ship-to destinations, product characteristics, and handling that can be accomplished easily.

Customer service is improved with more efficient and error-free order processing. The key to serving customers is the ability to deliver “perfect orders” with consistent cycle time, no errors, and continuous tracking.

Customers are clearly more delighted with no surprises, and the ability to execute each order every time is crucial. Technology has become fully embedded into the success of these processes.

The cost dimension of labor, expenses, and freight is addressed with technology to automate tasks and plan orders into efficient pick and shipment groups. Automated processing of customer orders, replenishment orders, and production/purchase orders minimizes labor. By taking time out of the order processes, costs are reduced with less touch time and fewer errors. Combining orders into efficient picking and shipping groups saves labor and freight costs.

Technology provides more capabilities to optimize production and sourcing costs. The data available for distribution activities and the technology planning logic provide more realistic plans, visibility, and analysis of alternatives to make decisions. These planning functions build on the customer order and other data to enable an optimized plan, which includes any impacts to sourcing and production costs.

Inventory can be tracked across the distribution network. Accuracy is improved and the effort to record, track, and monitor inventories is minimized. With near-real-time tracking, inventory management is improved as flows can be redirected in midstream. With better control and directions of flows, flexibility should be improved as well.

Assets are both increased and better optimized with technology. Technology investments do increase the asset base and therefore must bring a high return. As technology investments are added to that for buildings, equipment, and material handling, the distribution asset base becomes ever more significant. Technology enables faster flow of materials through the warehouse and across the distribution network, provided by material-handling systems and effective information control.

Enhancing Customer Service

A customer service definition may be summed up as the right product/service, at the right time, at the right price, every time. Other “at the” descriptions of the many attributes of service that customers expect can be added. Each attribute is important in some way to the customer and so must be delivered. To maintain or improve service, each attribute is important.

The last thing any customer or executive wants is to delay a customer order. Orders are the life-blood of the company from cash flow, service, and growth perspectives. Therefore, a monitor of customer order flows for cycle time, accuracy, and fulfillment are key measures. If the policy is to ship same day for orders received by 3 P.M., then it is a good bet a measure is in place to monitor compliance. Once a policy is set or commitment is made to a customer, then internal processes should deliver to those promises 100 percent.

At the same time, many checkpoints are placed in the path of each order. These checks existed in the past, and many were manual. Examples include: Ensuring that pricing is correct, order policies are followed, and customer preferences are enabled. These and other checks are important to complying with policies governing customer orders and relationships. The last thing someone in Customer Service wants is to hear that we just shipped a product to a customer who is not permitted to order that item. Other cases could be products shipped from the wrong warehouse. In each case, complying with policies and preferences is important to meet customers' expectations and internal policies.

Inserting checkpoints in the order process appears to create tension between checking each order and moving orders as fast as possible. Although accuracy is paramount, speed is critical as well. This is where technology capabilities have enabled fast and accurate processing of customer orders. Technology has allowed companies to perform the necessary validation steps that have the potential to slow down orders. Each validation can be performed automatically as the order is entered. Examples of these validations are shown on the main customer order processing steps in Figure 3.4.

Why does it take information technology to accomplish smooth processing of customer orders? Smooth processing of customer orders is critical to meet service objectives that can exceed 95 percent on-time delivery, requiring on-time processing at each step. If any one step slows down, the probability is that the order will be late. Consider why many companies have applied Six Sigma (quality equal to 3.4 defects per million or 99.9997 percent within specification) practices to the front office: if any one step in a six-step order process is less than 99 percent on time, there is little hope, other than pure heroics, of meeting 95 percent on time for the entire order. In fact, for a six-step order process where each step has a 99 percent on-time rate, the overall on-time rate would be closer to 94 percent. This

FIGURE 3.4 TECHNOLOGY-ENABLING CAPABILITIES



is just not acceptable, so each step must perform at “perfection” to attain an overall process capability close to 99 percent.

At each step of the process, technology solutions automate what previously were manual tasks. Credit checking during order entry and validation is one such step. For marginal customers, this is an important function. We do not want to ship an order to a customer who cannot pay. The system can keep track of authorized credit lines, current receivables, and open order values to determine whether the line has been exceeded. This speeds up order processing by allowing “approved” orders to move directly from entry to the next step with no time lost or manual intervention.

Customers expect current status as well as fast processing of orders. Web consumers on the leading sites see their order progress in a stepwise fashion. Consumers have been trained to expect this level of attention and visibility, and commercial customers expect no less.

Managing Costs with Technology

For the cost dimension, ERP has brought a high level of automation to supply chain business processes. Order entry, inventory management, picking, and many other processes are now well supported within these systems. Each process can be monitored to ensure that customer orders continue to move quickly and efficiently from start to finish. At each step technology automates tasks that previously took time or slowed down orders.

Cost management includes a multitude of capabilities that address the cost impacts of supply chain tasks. As orders are entered and processed, the quantity ordered can impact the picking and freight costs. ERP systems provide functions to check that case quantities or a truckload quantity is ordered to obtain advantageous pricing. These functions reduce costs by reducing picking time with case quantities and reducing freight cost by using full truckload shipments for an order. A decision point is presented for any order that does not meet the criteria: flag and hold the order, override, or seek approvals to change the order to comply with the cost guideline.

Service policies can be developed and easily applied across all customers, products, or locations. Enforcement is automated as orders are entered before inventory allocation, picking, and shipment. By enforcing policies, customers receive the service intended and products or inventory shipped to one customer that was meant for another is eliminated.

Other cost elements typically being managed transcend many distribution and supply chain functions. Freight is the easiest to point out. Many others exist with similar aims, such as minimum order quantities to ensure that sales dollars are sufficient to justify the costs of processing the order. Others may specify which warehouse is the default shipping point to a customer to minimize freight costs or meet certain customer preferences. In any case, the costs are usually considered.

Each of these cost-related policies is well intentioned and based on the most accurate data available at the time. Enabling the system to accomplish these policy checks can be accomplished only by a select few people, sometimes only people in the Technology Department. An unintended consequence frequently is that changes become more time-consuming and the organization is less responsive. A general rule is the more complex the systems, the further removed these maintenance roles are from people who operate it.

LOWERING PRODUCTION/SOURCING COSTS

Whether a company produces or sources products into the distribution stream, the acquisition process demands ever more value. The input to distribution is a cost per unit, basically driven by the purchase or production cost, inbound freight, and possibly some overhead burden. In reviewing distribution profitability, these acquisition costs are a major determinant of margin; therefore, these costs receive lots of scrutiny and pressure.

Buyers and planners focus on acquisition costs and have made deft decisions based on the timing of purchases or selection of suppliers. Particularly as suppliers provided opportunities to buy at reduced prices or with favorable terms, purchase decisions could be made based on the time value of money, forecasted demand, and the amount of additional margin to be generated. Clearly, buyers were highly motivated to find new opportunities for increased margin, and these special buys were a big lever.

Technology brought new methods to source products and services using Internet-based auctions to select suppliers with the lowest total acquisition and life cycle cost. With an auction, the buyer has reduced prices and in many cases discovers new sources. The process to build and conduct the auction enhanced the sourcing process.

For products that are produced, this connection between lowering costs and increased Distribution margins are driven by stable production rates and advantageous schedules. As the production planner develops the new schedule, an overwhelming driver is the cost profiles or ability for the plant to exceed the production cost targets. Longer production runs, combining runs for similar setups, and other techniques improve the total output for a given period of time and labor input, reducing costs.

Due to most standard costing practices, the reduced acquisition or production costs are reflected in positive variances in purchasing or the plant. Although this is good for the entire company, the connections between decisions in distribution to order more than required may be separated from the “benefits” in lower costs in purchasing and production. After making the commitment to order more than is currently required, distribution may be stuck with high inventories and more handling costs, while purchasing or production has positive variances.

Technology provides better enterprise visibility to these cross-functional decisions. Since distribution’s tangible measures do not benefit from these

ordering decisions, the capability for technology applications to simulate and display the enterprise profit implications can support making these decisions for the “good of the company.” Advanced planning systems (APS) use business models and current ERP transaction data to simulate future profit. By using these models, companies can test scenarios and determine which decisions deliver optimum profit prior to releasing plans to the plant and suppliers. Once a plan is confirmed, then performance targets for each function and location can be provided to support the plan.

A downside of these systems is the possibility for inaccurate models. The data in the model may be perfectly “correct”; however, this is not the question. The question is “Does it simulate reality?” When the model does not reflect reality, then one may create a plan thinking it is the most profitable scenario only to find problems or issues later during implementation. In general, the data and structure for the model are the critical components to create a plan that really maximizes profit across functional silos.

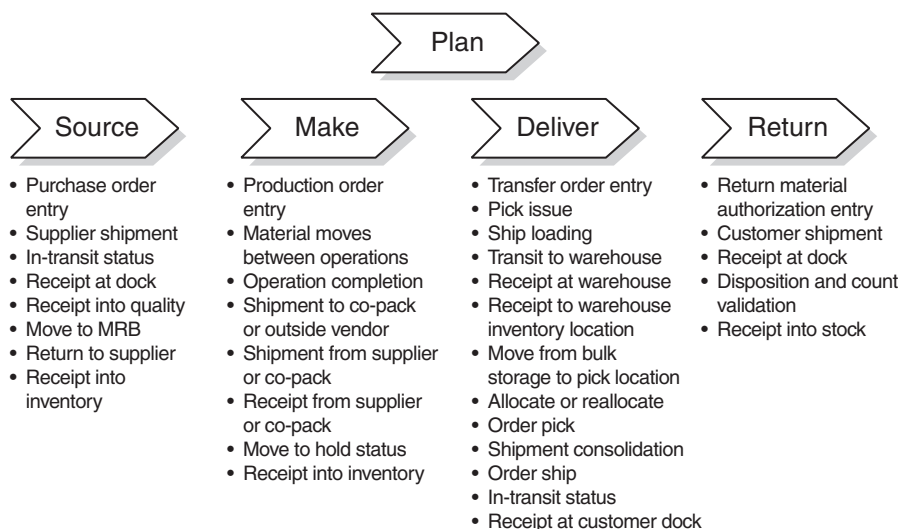
IMPROVING INVENTORY MANAGEMENT

Inventories are a keen focus for technology investments. This investment makes sense considering that inventory accumulation, storage, retrieval, processing, and shipment are the core processes of a distribution function. In order to manage flow, tracking inventory to maintain a current and accurate balance is the critical initial step.

Technology investment in tracking has been high on the list of priorities due to the high cost of data entry. Figure 3.5 shows the many points of possible data capture across the major processes represented by the five top-level processes of the Supply Chain Council’s Supply-Chain Operations Reference model (SCOR). These points include: incoming materials at purchase order receipt, inventory issuance from the stockroom, completed materials back into the stockroom, and then shipment to a warehouse and receipt into an assigned warehouse location. At each step, tracking historically required a person to enter a transaction into a computer terminal. At times data entry seemed like more work than the associated benefits, but as inventory tracking gained importance, many of these entry tasks were automated with bar codes.

Many ERP systems have the capability to capture more data points than are implemented, due to the costs of data entry. The typical procurement

FIGURE 3.5 SAMPLE INVENTORY TRACKING POINTS



business process life cycle tracks materials from receipt at the dock through various quality assurance and other stages until materials are posted into inventory. Some quality and other steps may be tracked on an exception-only basis. For example, a company may not even enter the “at dock” receipt because it moves so quickly to quality and then inventory. Tracking the exceptions requires less effort and enables management action on the items of interest.

As tracking improves, better decisions can be made, resulting in more effective inventory deployment. Making these inventory management decisions tends to be considered the payoff for many technology investments. Inventories can be allocated to the highest-priority customer order. Inventories can be shipped to the warehouse when required: neither too soon nor too late. Inventory levels may be monitored and adjusted as necessary to avoid stock-outs. All of these deployment decisions are improved with better inventory tracking available as technology costs and benefits enable more refined data capture.

As the thirst for more data grew, companies automated data entry points with bar codes and now with radio frequency identification (RFID) tags. Tracking has been improved to minimize the cost and maximize accuracy at each point where inventory is touched. With the cost of technology

continually decreasing, RFID is being implemented on more items and at more points in the supply chain. As of this writing, RFID is economically justified on high-cost items and transactions, such as cars on toll roads and bags traveling through some airports, but not to track every item purchased in the typical grocery store.

The end game is to track inventory all the way back through the supply chain. Retailers such as Wal-Mart have taken the initiative to drive tracking back from the point-of-sale (POS) device to each supplier, including intermediate steps at the DCs and in each store's stockroom. Suppliers will increasingly be pressured to drive their replenishment and operational activities from this movement data.

MAXIMIZING ASSET UTILIZATION

The investment in fixed assets and the associated depreciation represent another major portion of the distribution cost structure that technology can impact positively. With the investment in distribution assets climbing, the focus on the most effective use of assets is increasing to nearly equal the priority for production assets. Although production assets are nearly always viewed as generating revenue or reducing cost, sometimes distribution investments are viewed as net cost increases and should be avoided wherever possible. Despite the persistent view of distribution value, network modeling and other technology capabilities are providing the enterprise perspective to assess the appropriate investment and configuration of assets to best optimize performance.

There are three main approaches to enhancing enterprise results from the investment in distribution assets:

- Reduce network assets
- Trade off variable and fixed assets
- Increase utilization of assets

These approaches leverage IT in different but very complementary ways. The network configuration strategy can be assessed based on the extent of ownership of assets and the relative number of locations (refer to Figure 3.2). Although there is no absolute right or wrong approach, in general, there is a reasonably close optimum number and dispersion of

warehouses to place inventory and best serve customers. Ownership then becomes decisions related to capital allocation, confidence in the forecast, and time horizon. Reducing network assets and fixed versus variable (ownership) can be primarily about the strategic structuring decisions whereas utilization is more about how distribution processes are operated on a day-to-day basis.

Reduce Network Assets

Optimizing the distribution network should be the starting point for understanding profitability and productivity for customer order outbound or supply-related inbound logistics. Information technology applications can simulate and assist in optimizing the network by providing the enterprise view of how key parameters drive different cost and service results as the network configuration changes. Technology has improved to the point where personal computer-based applications costing a few thousand dollars provide effective models for most companies' networks. The trade-offs in warehousing costs, transportation, inventory and service can be fairly readily modeled and scenarios analyzed.

With a model-based analysis, many aspects of the environment can be assessed for the "sensitivity" to the model results. Sensitivity analysis seeks those data points where the results change dramatically for small changes in input parameters. For example, at what assumption for transportation cost per mile does the optimum number of warehouses change dramatically? If the number of warehouses does not change much until transportation costs go up dramatically, then the results would be considered less sensitive to the transportation cost input parameter. The modeler should be seeking the parameters that create large changes in results and those input parameters are the ones the model is sensitive to. Special care should be taken to accurately define these "sensitive" parameters to ensure the best results.

Trade Off Variable and Fixed Assets

Using the model results for the space required, approximate locations, and planned transportation lanes, decisions can be made relating to the ownership of facilities and capacity. Clearly, if space and locations results were very sensitive to input parameters, the ownership decisions may need to be driven more by confidence in the input parameters, such as the forecast,

than on investment or cost-related differences between owned and outsourced. Locations and/or total space could be very sensitive to a low-confidence forecast composed of new customers, markets, or products, the timing of which may be highly variable. With low confidence in the input, significantly outsourced strategy would mitigate some of the downside of a poor forecast.

For scenarios with confidence across the board on modeling inputs, ownership decisions may be driven by the availability of investment capital and real estate market conditions more than other factors. In the case for ownership, technology capabilities using geographic information systems (GIS) overlaid on demographic data can provide powerful capabilities to select locations. Once a general desired network is established, then finalizing the geography and selecting a location can be enhanced with the GIS data. GIS applications provide an overlay of demographic information such as labor availability with transportation access and other vital aspects of site location selection. The GIS-based analysis assists locating in areas with sufficient labor, appropriate cost base, transportation access, and possibly local incentives. GIS provides the remaining pieces to the network decisions, such that total build-out investment and operating costs meet planned objectives.

Technology plays an important role in operating networks with low ownership or a combined owned and outsourced model. Systems interfaces with the outsourced facilities are critical to effectively serve customers and operate the total network with consistent policies, processes, and outputs. A customer may be served from the outsourced facility or a company-owned warehouse depending on the specific conditions, such as stock or capacity availability in the company-owned warehouse. If this technology capability is not available, then capacity in one facility cannot be used to support others, resulting in suboptimal utilization. In cases where outsourced operations are paid on a purely variable basis, maximizing owned facilities would be critical to minimizing the external cost and utilization of outsourced operations.

Utilization

After properly configuring the entire network, utilization of space, pick capacity, and loading/unloading can be the focus to optimize results. Owned or leased facilities are “fixed” costs, and the more products that can be

stored and moved through them the better. This is particularly true when a facility is close to being full. Improvements in space utilization and picking can delay the requirement to expand or add new facilities.

Utilization of space is driven by the physical density and logical capability to maximize storage space. Physical density is a result of the racking systems and material handling of pallets and cartons. Increasing the stack height and access to individual items determines the density that can be achieved. Depending on the type of products and packaging involved, this may be as simple as pallet racking or as complicated as automated bins to store and retrieve small packages or items.

Consider the difference between loading a long-haul “moving” van and a local package delivery truck. The moving van is loaded with the last-to-be-delivered first, eliminating any open space to access products in the back. This contrasts with a local delivery truck, where most packages must be accessed quickly, despite the best efforts to load in the reverse delivery sequence. The difference: a local truck has lots of lost space in order to facilitate easy access, similar to aisles in a warehouse. The question becomes: Can a warehouse ever be loaded like a long-haul van? Probably not, because that assumes a fixed unloading sequence known well in advance, which defeats the purpose of a warehouse: to serve the variable demand of customers. So the compromise is to provide access based on how quickly products are moving and to stack with limited-access-only items that will not move frequently.

Warehouse management systems (WMS) provide the support to increase density based on usage and access requirements. A WMS segregates space into zones based on access, type of storage, and aisle factors. Wide aisles and high pallet racks may be nearer the front than narrow aisles with pallets stacked. The location-picking algorithm selects locations such that all space is used and access time is minimized. The trick is to avoid increases in labor and time to access products.

Other space and capacity limitations must also be addressed by WMS. Picking is more than just a labor issue, since the picked orders must be staged to build and ship loads. A WMS builds logic into pick sequences to enable smooth consolidation of loads. Receiving and shipping bays may also be a limitation to be scheduled and managed. Quick unloading and put-away functions are another example of floor space capacity that can be maximized with the WMS.

Increasing Flexibility

How technology enhances the flexibility dimension of distribution may be a difficult task for most organizations. Flexibility is rarely measured well. Nearly every organization measures service and possibly has some lead time or cycle time measures, yet even a crisp definition of flexibility may be elusive. For example, flexibility is not the same as maintaining some amount of capacity for special orders or emergencies. Flexibility is being able to change capability levels (and other aspects of operations) as customer demand or other conditions change. So, if it is not measured, how can a case be made that an organization is more flexible as a result of technology?

An approach to addressing flexibility may be to assess whether the organization can change processes and network design quickly after the technology is implemented. From this perspective, what is critical is changing the system setup and structure to enable significant change, say the addition of a warehouse or changing customer default assignments across warehouses. These changes to the infrastructure of the system indicate how ably the organization and fundamentally change distribution.

The more time it takes to make changes, the greater the tendency to *not* change. These systems are complex and sophisticated, so making what appears to be a simple change may have downstream or cross-functional implications. Changing a stock-keeping unit (SKU) from case to an each-unit-of-measure quantity may be one such example. Every customer that orders the new SKU may require a price or a specific discount off of list price. Planning and Purchasing need to revise vendor prices and order quantities. The numerous implications to this small change require coordination. Making the change takes effort and multiple people.

Technology enables cost management and customer service by maintaining a database of policies and the ability to check each transaction against the policies. Developing the policies, such as what constitutes a full truckload and qualifies an order for that discount, takes time and can be very extensive portions of the implementation. In a company with hundreds or thousands of customers, products, and warehouses, implementers have a huge task in defining these rules, entering the appropriate data, and tailoring the program. The larger this implementation effort, the greater risk that making changes will be resisted and require substantial amounts of time.

Automation has gotten to the point where new steps can be added at little or seemingly no cost. Compliance with policy may be one of the more insidious examples. In the past it was up to trained Customer Service representatives to identify customers ordering outside of some policy, such as ordering too much and taking inventory from other customers. These cases were most likely caught when the next customer ordered and no inventory was available, creating a service problem.

Cautionary e-mail alerts are another example of information from technology's ability to generate it at "zero cost." In the past it was too cumbersome and time-consuming to identify times when someone should be alerted to every possible issue. Now, with the ability to automatically send e-mails based on specific conditions, the system can track various parameters and generate e-mails. For example, salespeople can receive a heads-up when orders are placed on hold, when customers order specific products, when customers do not order, and the like. This may have happened in the past but only with the goodwill and relationships between Sales and Customer Service. Usually these communications did not happen until a service problem arose or were isolated to a very few customers and service representatives.

Why is additional communication important? Consider the implication of a customer *not* ordering for a specific period of time. Is the customer's forecast off? Did its typical production schedules change? Is someone in Purchasing on vacation or missing? Whatever the reason, a smooth flow of orders is important, and notification of changes should be made as soon as possible.

In each of these cases, technology is enabling new functions in today's fast-paced business processes, but is also requiring more maintenance overhead. Entering and maintaining policies, ever more.

TECHNOLOGY DIRECTIONS

ERP and the various distribution software applications have become fairly well ingrained in many distribution environments. The next level of benefits for these companies is where most of the variation still occurs: customer demand forecasts. With the significant variation of forecast input to planning processes, more accurate forecasts are high on most executives'

agendas. The primary approach to achieving better forecasts is increased collaboration with customers. Better forecasting techniques and processes are also of interest, but hold less hope for much improvement in forecast accuracy.

Companies are expanding their technology infrastructure to communicate and collaborate with customers. By exchanging more information with customers, the plan is to work together on special promotions, production/market plans, and demand forecasts. Working together may not do much to “bind” customers to the forecasts, but it should provide more information to suppliers and reduce surprises. The idea is that more information is better and that understanding the key drivers for the customer’s plan helps the company with its own plans.

Although many customers are avidly working and encouraging collaboration, the customer-driven trends are still cost reduction and inventory ownership. Customers continue to push on acquisition costs to improve margins and lower prices to their market. They are taking a variety of tacks to accomplish lower prices, so the question continues to be how to take more cost out of the supply chain so some of it can be passed on to customers.

Customers are also pushing inventory and replenishment responsibilities on to their suppliers. The Dell Computer model is to take ownership of inventory at the last possible minute and assign responsibility to suppliers for replenishment. In other examples retailers such as Wal-Mart expect suppliers to use point-of-sale data to drive short-term planning. These inventory examples show how customers are working to drive their costs and exposure out of the supply chain.

Another example of customers driving change to reduce cost is the RFID requirements coming from the Department of Defense, Wal-Mart, and others. RFID is the next technological leap from bar codes to better automate data capture for inventory movement. The benefits of RFID to the supplier have been somewhat nebulous thus far, with many suppliers piloting and confining their efforts to compliance in the warehouse. The end result is that customers are driving cost-saving changes into their supply base and suppliers are struggling to find benefits to pay for compliance.

What is clear is that suppliers seek more collaboration from their customers and technology investments are headed toward tighter linkages, yet customers seek to streamline their supply chains. Are these directions con-

sistent? Although many companies may view customer-driven initiatives as added burdens, it appears that an end-to-end streamlined supply chain is the objective, an objective Lean practices can address.

SUMMARY

Information technology infrastructures are typically well established around the fundamental business processes and data across an organization. Commercially available software applications address most or all of the six dimensions of distribution optimization:

- Customer service
- Operating costs
- Production/sourcing costs
- Inventory management
- Asset utilization
- Flexibility

Commercial ERP applications and add-on packages such as WMS incorporate a large amount of data about products, facilities, and policies to make trade-offs. Each trade-off is the product of current expectations and measurement processes for the supply chain. Critical considerations for the technology-driven optimization in each dimension are the numerous assumptions and data accuracy required. As the business and customers change, keeping all of these policies and assumptions up to date is a critical challenge.

Although technology brings insights and capabilities to optimization, executives are faced with distribution network structure decisions. Determining what assets are required, how much to outsource, and where to place facilities can lead to significant advantage or become a drag on earnings due to high costs and difficulty serving customers. As companies make distribution network structure decisions, the results tend to be one of four main asset structures:

- Outsourcers
- Owners

- Operators
- Concentrators

Once an asset structure is set, it is usually difficult to change. The positives and negatives of each structure can be determined only based on product characteristics, customer demographics, service policies, and other aspects of the total distribution chain.

The next steps with technology may need to be focused on how customers are driving change back into the supply chain. These customer-driven data relate to synchronizing total supply chain activities, which can conflict with how companies seek to optimize their internal distribution networks. Linkage and common objectives across these efforts may determine the next challenge for technology investments and business process change in distribution.



IT Transforms Distribution Processes

Technology gives the impression of accurate planning, when businesses must concentrate on flawless execution

Distribution business processes have been undergoing a technology-enhanced transformation. As the customer order flow and other distribution transactions are automated, the enterprise resource planning (ERP) data warehouse accumulates the data from across the entire distribution network. This master database of distribution information has enabled enterprise-wide distribution planning that can transcend locations. The shifting focus is to more centralized planning and decision making rather than within each warehouse or distribution center (DC).

The primary objective of distribution planning has been shifting from ensuring inventory availability to optimization. Optimization means reducing costs by improving the flow of goods and transportation. By analyzing the costs for various plans, decisions are made to lower total transportation costs and to build schedules to lower transportation per unit or per lane costs. Technology provides many functions to accomplish these plans by gathering planned replenishments generated from the forecast and calculating transportation needs. Then trucks can be filled to the maximum and shipment schedules frozen to enable freight routing and bids for specific runs.

These day-to-day optimization plans must be in concert with the prior decisions made for network structure and optimization. As the network

was structured, assumptions were made related to product flows, transportation costs, and many other factors related to the total delivered cost and customer service requirements. It is imperative, but sometimes unlikely, that day-to-day decisions can stay synchronized with these longer-term structure decisions. As the network is operated, controllable costs must be minimized wherever possible. The reality becomes that operating the total flow of product is optimized in the short term by distribution planning and in the longer term by network structuring.

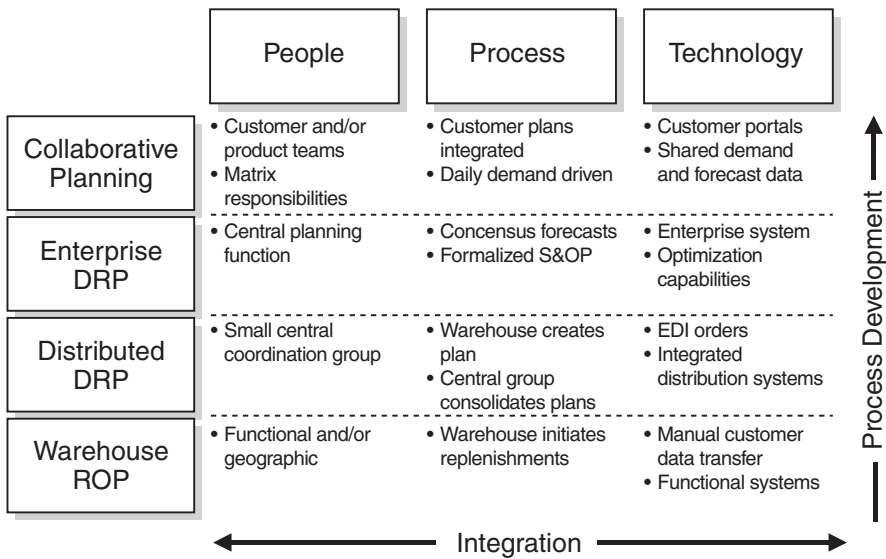
DISTRIBUTION BUSINESS PROCESSES

Information technologies (IT) have been transforming distribution business processes from a manual reorder point (ROP) approach to automated forms of enterprise distribution requirements planning (DRP). Figure 4.1 displays these transformation steps that build capability from the initial manual or only slightly automated ROP business process at each warehouse up to the latest collaborative planning with customers.

These four business process maturity levels can be summarized as:

- *Warehouse ROP.* An order point is set for each stock-keeping unit (SKU) at each warehouse and monitored locally. Replenishment orders are planned by the warehouse and released to the plant or regional DC, then grouped into plant schedules. Each warehouse is basically autonomous to run their operations as needed.
- *Distributed DRP.* Warehouse or DC-level forecasts drive local plans that can be consolidated up into an enterprise-level plan. As plans are consolidated, capacity checks, especially around transportation and plants, identify issues with any of the local plans.
- *Enterprise DRP.* Emphasis is placed on an enterprise forecast by customer and SKU that drives all planning. Each warehouse, distribution center, and plant is planned using the forecast driver by a “centralized” organization. DRP optimizes the whole in a series of re-planning steps.
- *Collaborative Planning.* Customer forecasts and operational plans drive internal planning efforts. A consolidated forecast is developed from each of the customer plans leading to an optimized enterprise business plan.

FIGURE 4.1 PLANNING TRANSFORMATION



Process development and integration are dependent on having technology capabilities, business processes, and organizational maturity. At each level in this transformation, the company is moving from local replenishment decision making into a more enterprise-coordinated model and organization. Progression along the maturity curve indicates that replenishments are being planned and controlled by a more central group with wide visibility of the supply chain. To accomplish that, this group uses a more formal sales forecasting process and, in particular, one forecast for the organization to determine all needs. There may be some overrides or local condition updates that modify specific portions of the plan, but the basic matter is a higher dependence on one company-wide forecast that drives one company-wide distribution plan.

Conflicts between service and inventory objectives surface in many conversations regarding the forecast for distribution planning. Who owns the forecast? Who owns finished inventory? These questions pertain to who is responsible when the forecast is wrong and finished inventory is high. The core issue still remains: at times this is looking to place blame and responsibility to “fix” these problems. If forecasts will always be somewhat

inaccurate, is there really anyway to fix these problems? Sales views forecast accuracy in total dollars or volumes; and Planning views the quantities for each unique SKU. The difference, of course, relates to the key drivers and needs for forecasting: Sales must deliver revenues and margin, whereas Planning must keep each SKU in stock. These differences in objectives must be resolved for a forecast to meet the needs of the entire organization.

A forecast that serves multiple purposes creates risk that neither objective will be accomplished. A revenue forecast may not require much detail at an SKU level, but should communicate more customer, market, and competitive information. So the revenue forecast objective carries with it less SKU detail but more information on the drivers for the total forecast result. Descriptions are important, since executives want to know what is driving key segments and the overall market. In contrast, a SKU-level forecast requires significant time and effort and must be revised on a regular basis and to a strict schedule. If a forecast is revised, then the entire planning cycle and processes may be adrift. The risk is investing so much time in the details that overall market and customer trends are not well identified and planned.

Despite these differences in objectives, the real question is: Can a forecast be accurate for every SKU? Can it be accurate for every SKU at each warehouse or stocking location? Consider a simple company with 500 SKUs spread across 10 plants, DCs, and warehouses—a relatively simple environment. For a six-month forecast, that company requires 30,000 forecast entries ($= 6 \text{ months} \times 500 \text{ SKUs} \times 10 \text{ locations/SKU}$). Just developing the forecast is an effort, even with a computer system that calculates and suggests future forecast entries, due the time to review and manually adjust entries. These adjustments are necessary as particular customers' locations have special sales promotions, new stores, or a varying production schedule that requires some manual override. Clearly, the effort to develop and maintain the forecast is substantial and must yield significant benefits.

Continued reliance on forecasts and plans at the warehouse level indicates how many companies get “stuck” at the levels 2 and 3 on the maturity model. The reasons are varied, but may center on the organizational tug-of-war between planning objectives and customer service. As long as the warehouse is held accountable for meeting customer service requirements, it will have ample say in inventory planning. On the surface this makes sense; the warehouse cannot be held responsible unless it has the

control to ensure proper inventory is available. However, this creates tension with centralized planning to perform its responsibilities for managing all inventories, optimizing the total plan, and reducing costs. The question becomes how to resolve this conflict, given the need to excel at customer service and yet meet the realities of cost containment.

ERP TRANSFORMATION

ERP provides the data, transaction processing, and planning capability to transform Distribution business processes from reorder point (ROP) to collaboration. The transformation is built on detail transaction data for all aspects of the business. ERP collects data for customer orders, purchase orders, production orders, and warehouse transfer orders. ERP calculates inventory balances and maintains product data to translate forecasts into plans for plants and suppliers. These plans encompass the entire enterprise and touch on nearly all functions from Marketing, Engineering, and Sourcing, to Finance.

Developed in part from the historical customer order and shipment data, forecasts are the top level of the planning pyramid. How forecasts are developed, maintained, and communicated are critical determinants of the accuracy of enterprise business planning. The ERP application or a specialized forecasting package is used to develop the forecasts, but either way, forecasts are seen as the critical first step in enterprise planning and optimization.

When combined with current customer orders, a forecast drives nearly all planning as the representation of future customer demand. Fulfilling this total view of demand is the ERP system planning logic's main objective. In nearly every organization, fulfilling all customer demand is paramount and typically nonnegotiable. The suppliers, plants, and warehouse plans are created to have inventory and capacity available at the appropriate time.

ERP has an impact on more than just developing the forecast. The entire planning and management processes provide a great deal of value and structure around the distribution function. The key is to understand how ERP works, what drawbacks there are, and which factors can be utilized to maximize the results. By fully recognizing the strengths and pitfalls of ERP, executives can be better prepared to assess the connections with Lean principles and optimize distribution planning.

Developing the Forecast

Forecasting starts with 12 to 24 months of customer order shipment data. Forecasting algorithms, such as exponential smoothing and moving average, may be applied to the historical data to calculate a future forecast. Selecting the proper algorithm and approach is the subject of entire books written on forecasting, which is not covered here. Whichever forecasting models are used, the idea is to generate the initial forecast by product for each time period going out through the entire planning horizon. The time periods may be weeks or months for the near-term portion of the horizon and then quarters for the remainder.

Once initially prepared, the forecast goes through a number of reviews and revisions. Important steps are to add market intelligence and management perspective to the forecast. These steps may be fairly complex and include input from key customers, possibly including using a customer's schedule as the forecast rather than generating one from historical demand. Internal reviews and modifications come from planners who may summarize customer forecasts by product and compare to trends and challenge the entire forecast results versus past history. However the process is operated, at the conclusion, a consensus forecast to drive planning should be the result.

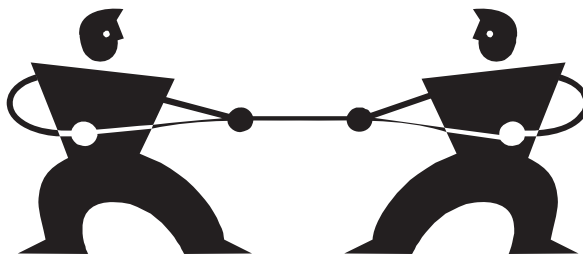
The consensus forecast should be the best representation of future customer demand. The forecast must not be biased in any way, because it drives the entire planning process and all the supplier, plant, and distribution plans will be off if the forecast is tilted in some way. In most organizations, the reality is the forecast is "influenced" by factors that relate to valid business concerns, but may not necessarily fit the needs of a forecast for planning purposes. Some of the internal objectives that can influence a forecast include:

- Desire to increase the forecast to the business plan. When a unit-based forecast results in projected revenue dollars below that for the business plan, there can be extreme pressure to increase the forecast to equal the planned revenues. The idea may be a good one: to align the business plan with the planning forecast, the downside being that it is no longer a forecast of customer demand. Unless the unit-based forecast was actually too low, the result could be excess inventory that requires sales incentives later.

- Measures that reward exceeding forecast for actual sales creates incentives for a conservative forecast. If Sales incentives favor a low forecast, then a low forecast is likely will be the result. The downside is ensuring that sufficient material and capacity are available when the actual orders come in, a challenge for a plan based on a low forecast. The probability is that Planning will increase the forecast and plan more material in order to be prepared for the inevitable higher level of sales.
- Cost or productivity measures established based on the forecast. In this case Operations would desire a low forecast such that per unit costs of production is high as overhead is spread across fewer units in the production plan. If production volume is higher than forecast, the per-unit cost target should be easier to attain.

This “tug-of-war” between conflicting forecasting objectives is shown in Figure 4.2 as the difference between objectives for Operations and Finance. These objectives and conflicts are valid from each functional perspective in the business. The concern is the clarity of business forecasts and plans for operations, to optimize the enterprise and to enable excellent customer service. Only with a customer demand forecast and business plan that best

FIGURE 4.2 FORECAST USAGE TUG-OF-WAR



Operations:

- Meet forecasted customer demand
- Provide cushion
- Product-centric
- Revised weekly
- Rolling plan

Finance:

- Meet external financial projections
- Create stretch targets
- Dollar denominated
- Monthly results focus
- Frozen annual plan

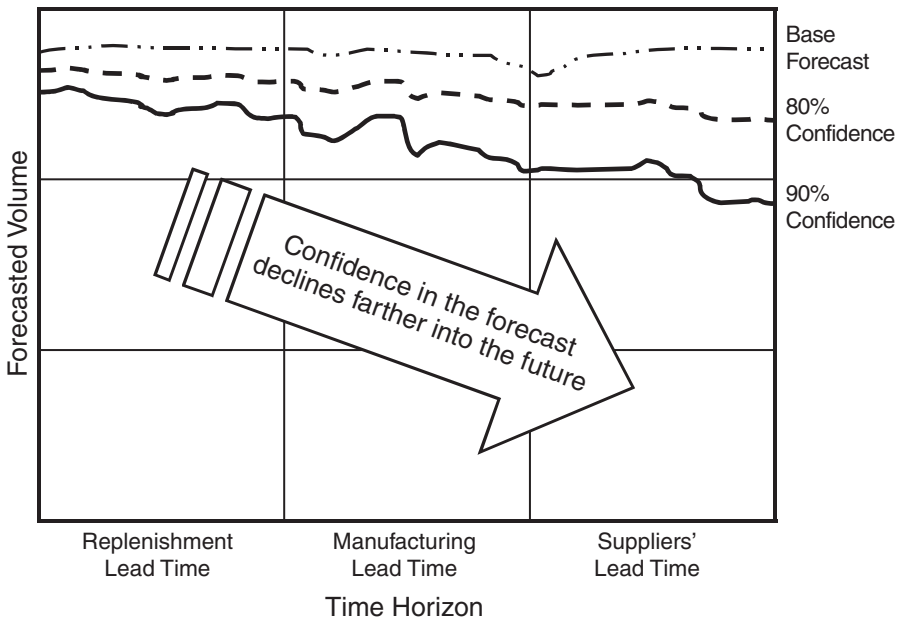
represents market reality can optimization occur. If conflicting internal objectives cause the forecast to become different from a reflection of the market, then the entire planning process is built on an optimistic forecast.

Organizations can meet the financial plan by separating the market forecast from the actions to close the gaps with the business and financial plan. Maintaining consistency between the financial and operational plans may include tactics to vary commitments to certain markets or customers, which can be addressed separately in the planning process. Assuming the market forecast is below the financial plan, there may be markets or particular customers where Sales seeks to increase the commitment. These “swing” markets or actions can present a significant operational risk of excess materials and capacity if the sale is not made. These swing markets can be the buffer between the total revenue plan and the forecast for “core” markets where sales rates will vary with seasons, the economy, and other business factors. The key is to ensure the sales forecast and operational plans are aligned and one or the other is not a “wish list.”

Once the financial and operations forecasts and plans are aligned, the forecast will never be correct. Every forecast has some degree of error, and no one ever knows where the error will be until the actual results come in. Sometimes companies believe their forecasts are very accurate, because revenues for the month or year come in on plan or at “forecast.” This is an erroneous conclusion, because error should be measured in units used for planning, not total revenue dollars. A unit-based measure is important for planning purposes, and many companies understate their real error by considering hitting a planned revenue number, as evidence the market forecast is accurate.

Dealing with inaccurate forecasts starts by structuring the plan around the level of confidence and commitment. Forecasts are nearly always more accurate in the next month versus several months or a year into the future. Customers have a more concrete schedule next month than next year, so the degree of confidence in forecasts goes down farther in the future. Figure 4.3 depicts the general idea of declining forecast amounts with the level of confidence (the 80 percent or 90 percent confidence lines). The higher the expectation is for accuracy (the confidence level) the lower the forecast amount. The base forecast is expected to be inaccurate with some months over and others under. To assure a 90 percent confidence that the actual will be at least the forecast means a much lower number than the baseline.

FIGURE 4.3 FORECAST CONFIDENCE OVER TIME



The rub on forecast accuracy and planning time horizon is that the critical commitments are made far into the future. Since the forecast is the most inaccurate far in the future, say out where commitments are made to suppliers, the planning system and processes are indeed relying on inaccurate forecasts. Yet nearly all systems and processes use the “base forecast” for all planning and commitments into the future. Using the base forecast, the entire plan seems to shift with every revision of the forecast, when only that portion above or below the 90 percent confidence line is probably shifting.

Creating the Plan

Planning that leverages total visibility across the distribution network is the real payoff for an ERP application. Most of the significant benefits are achieved by optimizing customer service, inventory, and operating costs. To prepare a plan for distribution, the forecasts for each warehouse location and customer order shipping point are compared to inventory, current replenishment orders, and planning parameters.

Planning for distribution, as embodied in DRP logic, cascades down from customer order shipping points through the network and ultimately to the plants or suppliers. The forecast and existing customer orders are the “requirements” to drive this planning. This DRP and material requirements planning (MRP) logic is shown in Figure 4.4.

The warehouse forecast is a steady 5 units per week for this specific product. The warehouse replenishments from the distribution center take

FIGURE 4.4 DRP PLANNING LOGIC

Warehouse DRP

Lead Time = 2

Order Qty = 25

Safety Stock = 10

| | Weeks | | | | | | | |
|----------------------|-------|----|----|----|----|----|----|----|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Requirements | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Replenishment Orders | | | 25 | | | | | 25 |
| Ending Inventory | 15 | 10 | 30 | 25 | 20 | 15 | 10 | 30 |
| Orders to release | 25 | | 25 | | | 25 | | 25 |

DC DRP

Lead Time = 2

Order Qty = 50

Safety Stock = 5

| | Weeks | | | | | | | |
|----------------------|-------|----|----|----|---|----|----|----|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Requirements | 25 | | 5 | 5 | | 25 | | 10 |
| Replenishment Orders | | | | | | 50 | | |
| Ending Inventory | 40 | 15 | 10 | 5 | 5 | 30 | 30 | 20 |
| Orders to release | | | | 50 | | 50 | | |

Plant MRP

Lead Time = 3

Order Qty = 100

Safety Stock = 10

| | Weeks | | | | | | | |
|----------------------|-------|----|----|-----|----|----|----|----|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Requirements | | | | 50 | | | | |
| Replenishment Orders | | | | 100 | | | | |
| Ending Inventory | 25 | 25 | 25 | 75 | 75 | 75 | 75 | 75 |
| Orders to release | 100 | | | 100 | | | | |

2 weeks and come in a quantity of 25 due to the number that can be shrink-wrapped on each pallet. When the warehouse runs below the safety stock of 10 units (2 weeks' supply) in period 8, an order is released. Warehouse replenishment orders are released to the DC in weeks 1 and 6 with planned receipt at the warehouse the end of weeks 2 and 7 respectively. Since the planning logic is based on weekly time buckets, replenishment orders are not considered available inventory for customer orders until the beginning of the week following receipts, weeks 3 and 8 in this case.

Distribution center planning receives the warehouse replenishment orders and forecasts for any customer orders shipped from the DC to create planned orders for the plant. The DC's planning parameters are order quantity of 2 pallets (50 units) and a delivery lead time of 2 weeks. Like the warehouse, the DC does not recognize inventory as available until the week after planned receipt, because a Friday receipt in week 5 does not help it meet a shipment to the warehouse until week 6.

At the plant, all of the DC plans are summarized to create the production schedule. Plants typically operate with larger order quantities and longer lead times than DCs or warehouses. In this example, the plant has a lead time of 3 weeks and an order quantity of 4 pallets (100 units). The plant safety stock is 10 units.

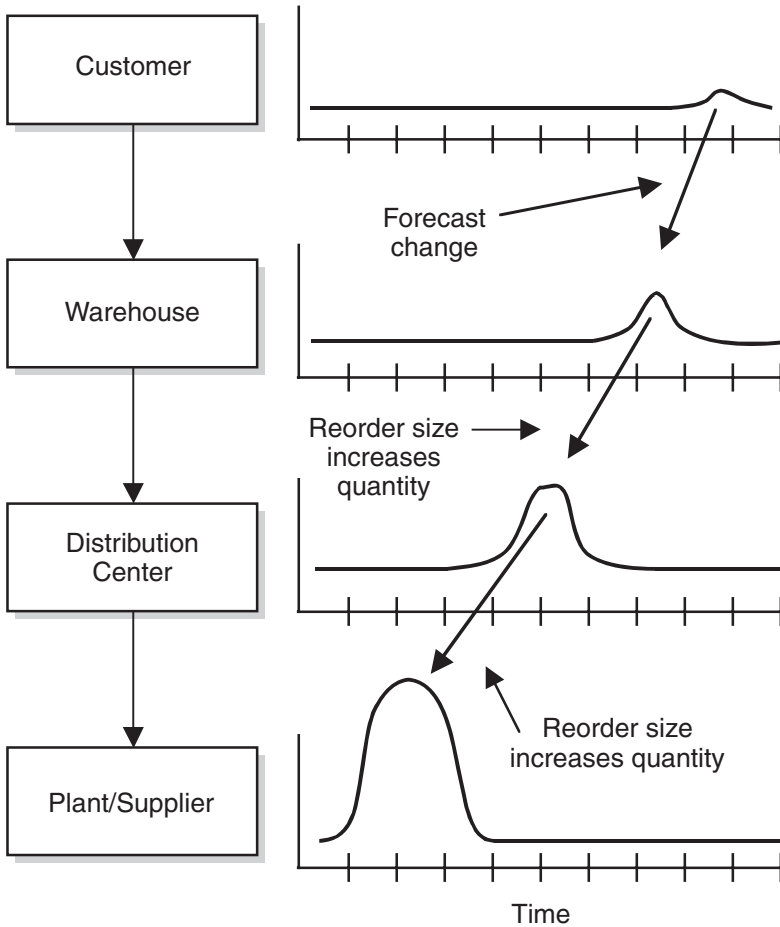
For the plant to release an order in week 1 (the current week), the requirements for a warehouse must be known 8 weeks into the future. Based on the warehouse to DC to plant planning process and the lead time for each step, a minimum 8-week forecast is imperative to schedule the plant's current-week production. In fact, to provide the plant any level of future schedule visibility, a forecast for 12 weeks or more is required. This example is a fairly simple one due to short lead times, but the critical issue is that a 12-week forecast is driving today's actions in the plant.

Distribution planning must be revised, as the customer forecasts are updated and actual orders received. As the customer forecast changes somewhere over the 8 to 12 weeks into the future, each level in the planning process must be updated and order data communicated back ultimately to the plant and suppliers for action required today. Assuming that each planning cycle can occur fairly quickly, the entire planning system requires a reasonably stable 12-week forecast. If there are time delays between steps in planning process, say for planners to receive, review, and take action on reports, then 12 weeks becomes a longer time horizon to obtain a stable

forecast. It is safe to say that a stable forecast is required for the time horizon composed of all lead times added together.

Plant schedules will be highly variable if future forecasts are revised and modified even slightly. For the example requiring a 12-week stable forecast, if the forecast is changed slightly 8 weeks into the future by the customer, then large changes snowball down the supply chain, as shown in Figure 4.5. This impact from changes with the 12 week forecast is called the “snowball effect,” which represents the increasing size of the change as it is planned back to plants and suppliers. Since forecasts are never exactly

FIGURE 4.5 THE SNOWBALL EFFECT



correct and therefore typically are being revised, the forecast is usually changing with every new planning cycle, causing many changes back in the supply chain.

Snowball effects are caused by planning policies. For the example, the policies are primarily the order quantities and lead times used in each step. If lead times were near zero and order quantities were 1 (lot for lot), then a one-unit change in the customer forecast 8 weeks into the future would be reflected as a one-unit change in the plan for the plant 8 weeks into the future. Unfortunately, planning systems just have not been able to bend the laws of physics quite yet, so zero lead time is an unreasonable example. But the zero lead time and order quantity example does show how planning must be careful not to overreact to future forecast changes, because any change pushes “snowballs” that increase as they go back into the chain. The magnification of forecast changes in the planning processes from the snowball effect means plant and supplier schedules can be easily disrupted.

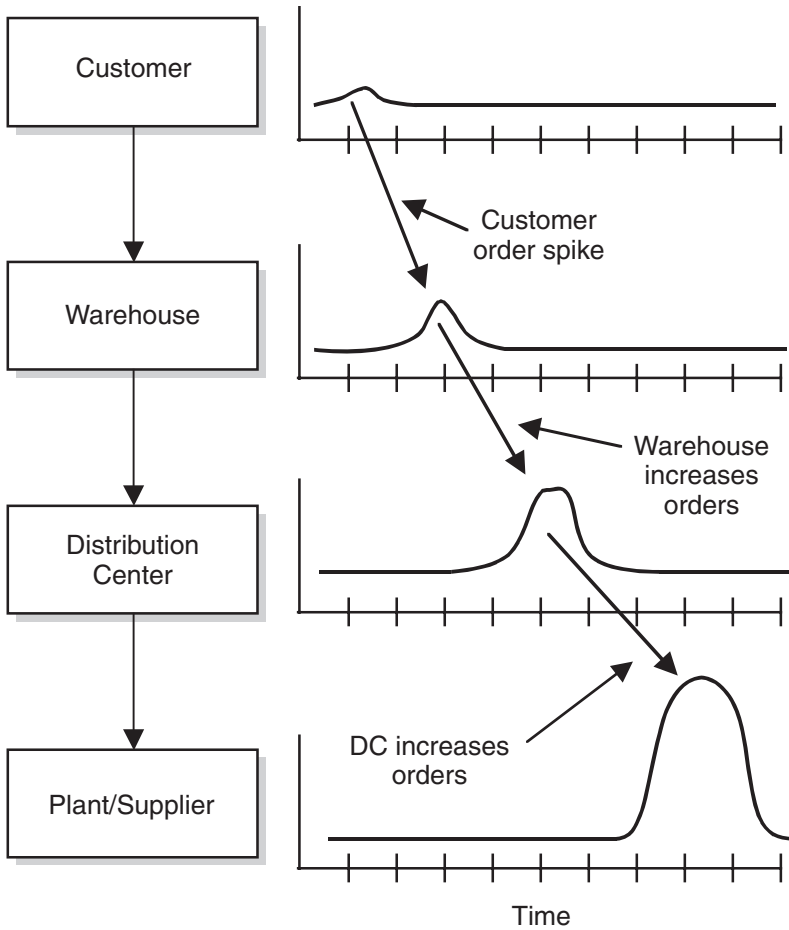
Due to the snowball effect, small forecast revisions can disrupt downstream schedules more than help planning. Despite the unreasonably short nature of the lead time assumption here, as changes are made for week 8, the forecast may be up and then down, “canceling” out prior revisions. These planning-driven changes, when added to those changes caused by other supply chain variations, create an unstable plan that is like trying to hit a rapidly moving target.

Executing the Plan

Other authors have described a phenomenon similar to the snowball effect called the bullwhip effect. Bullwhip typically works under the assumption that small changes to actual customer demand ripple back through the supply chain to become big changes, shown in Figure 4.6. The principles are similar: the planning policies and lead times cause the magnification back to plants and suppliers; however, with bullwhip the emphasis is reactions to actual demand patterns rather than plans caused by forecast changes. The solution to bullwhip is to synchronize the supply chain, thereby allowing the small changes in demand to flow back through the supply chain without magnification.

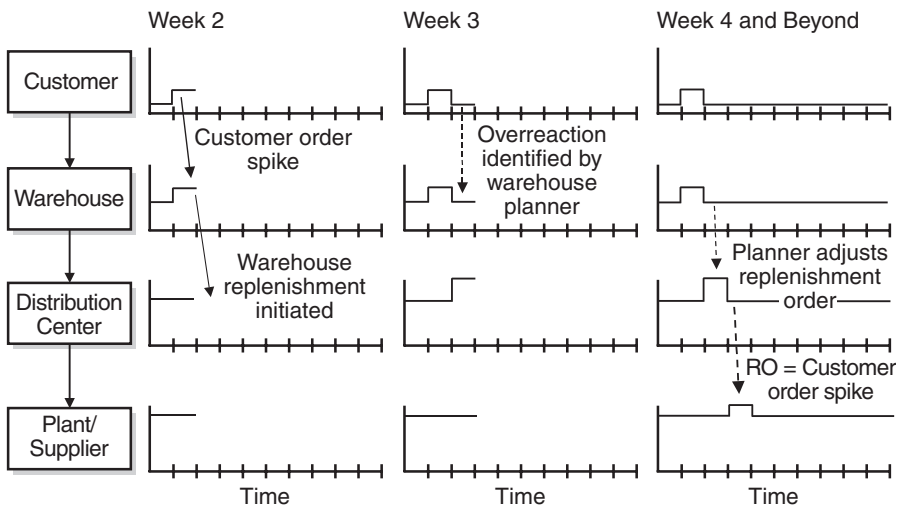
The solution to the snowball effect is to moderate how forecasts are used for planning. Since forecasts 12 weeks in the future for the prior example

FIGURE 4.6 THE BULLWHIP EFFECT



are used to initiate production at the plants and suppliers today, the forecast must be addressed prior to the communication of actual demand patterns occurring at the warehouse today. The production schedule at a plant or supplier today can be upset by reaction to current demand as additional replenishment orders are placed on DC and then the DC places more orders on the plant. But these reactions to current customer orders (orders in week 1) take time to file back through the supply chain, based on the replenishment order lead times.

FIGURE 4.7 SOLVING THE BULLWHIP EFFECT



The bullwhip and snowball effects must both be addressed to improve distribution planning. They have a common set of causes: reactions to customer demand/forecast and planning policies. The major difference between the two is that for the bullwhip, the organization “should” be able to identify after the fact that the customer order change was an isolated occurrence, whereas with the snowball effect, it is not known until weeks later when actual customer orders arrive. With bullwhip, an organization should be able to go back and revise replenishment orders from the DC to the warehouse prior to the DC making big changes at the plant. This can be seen by walking through vertical slices of time in Figure 4.6 to “see” how a warehouse planner could communicate back before disrupting plant and sourcing operations. Figure 4.7 displays the warehouse planner’s correction to the replenishment order triggered by excess customer demand.

Although this example of “solving” the bullwhip effect seems simple, it is much more complicated in a real operating environment. Each planner probably has many products, possibly even hundreds, to plan and track, so watching each one closely is difficult. The ability to detect an isolated demand incident, both up and down, must be built into the processes such that exceptional actions to override are not required.

Planning Pitfalls and Obstacles

A reliable forecast often is presented as the primary obstacle to better planning. An improved forecast has been called the “solution” to operating and customer service problems for decades, or at least as long as technology and business processes have enabled planning with forecasts by product. This perspective can be found by those who say “Give me a forecast I can follow and we will make it.” Of course, there is no accurate forecast, but at times this shifts the focus for a customer service solution to improving the forecast.

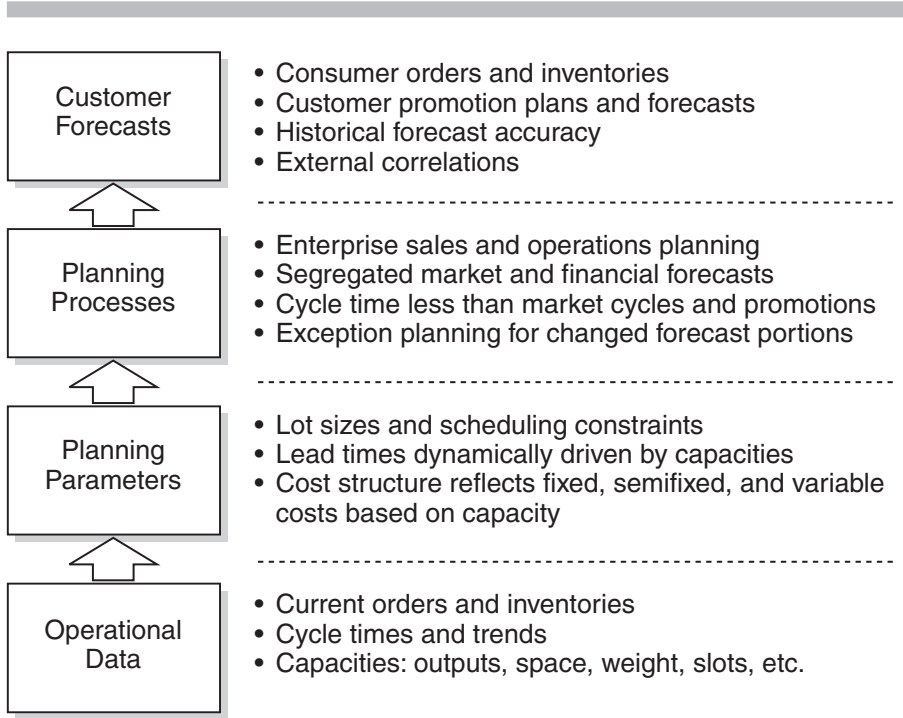
So what would happen if a 100 percent accurate forecast were available? Are there other variables that might impede successful customer service, low inventory, and low cost? Basing the solution on planning with a stable and accurate forecast is fraught with assumptions for operating conditions that may or may not be accurate even if the forecast is. Figure 4.8 shows a hierarchy of the data required to plan effectively with customer forecasts.

These parameters appear to be straightforward and exist in nearly every company, but looking closely reveals how some must change based on current operating conditions. Lead time is a good example of a parameter that continually changes. A standard lead time is rarely the experience for each production order or replenishment order. It is an average that varies and is influenced by capacity utilization. So planning using a standard lead time across all time periods may not represent reality. Despite the perfect forecast, planning with standard lead times that are fixed numbers will provide a plan based on a lead time assumption that probably will not be correct in total and certainly will not be correct for each product or order. Creating a plan based on numerous assumptions, but with a perfect forecast, does not yield a perfect plan. Only to the extent that all of the assumptions for all of the products and all of the work centers are accurate does planning with a perfect forecast yield close to a “perfect” plan.

If there is no perfect plan, is there such thing as a good enough plan? If there is “good enough,” what are the critical components? Clearly a reasonable demand forecast is one key ingredient, but how many of the others must be equally as accurate?

The solution to accuracy for planning may come from the decisions to be made and the accuracy of operations. For example, a laser sight on a shotgun just does not make much sense: the ability to aim would be much

FIGURE 4.8 PLANNING PREREQUISITES



higher than the accuracy of the shots. Just pointing the gun is probably good enough, given how much it sprays the shot. The same case can be made for planning: How accurate are operations? In most cases, a good enough plan executed flawlessly is much better than iterating a plan many times to attain a perfect plan that is not well executed.

SUMMARY

Technology-enabled processes are heavily dependent on an accurate sales forecast for success. The responsibility for forecasts rests with Sales, which are provided for a variety of purposes, and across the organization to Planning, Finance, and Operations. The forecast in its various forms drives network structure, enterprise optimization, and replenishment planning. In each case, the trade-offs of operating costs, customer service, and inventory come into play to find the best solutions.

Due to the various departments that use the forecast, differing objectives and needs can create conflicts for forecasting. The main conflict can be described as a tug-of-war between operating and financial objectives. Operators seek an accurate depiction of customer needs, while Finance looks to align the forecast with planned financial results. All the while, the forecast is used to plan and make commitments far into the future, despite the declining accuracy any forecast has over time.

Forecasts may be reasonably accurate in the aggregate, but they are not accurate at a SKU level and frequently require significant effort to update regularly. Closing the accuracy gaps may never happen. Therefore, the basis for most of the distribution plans may be questionable for near-term detail planning necessary to create replenishment orders and schedule freight carriers and to optimize variable costs. Forecasts may only be reasonable for longer-term and aggregate planning.

Distribution processes rely heavily on accurate customer demand forecasts, lead times, order policies, and inventories for planning. In order to improve customer demand forecast accuracy, organizations make continual updates to the forecast. As forecasts are revised for near-term DRP, the order policies and lead times used in planning creates the snowball effect and magnifies small changes in future forecasts to create large changes in schedules. Whenever the lot size and lead time planning factors can be reduced, the snowball effect is minimized and the overall supply chain becomes more flexible to market conditions.

The need for more accurate forecasts tends to be one of the critical issues facing distribution planning and optimization. Changes to the forecast ripple through the network, negating attempts to freeze schedules and take cost reduction actions. In the end, inventories are higher than required, and transportation is the main target and beneficiary of optimization efforts.



Lean Operating Capabilities

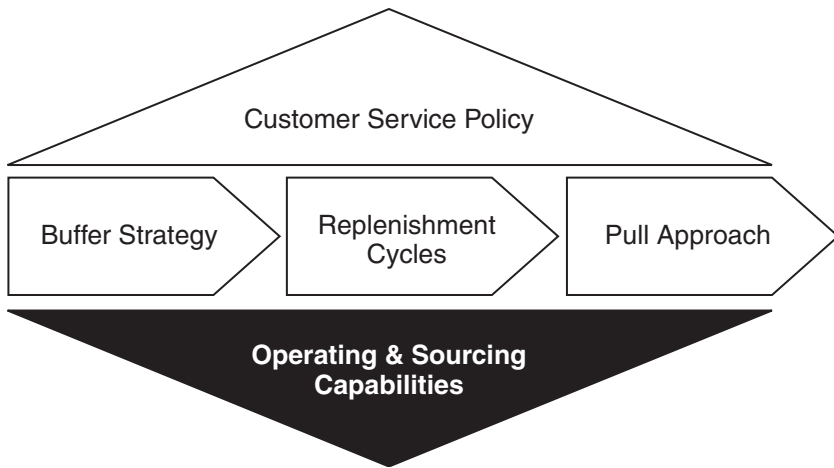
Ship one, replenish one, and make one is Pull perfection

Improving distribution operations is stymied by inaccurate customer demand forecasts on one side and the relentless pressure from customers to reduce costs on the other. These challenges create contention in the planning process as attempts are made to further reduce, say, transportation costs, by planning farther ahead to firm up routes enabling carriers to reduce costs. Because forecasts are not accurate, as revisions are made, the transportation plan must be revised, delaying or jeopardizing the cost savings so desperately needed. At the same time customers push for more technology and processing changes in distribution to reduce their supply chain costs.

For Lean to be successful in distribution, the principles must be able to simultaneously reduce costs and address forecast inaccuracy. This twin-pronged challenge is the heart of the issue for distribution. While planning processes and technology have improved distribution operations, forecasts are the starting point and clearly the barrier to further improvement. Despite enhancements in distribution requirements planning (DRP) and other technologies, continual changes and fluctuations in the forecast will cause problems, as seen with the “snowball effect.”

Lean successfully moves operations away from relying on forecasts to making to actual demand. Forecasts are still a critical component of Lean planning processes, but are leveraged for longer-term and more aggregate planning. Rather than using DRP to plan each replenishment order, Lean

FIGURE 5.1 LEAN DISTRIBUTION FRAMEWORK



triggers orders based on actual demand from customer shipments. Working to demand is called Pull and refers to an invisible “pulling” and “linking” of inventory through the supply chain. The linkage of Lean practices is shown in Figure 5.1. It displays how Lean provides the buffer strategy, replenishment cycles, and Pull approach to bridge the gap between operating capabilities and customer service policy.

The benefits derived from Lean in a distribution environment are lower *total* costs, lower working capital, and improved customer service. These may seem like the same benefits promised from DRP and other approaches, but with Lean the idea is to simplify critical aspects of the distribution chain such that the entire network operates more effectively, including DRP. With Lean, the key DRP planning parameters such as order quantity and lead time become more stable and optimized, thereby improving future requirements planning as well.

THE LEAN APPROACH

How is a Lean approach different? Lean focuses on replenishing based on actual demand or consumption, allowing a customer order shipment to “pull” its replenishment in behind it. As an order is shipped from a specific

warehouse, this demand is sent back to be consolidated and then filled based on replenishment policy. There is little second-guessing when to replenish; the policy is based on how frequently or in what quantity the replenishment process operates most effectively. The inventory level at the warehouse is determined based on the replenishment frequency and customer demand variation. With a fixed and fairly short replenishment cycle, inventory goes down and planning replenishment orders is simplified.

Back to the sports analogy: a Lean approach builds on the fundamentals first and foremost. The plays (replenishment orders) are easy to call and execute. There is little to forecast or plan unless there is some major change at the customer, the plant, or another part of the supply chain. Simple processes are the easiest to execute, and Lean focuses on flawless execution first. Once replenishments can be counted on near perfectly, other portions of the chain can be improved. With Lean, the players work to improve execution by continually assessing whether the replenishment cycle, inventory targets, and other factors are right and making adjustments within the existing replenishment processes.

Lean and ROP

Does Lean sound like reorder point (ROP) logic? It might, but there are major differences. Most important, there is a direct connection between demand and replenishment called a kanban. This may sound like ROP's approach of triggering an order when the inventory level falls below the reorder point level, but there are big differences. Figure 5.2 compares Lean and ROP approaches to show the contrasts between replenishment cycles, quantities, and target-level setting. ROP is primarily based on managing each stock-keeping unit (SKU) individually, whereas Lean processes work to manage the total flow most effectively. With ROP, an override is necessary to group replenishments into shipment quantities to manage transportation costs. Lean processes and policies were developed to optimize costs across many dimensions, not just transportation, and require fewer overrides on a daily basis.

“Inventory level” refers to two different ideas. For ROP, the inventory level is the trigger point for an order. It is expected that inventory will “seesaw” above and below the inventory level using a ROP approach. After customer orders ship and inventory dips below the level, it is expected

FIGURE 5.2 COMPARING ROP AND LEAN PULL

| | Reorder Point (ROP) | Lean-based Pull |
|-----------------------------|---|---|
| Inventory level | Based on average usage, order quantity, lead time, safety stock | Based on average usage, demand variation, replenishment frequency |
| Trigger to reorder | When inventory falls below the reorder point level | Every replenishment cycle (time) |
| Reorder quantity | Fixed reorder quantity | Actual demand during last replenishment cycle |
| Connection across the DC | Each level managed independently | Same replenishment cycle for groups of items |
| Key “stability” assumptions | Replenishment lead time Forecast continuity | Replenishment cycle Surge capability |

that additional orders will ship prior to the replenishment being received. It is hoped that inventory will rarely drop below the safety stock level, and it should never go all the way to zero. In the worst case, inventory dips below the ROP, a replenishment order is shipped, and the demand dries up, resulting in inventory equal to the ROP and order quantity.

A Lean inventory target is less a “line in the sand” and more a high and low “band” that inventory should seesaw within. The calculation for Lean inventory looks similar to ROP except with Lean, the focus is on calculating demand variation. Another major difference is that Lean calculations are parameter driven and can be updated as operational parameters, such as replenishment frequency or lead time change.

Triggers to reorder are drastically different between ROP and Lean. ROP initiates orders for each product individually based on inventory going below the reorder level. With Lean, daily demand is communicated back to the replenishment point and then a replenishment is issued for all items or particular groups of items on a consistent schedule. In the unlikely event that demand for a particular item is high, then the replenishment timetable for that item or a group of items may be revised. The quantity replenished under Lean varies based on the actual demand, whereas with ROP it is a fixed order quantity. In this way, Lean Pull signals modify replenishment based on the market need.

The bottom line is that ROP is based on traditional economic order quantity (EOQ) thinking and assumptions. Many people seem to forget some of the assumptions associated with EOQ and thereby are disappointed with the results. There are three key assumptions:

1. *Continuous demand.* Demand pattern is a continuous stream, meaning it does not break into “binary” and disjoint points, such as orders in week 1 and then none for two months.
2. *Variable ordering costs.* The costs associated with an “order” can be saved if the order is avoided by ordering more in one period and then not ordering again the next period
3. *Cost of capital.* There is a reduction in earnings caused by employing assets.

Consider whether any of the three assumptions is really valid. The demand pattern for a specific business may or may not be contiguous; this depends as much on relative volume as any other factor: low sales items would statistically have a more disjoint pattern. High-volume items sold to many different customers would have a more contiguous demand. Variable order costs seem difficult to accept for most organizations. Can labor costs be saved? Are there sufficient paper and computing cost savings? It is not likely, except possibly in situations with extremely high volumes. And cost of capital may be an established financial principle, but when applied to the trade-off of inventory for an individual stock-keeping unit (SKU), it may be a stretch. Basically, all three assumptions are difficult to apply to planning individual SKUs except in isolated situations.

With Lean there are fewer assumptions and more recognition of the realities of today’s cost structures. The main differences between ROP and Lean are fixed or variable costs assumptions and the drivers of lead time. With ROP, the best order point and replenishment quantity for each SKU is based on optimizing service, inventory, and order cost for that item. In most companies, administration costs rarely change based on the volume of orders being processed; quite the opposite, in fact. Most companies are staffed for high end volumes, and low-volume days cause concern rather than celebration. The volume of orders does not really make much difference in operating costs. With Lean the total flow is the focus and all SKUs or at least groups of SKUs are placed on the same replenishment cycle.

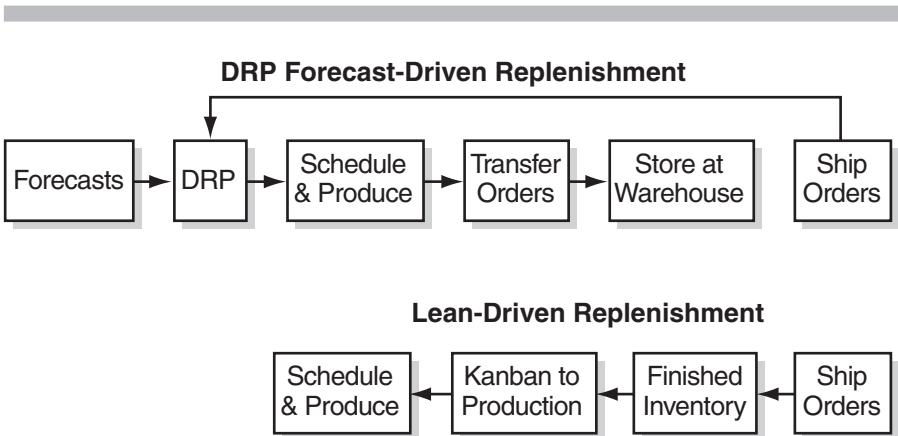
Using the same replenishment cycle increases the frequency of replenishments, thereby maximizing customer service while controlling costs and inventories.

Lean and DRP

Another view of the differences is to contrast the DRP approach to replenishing a warehouse inventory with Lean. For DRP, the starting point is the forecast, customer orders, inventories, and planning parameters. The idea is to plan into the future when replenishment orders should be created and then seek ways to optimize shipments and processing. With DRP replenishment orders are planned, created, and released in anticipation of customer orders being shipped. Figure 5.3 shows this flow from left to right of the forecast to DRP and ultimately into warehouse inventory to wait for a customer order.

An arrow is missing between the Ship Orders and Store at Warehouse boxes for DRP. This is to show how DRP works to the forecast and continues to ship product to a warehouse if current customer orders drop off. The forecast must be changed to adjust the DRP replenishment orders, because the system typically looks at the greater of customer orders or forecast as the planned requirement. If customer orders exceed forecast, then DRP would trigger additional replenishments. Obviously, as a planner sees

FIGURE 5.3 LEAN VERSUS DRP ORDER FLOW



the customer order pattern change, a request should be made to adjust the forecast and run DRP, which will reschedule all of the planned replenishment orders. The planner can then review the reschedule messages and take action as appropriate on the orders. These reviews and forecast revisions take time and must be done for every SKU.

The basic difference with a Lean approach is to link replenishments directly to shipment of customer orders using Pull. Working from right to left on Figure 5.3, as orders are shipped, this demand is communicated back to the plant or supplier for replenishment. If no customer orders are shipped, then the plant or supplier does not replenish. In essence, Lean is creating a linkage to smoothly “pull” inventory through the distribution network. If an order ships, the demand is communicated back. If no orders ship, then no replenishments are initiated.

Lean Success

Speed and consistency of replenishments are the foundation for the success of Lean in a distribution environment. Rather than continually replanning when to replenish, as with DRP, Lean moves product to the warehouses where sales are occurring. The direct connection of Pull from the source to the warehouses with the most sales optimizes service and inventory with a simplified replenishment process. The faster the replenishments can occur, the more quickly inventory flows to the right place, at the right time.

The business process transformation with Lean allows replenishments to occur with little oversight while planners focus primarily on managing the overall process. This entails planning for the variability inherent across the supply chain in order to stabilize the day-to-day replenishments. Planners spend less time “touching” any replenishment orders and more time updating and managing the parameters and methods used in triggering replenishments. Their focus on variability means that replenishments and service continue to improve, enabling more cost reduction and flexibility.

Implementing Lean replenishment and business process transformation must address managing uncertainty across the supply chain and connecting with existing enterprise resource planning (ERP) processes and technologies. Uncertainty is a way of life in business, and Lean cannot magically eliminate it in the short term. Lean practices can reduce and nearly eliminate

most variation over time, but initially the Lean approach must recognize and plan for variation in demand, supplier input, and internal lead times. At the same time, a Lean approach must operate well within other business processes and technologies. Integration to ERP and DRP is critical to success with Lean and overall business profit improvement.

MANAGING UNCERTAINTY WITH LEAN

A common misconception about Lean practices is that smooth demand, outstanding quality, and high reliability in operations are required. Although those characteristics are indeed objectives for Lean, they are not prerequisites. Quite the contrary, Lean practices incorporate strategies to manage uncertainty in order to gain effective certainty downstream. In other words, if there are quality problems at an upstream operation, Lean provides strategies to protect later operations and ultimately delivery to customers while the quality defects are being improved.

Buffer Inventory Strategies

Nearly all companies have inventory somewhere in the system that acts as a buffer against variation and change. The inventory may be in the form of raw materials, semi finished products, and/or finished products. Depending on the product characteristics, operational processes, and customer service expectations, inventory may be in all three stages. Due the significant costs and customer service exposures, the strategy behind how much inventory to maintain and what stage it should be are major strategic decisions.

Unfortunately, inventory decisions are not always made from a strategic mind-set, and inventory is placed based on a number of historical factors or preconceived notions and traditions. Buffering from customer lead time requirements may be the most straightforward due to shipment lead times and what are frequently incredibly short delivery time expectations from customers.

Finished inventory protects against the fluctuations of market demand and specific customer orders as well as the lead time for delivery. Market demand may increase suddenly, providing opportunities to capture share or serve growing customers well. Some inventory may be held to buffer against these swings in overall demand. Likewise, specific order rates vary

and cannot be predicted. The exact timing for customer orders requires inventory available on that particular day, even though the order rate may be fairly consistent from week to week. Buffer inventory can be thought of in the aggregate as well as for specific products at warehouse locations.

When customers expect a two-day delivery and the distribution center (DC) or plant is farther than two days away, a warehouse is required to hold inventory close by. This inventory must be sufficient to cover average demand and the variation for the entire time it takes to replenish inventory from the DC or plant. This inventory at each warehouse increases as the lead time to replenish increases.

Safety Stock

Safety stock is a critical protection against variability across the supply chain and can be an emotional topic. Variability within and outside an enterprise is a fact of life, but one that should not impact commitments to customers. Safety stock is the main insulation of customer orders and delivery time from variation. At the same time, the approach to establishing and maintaining safety stock may elude most executives.

Variability derives from both replenishment orders being late or less quantity than required and the timing and quantity of customer orders. The usual source of variability complaints is from customer orders. The timing of specific orders and the quantities ordered may drive seemingly high levels of variation. Because there are severe penalties for being out of stock and impacting customer service, safety stock must be set sufficiently high to mitigate nearly all possible variations from both customers and replenishments.

Setting the stock level fairly high rather than low appears to have few downsides. There are more measures and focus on customer service than inventory, so setting the stock level a little high is better than setting it a bit too low. Consider the implications of lost or late orders due to stock-outs: the feedback is nearly instantaneous. On the other hand, tracking inventory may occur monthly with feedback several days or a week after month-end. More immediate and substantial feedback on problems comes from the customer side, indicating that setting high inventories reduces the daily service problems and may result in an inventory concern once a month.

The question becomes how to set safety stock. Due to service concerns, setting safety stock would seem to take a statistical approach. The statistics in the approach could evaluate the actual and expected demand variation to set a level sufficiently high. In practice, few planners have the time or the tools to rigorously establish statistically valid safety stock levels. Actual practice may take a number of forms, such as a set number of weeks' supply. By setting a number of weeks' supply, the stock level can be easily calculated and applied across a large number of products and warehouses.

The statistical approach is not an academic exercise; it is an approach to developing a fact basis for setting a critical determinate of customer service. Because safety stock by its very nature raises emotions and a protectionist stance, facts are important to establish proper levels. In addition, demand variation can be underestimated as well as overestimated. Underestimates are common on highly variable items, causing more expediting and confusion. Conversely, for more stable products, higher levels than are necessary may be set due to "gut-level" concerns that low inventories "just seem too low." Setting the right level is more than concern over working assets; it is a concern over service levels and disruption throughout the supply chain.

Obtaining the data may be the other half of the battle to calculate safety stocks. The primary input is demand variation. Variation can be stated in terms of the mean absolute deviation (MAD) of the historical demand points. This is not a typically easy piece of data to obtain, but it is the clearest measure of how much variation is occurring. Average demand allows highs and lows to cancel out creating an artificially low measure of variation. Only a statistical assessment like MAD provides a solid foundation. If calculating MAD for each product is not feasible in the short term, then applying one from a group of several "patterns" may be an effective first step. One can calculate the deviation for a typical product in each major product class and then match individual products or groups of products to the different demand patterns to assign the MAD.

Once demand variation is based on fact, inventory can be set based on policy drivers and replenishment parameters. Policies relate to the service-level expectation, such as the percent service level (fill rate). By using a specific statistical calculation, the implications of 95 percent versus 99 percent fill rates can be consistently calculated. Planners are then able to set realistic service targets, because safety stocks rise dramatically with each 1 percent increase in service level.

Replenishment parameters are the other key drivers and relate to lead times and order quantities. Shorter lead times reduce the need for safety inventory. Imagine the ability to refill a warehouse every night with the quantity shipped during the day. With this replenishment lead time of less than one day, safety inventory could be very low, roughly equal to the highest one day of sales. This approach is the same for longer lead times; inventory is roughly the maximum expected sales for the total replenishment lead time.

Safety stock with a Lean approach can be established based on variation and lead time for consistent service. Using a methodical approach to calculate safety stocks takes out the emotion and focuses energies on the real drivers: variation and lead time. By minimizing these factors with Lean principles, service can be improved and inventory reduced.

Mitigation Strategy

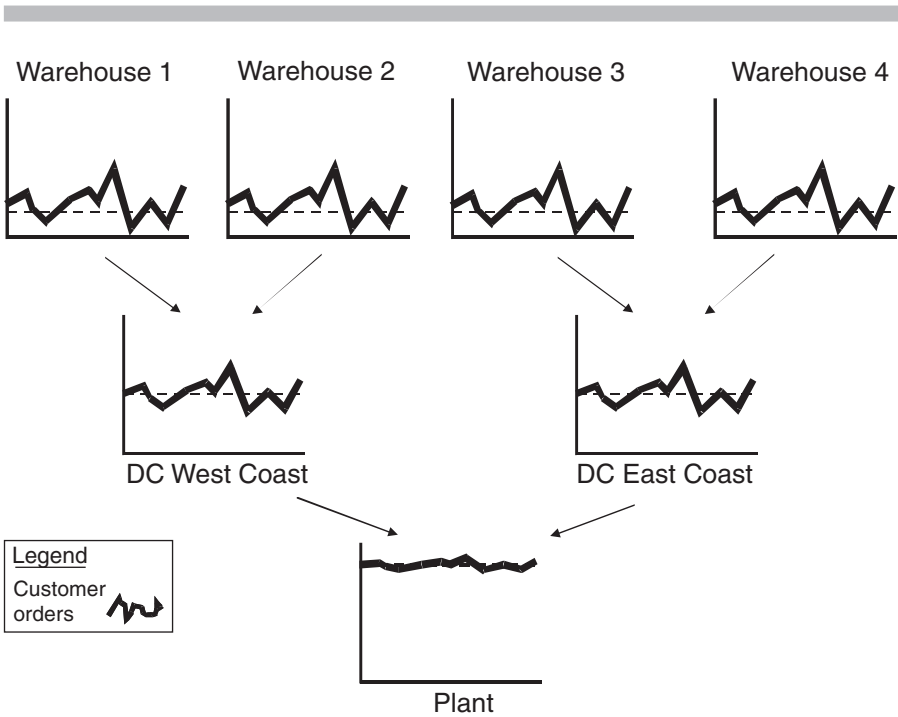
A strategy is required for the placement of inventories to protect against spikes in demand. The levels must be calculated based on the location of inventory, source of replenishments, and destination of demand. How the existing physical network location structure is operated determines these factors as each part is operated. The DC may contain sufficient inventory to buffer demand, or it may be a cross-shipping point with limited inventory. For a warehouse, the DC with limited inventory requires a replenishment lead time going all the back to a supplier or the plant rather than just the shipping time from the DC to the warehouse. The strategy for placement of inventory at a plant versus the DC versus the warehouse is an example of the mitigation strategy being employed.

Conventional wisdom places inventory close to shipping locations and customers in order to meet expectations for delivery lead time. Because customer order variation is viewed as the dominant factor in setting safety stocks, it seems to make sense to place inventory close to customers, such as at the warehouse shipping point. As customer orders are shipped, safety stock inventory at the location is immediately available for any spikes in demand. As excellent customer service is the objective, placing the buffer inventory at the shipping point seems to make the most sense.

In most cases, the argument holds that demand variation is greatest closest to the customer. Is this a correct assumption? Consider the variation for

a warehouse shipping the same product to many customers: the variation for one specific customer is much higher than the variation for that same product across all customers. This is a fundamental axiom of statistics: fluctuation decreases as more data streams are grouped, meaning the demand is more predictable for all customers of the product at the warehouse than the demand for any one of the customers. Although there certainly could be exceptions, as there are for any general statistic, the exceptional customer must have an extremely stable demand. Grouping these demands from warehouses up to their regional DCs and finally back to the plant, the customer demand variation for a particular product stabilizes as shown in figure 5.4. This summation of demand is for the actual daily customer orders and not replenishment orders. As was seen with the bullwhip effect, the internal orders created to replenish warehouse inventories create larger variation at DCs and the plant. Figure 5.4 shows how the customer orders in total are a more stable total demand.

FIGURE 5.4 SUMMING CUSTOMER DEMAND



Recognizing that variation drops as demand is summed, an effective mitigation strategy places inventory at the points of greatest leverage. Going back to conventional wisdom, does placing safety stock at the shipping point provide the most leverage of inventory against spikes in demand? Because demand variation is greatest closest to the customer, buffer inventory will be greatest if kept at the warehouse. Therefore, a strategy to maintain inventory at the warehouse yields the greatest total inventory.

The obstacle to moving inventory back from the warehouse is the lead time and quantity available to replenish the warehouse. Back to the safety stock calculation at the warehouse, the inventory must be available to cover any spikes in customer demand. Confidence that inventory at the DC or plant will be available is critical. Considering that variation can seem very high at the warehouse, setting the replenishment lead time and quantity become drivers of high levels in the warehouse: there just may not be trust that the DC or plant can ship inventory quickly to replace large spikes in customer demand.

With smaller variation from the total demand seen at the plant, inventory can be available more readily for spikes. If there is a temporary increase in shipments at one warehouse, lower demand in another warehouse over a short period of time should level this out, enabling the plant to ship more in one direction than another. Inventory maintained at the plant or this one main consolidation point can be smaller and yet protect against much larger swings in demand.

Capacity Buffer

Another approach to protect against spikes is allocating capacity to refill the pipeline. Inventory is simply stored capacity, so having some available capacity and raw materials can also be part of the mitigation strategy. The strategy can be a combination of inventory and capacity based on the lead time and flexibility of operations to replenish the consolidated inventory. Along with flexibility, as Lean reduces lot sizes and lead times, schedules become more stable and capacity can be a larger portion of the buffer. Depending on the degree of flexibility in capacity, some portion can be utilized to fill more of the variation in demand.

Flexible capacity works particularly well as a buffer in environments where multiple products share capacity and materials. As the demand across

the multiple products is summed, the variation in capacity required for all products can be fairly low. The capacity required to refill inventory levels, therefore, should be more consistent the more products share similar production capacity.

Lead times and lot sizes become the dominant factor in sizing the inventory buffer for this mitigation strategy. To set a consolidated buffer inventory, the lead time and lot size for replenishments are the key factors to calculate the amount of inventory required. If the inventory is supplied by a Lean plant or supplier, then both of these factors become smaller, yielding a more reasonable buffer inventory. As buffer inventory is a function of variation, lead time, and average demand, as lead time decreases, the total inventory required decreases.

LEAN AND DRP: COLLABORATION

Inventory and flexible capacity cannot protect against all market conditions, trends, and plans. A seasonal product, for example, requires advance planning and most likely a buildup of inventory. Likewise, special promotions and other demand modifiers should be coordinated and managed in advance. For these many situations, a Lean Pull-based approach should be combined with DRP to face off against the foreseeable future market conditions.

How can the DRP forecast-driven and Lean Pull-based approaches be linked? This seems like a push-pull scenario that is bound to not work. Success relates to which portion of the planning and replenishment equation is being addressed. It must consider the assumptions underlying each approach, build on the strengths of each, and enable the two to collaborate.

Lean and DRP Approach Differences

For a Lean distribution environment, the methods and assumptions behind DRP can run counter to Pull. The objective of DRP is plan ahead and optimize; for Lean the idea is to respond to the market and focus on building the capability to respond faster and more effectively. The overall difference is a DRP plan-based optimization and the Lean drive to improve capabilities.

FIGURE 5.5 COMPARING DRP AND LEAN

| | Distribution Requirements Planning (DRP) | Lean Distribution |
|----------------------|--|---|
| Buffer inventory | Close to each shipping point; therefore, high. | Consolidated at one point; therefore, low. |
| Reliance on forecast | High: at least as long as total lead time. | Low; use for longer-term planning. |
| Changes to forecast | Requires re-planning for all products and orders. | Consider adjustments to target levels. |
| Transportation plan | Changes with forecasts and orders; variable. | Replenishment cycle driven; stable. |
| Optimization | Cost reduction within constraints. | Product flow to daily customer demand. |
| Key assumptions | Forecasts are accurate and stable. Transportation dollars must be reduced. Manage detail orders to a “perfect plan.” | Demand variation can be effectively buffered and pulled. Inventory, handling, and storage costs are understated. Manage within boundaries of variation. |

Evaluating each of the methods and assumptions behind the approaches provides a basis for collaboration. Combining the two approaches should leverage the best of each in the proposed operating environment, while not creating conflicts. Figure 5.5 contrasts some of the important assumptions behind DRP and Lean. Further assessing each method and assumption provides some of the strengths for collaboration.

- **Buffer inventory.** DRP processes and systems use buffer inventory as a safety factor against the changes occurring within a planning cycle and too soon for the replenishments to occur. If replenishments in a DRP world could occur instantaneously, there would still be a requirement for buffer inventory due to the time required for each planning cycle. Until a planning cycle is completed, the supplying plant or DC would not have an order to ship a replenishment order.

The DRP planning cycle could be operated daily and focus on the warehouse replenishment orders, but that would defeat the DRP mantra to plan and optimize the entire network, thereby diverting time and resources from the more profit-sensitive activities. For Lean buffer inventory is primarily held at sourcing points, such as a plant, and the buffer maintained at shipping points covers the time to respond with replenishments initiated daily by kanbans. The process is built to make daily replenishment “automatic.”

- **Reliance on forecasts.** DRP relies heavily on a customer order forecast for planning, while Lean has little inherent forward planning logic. The forecast input to DRP must be long enough to cover the total lead times for distribution, production, and sourcing. A forecast must be structured by product in order to fit the materials requirements planning (MRP) and bills of material planning logic. DRP provides the ability to plan and coordinate based on a forecast that is different from current demand patterns. Lean can basically only respond and adapt to current demand patterns with little capability to produce or replenish in anticipation of significant changes in demand.
- **Changes to forecast.** Each change in the forecast ripples through DRP. Quantity and timing changes in the forecast trigger changes to the stream of replenishment orders created by DRP, which may require action by planners, operations, or suppliers. If the changes are small and sufficiently far into the future, then little action may be required. Forecast adjustments within the total lead time for materials, production, and replenishment have the possibility to initiate changes to existing open purchase orders, manufacturing orders, and/or replenishment orders. Each DRP-suggested change must be reviewed and acted on as long as the change is a significant number of days or quantity. Reviewing these DRP messages can be a nearly a full-time job for most planners. These DRP messages identify changes required in lower-level plans to meet the new forecast, which is advantageous when the forecast is different from today’s demand patterns and has a high degree of confidence.
- **Transportation plan.** DRP plans from the forecast and then optimizes transportation for all of the planned and released replenishment orders. For day-to-day replenishments, there can be a significant level of

change whenever customer demand or the forecast changes. All of these changes create some tension as transportation works to stabilize a plan that can be executed, while DRP continues to suggest changes to replenishment orders with each forecast or customer order change. Lean takes the somewhat opposite approach by identifying the most efficient transportation schedules and then structuring kanban replenishments around the transportation plan. With Lean the transportation plan must be reviewed periodically to assess whether the overall replenishment structure should be changed to further improve service, transportation, and total cost.

- **Optimization.** Optimization from a DRP and the related advanced planning systems may vary significantly based on the configuration and operation by the users. It can range from a profit optimization formula using variable market demand to cost optimization driven by a specific forecast and set of customer orders. In either case, the optimization strives to move orders in the plan to accomplish the objective of reduced costs and/or optimized sales/profit. A Lean approach takes the current shipments and optimizes product flow in response. Perfection with Lean looks like a water pipeline: the next drop flows to replace the last one used, no matter where it was used. Ship one, replenish one, and make one would be a good definition of Lean perfection.
- **Key assumptions.** A reasonably stable forecast is critical for DRP success. If the forecast changes dramatically, all of the lower-level supplier, plant, and replenishment plans change, and it is nearly impossible for a planner, let alone the plant or suppliers, to keep up. For frequent forecast changes, the planners can focus only on the largest and most important changes. By ignoring less important suggestions from DRP, the plan will result in some replenishment orders early and others late, which must be buffered by extra inventory. The optimization logic typically focuses on variable costs, such as transportation. Variable cost is the near-term focus, because a plan can have very little impact on fixed cost, so minimizing variable costs provides the “best” result. Lean works to another reality: that fixed costs are variable in the longer term, but only if the capabilities have been developed to reduce them. Take warehouse or shop floor space: in the

near term it is a fixed cost, but with Lean the driving objective is to reduce required space, reducing costs in the longer run. For the Lean approach, minimizing transportation and other “variable” costs entails more inventory, space, and overhead, which are undervalued. A key assumption for Lean is that customer demand variation can be buffered and pulled effectively, which is a challenge for seasonality and special promotions. DRP excels at planning for special promotions, seasonality, and other planned future changes to demand.

Summarizing these differences points to DRP’s strength to plan future changes to demand and Lean’s capability to execute replenishments and drive cost out. In crafting a collaborative approach, the key is to consider and mitigate the assumptions for DRP and Lean.

Advantage DRP

There are environments where DRP will produce better results than Lean in replenishing a distribution network. These can be found through careful assessment of the assumptions listed in Figure 5.5 to find ones that DRP meets well, ones that do not fit Lean, and/or ones of little importance. As DRP attempts to simulate reality and then plan the required replenishment orders, the closer it can get to the “real world,” the more accurate the results. As Lean is working to current demand, anywhere current and future demand are disjoint but readily planned may be a difficult fit. Assumptions that are of little importance to a specific operating and market environment would be another opportunity for DRP to outperform Lean in replenishment.

Considering some of the assumptions underling DRP, forecast stability typically causes most of the disruption. For example, if forecasts are extremely accurate, then DRP should provide stable results and a chance to tweak each portion of the network. Planners would devote the vast majority of their time to optimizing and enhancing replenishments rather than reacting to the many changes caused by forecast revisions. Stable forecasts would be next to nirvana for most planners, their dream come true. With stable replenishment orders, DRP and advanced planning systems could really do some serious optimization, because the orders would not change later and disrupt the well laid optimized plans.

For the optimization to add real value, variable costs must be significant. Optimization algorithms move and adjust replenishment orders in order to reduce variable costs, such as transportation. For this optimization to have any real effect, transportation costs must be variable and significant. A company with an owned fleet may have limited variable costs in transportation other than fuel, possibly labor, and cost-per-mile maintenance. However, a company primarily shipping less than truckload (LTL) that can ship many more truckload quantities may actually receive significant and measurable benefits from optimization. Measuring the number of LTL and truckload (TL) shipments and associated transportation costs would clearly demonstrate the benefit achieved.

The other side of variable costs is whether many “fixed” costs could be reduced over time and yield more impressive savings. For example, the current distribution network was designed around the need for a warehouse to serve some specific location or market. With Lean reducing lead times and lot sizes, that may not be the case. Optimization would attempt to strike a balance among warehousing costs, service, and transportation costs within the existing capabilities and lead times. The cost to operate a warehouse is significant and cannot easily be eliminated by an optimization approach without the underlying capabilities from Lean in shorter lead time and flexibility.

For some organizations, other fixed costs may be insignificant. An example could be an organization with outsourced logistics and a cost structure that varies directly with volume and transactions. An optimization approach may provide substantial benefits by timing shipments to reduce storage time and grouping shipments to eliminate handling. Any optimized replenishment order may provide tangible savings in this case and could warrant a stronger DRP focus.

With an accurate forecast and predictable order patterns, DRP may provide better replenishment. For example, consider a shipment to the warehouse just prior to the end of the month for a customer order that usually arrives on one of the first days of each month that must be shipped the same day. This demand appears highly variable to a traditional Lean Pull approach: inventory would ship the first of the month and then be quickly replaced only to not ship again until the first of the next month. A case could be made that inventory should not “sit” at the warehouse all month when it is known the order arrives in the first few days of each new month.

Some buffer inventory may still be required at the warehouse to meet the “same-day” service delivery time. The replenishments appear highly predictable, because the warehouse inventory serves to buffer against the small changes in the customer order receipt and ship date.

A last predictable forecast may be one for a season or special promotion. For seasonal sales patterns, such as the year-end holidays, planning with a long-range forecast is mandatory. The forecast must be used for capacity planning and to initiate supplier orders at least as long as the total accumulated lead time for the product. The capacity plan must determine how to build and where to store sufficient inventory for the season’s demand. The most likely scenario is inventory built far in advance of the season, with a fairly level production schedule during the entire year. Some increase in production may occur for some period of time, but it would not be an issue if the seasonal merchandise could be produced just prior to the ship dates. To have the entire season planned and organized, DRP and optimization capabilities and processes are required.

Special promotions can be similar to seasonal planning. For promotions, a single set of orders must flow through the suppliers, production, and then the plant in preparation for the promotion date. These activities are driven by the forecast and not market Pull signals. A forecast is the necessary starting point, and modifications to the product configuration may be crucial, which also requires a promotions-only bill of material for planning. These complications require a DRP and MRP planning approach to initiate purchasing and production long before the planned promotion date and in the forecasted quantity.

LEAN-ENABLED COLLABORATION

Recognizing that the forecast is the input to all planning, developing an accurate demand forecast seems to be an evasive dream. Like Don Quixote tilting at windmills, it seems that no forecast will ever be accurate or detailed enough to please everyone. But maybe we are missing the real question about forecast accuracy: What needs to be accurate and when? Depending on the decisions and commitments being made, the forecast in the aggregate may be acceptable. But if purchase orders for specific products are being issued, then much more detail is necessary to calculate what is needed two years into the future.

Forecast Accuracy

The difference in time frame and detail is what separates accurate forecasts from inaccurate ones. Think about a forecast for sales in this calendar month two years from now. How accurate can that forecast be? Considering that few organizations have the capability to measure accuracy for a forecast out two years into the future, it might as well be perfect or, say, 50 percent off. Why is accuracy not critical? For some organizations, important commitments are made two years into the future, and the forecast is used to determine how much to commit. So accuracy is clearly key, right?

Forecast accuracy is relative to how it is used and managed. Image a pendulum swinging back and forth past the lowest point on its arc. At some point it will come to rest at the bottom, but in the meantime it is up, then down, then up again. How is the pendulum like a long-range forecast? Going back to the forecast for two years into the future, as each month goes by, the forecast for that future month changes; it may be up or down, but the general direction up or down is of most concern. In other words, is the low point for the pendulum changing?

Applying this idea to the long-range forecast, the general trend rather than an absolute number for a month is important. As each adjustment is made to the forecast, the next month in the time horizon can be adjusted to compensate. The result is a series of “waves” of product progressing through the supplier, which are used by the supplier to purchase materials and allocate capacity. Some of the waves crest high, others crest low, based on what is happening in the market and the forecasting process. The lesser concern is the exact accuracy of any one forecast.

All of the waves flowing through the supplier add up to a total amount of material in the pipeline. The focus is to balance the total pipeline quantity and worry less about any one month far out in the future. The total pipeline view is a simpler approach to supply chain management that departs from traditional DRP planning by not aligning the forecast and supplier orders for each month (or week) out into the future. Concentrating on the total “released” to the supplier mitigates the confusion resulting from each forecast revision. Thinking back to the pendulum, each forecast revision makes changes all along the time horizon, changing orders for nearly every period out into the future.

Supplier Connection

This Lean concept is to pull the forecast, which is similar to the pull for replenishments at the warehouse. That is, it is similar at least in connecting one end to the other. Forecast Pull works to balance the total pipeline by adding or subtracting to the next month's forecast changes in the forecast for previous months. As the next month comes, any net change for prior months is added to the rolling forecast quantity. Say the forecast went down slightly; there would be a small reduction in the next month's forecast.

Forecast Pull creates a quasi—"open to buy" for the supplier. It is then up to the supplier to manage the flow of product. The real trick is at the other end of the supplier's process: Lean Pull kicks in again, connecting the supplier to pull from the next step in the supply chain. Excluding large swings from seasonal or promotional peak demands, these two Pulls align the supplier with the next step in the chain, whether that is a distribution center or manufacturing plant.

Suppliers have been known to initially react negatively to this Lean approach. They want firm orders to produce and ship. There is a perceived high level of certainty with having firm orders on the books. Well, that is all well and good until the bullwhip and snowball effects kick in. Then the supplier is put through large peaks and valleys of work. It has already been established that pulling to actual demand resolves the bullwhip effect and eliminating the magnification from planning policies resolves the snowball effect, which both drive peaks and valleys of orders to suppliers.

There will be cost advantages with the Lean approach for both the supplier and the customer. As the peaks and valleys are removed from the supply chain, more long-term focus can be placed on cost reduction, especially for all of the fixed costs that are so difficult to address, such as warehouse space. Cost sharing should be part of the relationship with suppliers to move toward a Lean Pull approach. Otherwise, it continues down the line of a win-lose relationship with the buyer seeking lower prices exclusively.

Making an appropriate offer and convincing the supplier this is good for both companies is no small task. The objections relate to currently viewed "intangibles" of lower overall supply chain costs, and the downsides seem weighty. Therefore, a Lean value stream analysis and problem-solving effort would be required to gain common ground on the situation and pos-

sible solutions. By mapping out and quantifying the entire value stream, the total reduction potential and requirements can become clear to all parties and a win-win arrangement can be obtained.

Value Stream View

Lean concepts are best leveraged to improve the entire value stream. The value stream definition is as broad a scope as the organization can possibly influence, including customers and suppliers. By viewing the entire stream, actions to optimize the whole value stream may not optimize every part. For example, the plant can optimize shipments out to a warehouse by only shipping in full-truckload quantities, but the trade-off becomes fewer shipments (fewer shipments means less customer service) and higher inventory in the warehouse. If the plant ships multiple trucks per day to this warehouse, this may not be an issue; however, if one full truckload is going every few weeks or so, there might be a significant trade-off. What is the right answer? Only by viewing the entire chain can the best answer be obtained.

The Lean approach to a value stream focus initially builds a map of the entire chain. A map can be created by just taking a walk through the entire process, step by step. One must document what is seen and how each step relates to the next. Then one considers how to document the life cycle of one unit of material as it flows. Where does it come in? How does it move? How long does it stay at any one stage? The end result should be a list of steps and a visual of the entire process showing value-adding and non-value-adding steps. One might build multiple levels of “magnification” such that one page shows the entire process or critical areas that are somewhat self-contained. Entire books have been written on value stream mapping, so further reading on this topic is definitely recommended.

As the value chain is mapped, one must identify the key performance drivers at each stage. For example, material that has been received but not accepted into inventory may be waiting for quality inspection or disposition. The amount of material received is related to the purchase order quantity and lead time. Considering that material received but not in inventory cannot be shipped out to the warehouse, how have the parameters of purchasing lead time, order quantity, and quality inspection time changed? Clearly a decision was made to set the purchase order quantity,

but what has it been based on? Have the drivers of the order quantity changed? Are these drivers the same for all items or all items in a specific group of “like” products? This evaluation and questioning may seem like a lot of work, but in many cases the answers will be surprises or provide insights to linkages and the overall value chain.

One must develop deep understanding of key linkages to avoid suboptimal results. Some linkages will seem basic and easy to understand, such as the receiving example. Delving into the order quantity may be an interesting example. The smaller the order quantity and more frequent the replenishments, the better service and synchronization of the entire supply chain (refer back to solving the snowball effect). The smallest order quantity is best for the overall value chain; however, realism must be considered. Rarely does someone buy just one egg at a store; they are sold in dozens or sometimes half dozens. Likewise, order quantities can reflect some of these realities, but also they may include some preconceived notions about cost trade-offs. Cost-related trade-offs frequently provide the best fodder for improvement due to the local performance many are focused on. A large order quantity may be based on quantity discounts, shipping discounts, and internal ordering guidelines or cost allocations. In many of these cases, the order quantity implications to the entire value stream are either not well recognized or quantified. A good rule of thumb is that there are no effective measures of local performance, only local parameters that drive total value stream performance. Decisions made within a confined area rarely will improve the entire value stream.

The entire chain needs measures of performance. The entire value chain must perform for the organization to perform. It is just that simple. There can be talk about each part or department or function, but any one piece of the overall chain can bring down the whole. One key supplier can bring down customer service. This weak-link theory applies to nearly any department in the organization. Consider a local sports team. All the good statistics in the world do not make up for the score at the end of the game: Who won? Everyone knows the end score and a few know some of the statistics, but does anyone know all of the statistics? The same goes for an organization’s performance. There are many statistics for various parts of the business to focus on, but few if any effective definitions of relationships between the key ones and company profit, cash flow, and return on investment. Lean improves cycle time, lot sizes, and speed of response, which

in turn reduce costs, inventories, and overhead. But these benefits are not easily observed without seeing the relationship between each metric and the overall value chain.

Lean value stream mapping must bring together these concepts of measures, linkages, and current performance to provide a basis for long-term fundamental change. Lean changes require counterintuitive changes at times, which are difficult to support without recognizing these relationships. For example, pulling replenishments to the warehouse may make little sense if a forecast can be used to plan and optimize all of the variable costs associated with distribution. Pull starts to make more sense after visualizing and ingraining the relationship between forecast inaccuracy and DRP optimization that causes the snowball effect, thereby magnifying variation and increasing costs. The relationships are the lead times and order quantities in DRP that magnify forecast revisions and “snowball” back through the distribution network. Reducing order quantities and lead times eliminates the large waves of replenishments and stabilizes the environment, yielding more cost reduction. This relationship becomes clear as the value chain is mapped, analyzed, and optimized as a whole.

SUMMARY

DRP-based business processes and information technologies provide many capabilities for planning and optimizing the distribution supply chain. These processes create plans based on customer order forecasts and data that can optimize each of the distribution costs and assets. The optimization sought to increase profit, but may actually reduce some costs while increasing others. Even with the most advanced planning systems, the total profit simulation is dependent on factors and variables that are assumed to represent reality but are based on numerous assumptions. Results of these plans carry the weight of fact in business decisions, yet the forecast foundation may be the weakest assumption of all. As the forecast and these optimization plans continued to improve in sophistication, there was a tendency to view the forecast as “fact” and seek to freeze the resulting operational plans for effective implementation.

Attempts to freeze operational plans to achieve cost savings run into the roadblock of imperfect forecast accuracy. Despite the most effective forecasting models, there will always be some error. Markets move more

quickly than ever before and customers are less inclined to take the inventory risks for changes to plans and their market. This puts suppliers in the position of continually responding, even in small course corrections, as markets and customers shift.

A Lean transformation in distribution reduces the dependence business processes and information technologies have on forecasts. Forecast accuracy has long been a complaint for planning and operations, so reliance on the forecast must be done judiciously. Updating forecasts for more “accuracy” increases variation of plans due to the magnification of the change by planning factors such as order quantities and lead times. The increased variation has been termed the snowball effect to demonstrate that small variation at the warehouse or customer level builds into large variation farther up the supply chain. Separation of the time frame for action on the forecasts between the replenishment cycle and sourcing cycle minimizes the snowball effect. At the same time, the bullwhip effect concept was introduced nearly 20 years ago, to show that changes in actual demand patterns ripple through the supply chain. Bullwhip can be minimized by using Pull to replenish and synchronize the supply chain.

The Lean transformation takes a holistic value chain view. A thorough mapping of the value chain is a necessary first step to identify and quantify the parameters driving performance. Lean principles improve operational parameters such as lead times, order quantities, and responsiveness, which are crucial to improving the entire value chain. But local cost improvement efforts and trade-offs can slow value chain performance and must be routed out.



Customer Service Policy

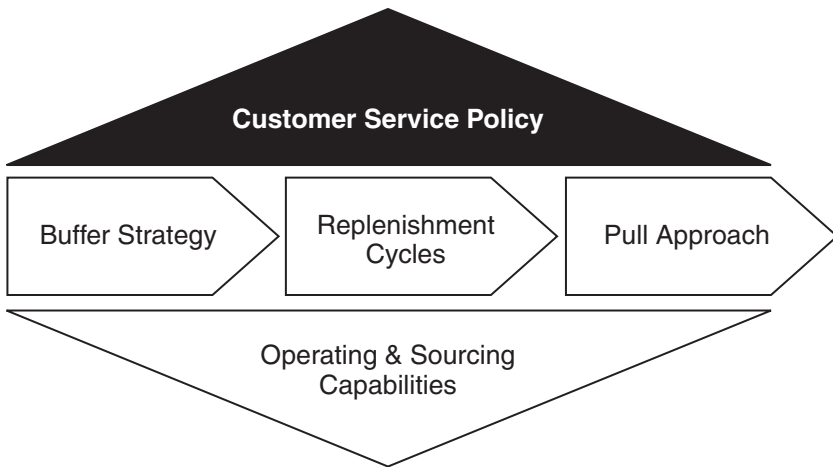
Service excellence builds sales confidence

It all starts with the customer. This is the ongoing mantra of business that focuses business processes and energies around customer value creation and service. It can be found in any number of discussions and initiatives from information technology projects, quality improvement, and new products. The common theme is to provide what the customer needs, consistently and with a smile. A concern with this mantra can be that customer needs and value may not always be well understood, communicated, or consistent across the organization. Differences of opinion about customer needs and service requirements can make life difficult or, at the least, confusing.

Starting with the customer is a must for a Lean transformation. Understanding customer service needs is a paramount ingredient for the design of Lean practices that are necessary to consistently deliver accurately and on time. The critical driver for the Lean Distribution framework is the definition of customer service policy that delineates customer needs. Figure 6.1 shows customer service policy on top of the Lean Distribution framework to show that customer needs must drive the entire design for Lean in Distribution.

Specific customer needs may not be well documented or known. For Lean to operate, clear and specific customer service policy is necessary to define the buffer strategy, the replenishment cycles, and the Pull approach that connect customer needs to the operating capabilities. These three elements of the Lean framework must leverage operating capabilities, but not

FIGURE 6.1 LEAN DISTRIBUTION FRAMEWORK



overextend them. It can be a delicate balancing act to use key aspects of Operations to better serve customers without over-committing what Operations can deliver.

CUSTOMER SERVICE POLICY

Customer expectations for delivery form the foundation for any approach to distribution and Pull. The structure and operations of the distribution network are focused on meeting customer needs and the agreements for delivery. If customers were willing to wait for the product, then companies could make to customer order and ship at their convenience. However, customers are not that tolerant and expect delivery within agreed-on lead times, which is the reason for distribution in the first place.

Given that customer expectations are critical to the business, the agreements should be formalized, structured, and agreed to. Each customer and product combination should have a documented understanding of service policy that includes description of how the customer uses or consumes product and what parameters are critical to demand patterns. As the service policy is documented, it should be agreed with the customer. Once docu-

mented, service policies form the ground rules for structuring Pull and replenishment processes.

Service Policy Contents

There can be a major difference between these internal definitions and what customers actually need. These differences show up most prominently for “blanket” service policies that apply to all customers or products. The two policies listed above to ship within 24 hours of order receipt or in-by-3-P.M.-shipped-same-day rules may apply to all customers and products as a “blanket” policy. Clearly, a blanket policy does not specify unique customer needs. These “needs” may actually be created by advertising to customers a certain level of service is the standard rather than uniquely determining which customers actually require that stringent level of service. As a rule of thumb, if the service policy applies to all customers, it is difficult to believe that all require that level of service; therefore, some or possibly many customers will be overserved by the blanket policy.

Underserved and overserved customers respond differently. Anyone can recognize an underserved customer: they complain, sometimes very loudly. Complaints can be painful and lead to lost business. Unfortunately, complaints from a few may result in high levels of service for many. Worse, the complaints may or may not be solved by stricter service policy and performance.

Overserved customers may be more difficult to spot. They tend to not complain about service but rather about price and may leave for a more competitive combination of price and service. For an overserved customer, providing a lower service level may enable price adjustments necessary to keep the business.

Network Implications of Service Policies

The entire network structure is driven by the internal views of customer expectations and service policies. As was discussed in Chapter 3, network location analyses are heavily dependent on the customer expectations for lead time to determine the number and location of facilities to meet delivery time frames. As delivery lead time decreases, the number and dispersion of facilities increases, thereby increasing the fixed and warehousing costs of

the network. In general, customers that can tolerate long lead times, such as the time to ship directly from the source, would require no distribution locations, except as cost trade-offs warrant.

Facility locations driven by customer delivery lead times bypass the network modeling algorithms to reduce total costs. The typical network modeling approach constrains how far facilities may be located from customers based on the delivery lead time. Think of this as concentric circles drawn around each customer location. Anywhere the circles intersect or overlap would be considered a feasible solution. Once the range of feasible solutions is identified, then cost, inventory, capital investment, and other factors determine the optimal solution. Through these modeling efforts the most attention may be placed on identifying and modeling the various cost trade-offs, such as transportation and warehousing costs, in order to build the case supporting any one alternative.

Service policy is the initial determinant of the range of network solutions. No amount of cost in these models can provide a solution outside the range of feasible solutions. The feasible solutions require mathematical comparisons to find the lowest total cost scenarios and options. As any one location for a warehouse is used in the model, a transportation cost to each of the customers can be calculated and summed for comparison to the warehouse and other costs.

Network models that can accommodate the implications of variable service policies are unusual and very sophisticated. These models must estimate and calculate the lost revenue and margin for scenarios where the delivery lead time is not maintained. These calculations require a mathematical relationship between service and revenue and/or margin. For example, one can try defining which customers would be lost if one additional day was added to delivery lead time or how much of any customer's revenues would be lost to this increase in lead time. These are tough judgment calls more than empirical formulas, a fact that usually stymies the modeling effort. In most cases, the modeling effort must use a more binary approach that establishes the customers, revenues, and ship-to locations based on compliance with service policy.

Alternative scenarios may be developed using variations for revenue and margin due to different service policies. These would operate duplicate models to simulate varying results as revenue and margin change to reflect lost business from lead time increases. For each service policy and revenue

scenario, an optimum can be found and then each of the scenario optimums can be compared. This is a rather complicated approach, because the focus is maximum profit and with each scenario there are different revenue, margin, and network costs.

Despite the modeling approach, some amount of revenue and/or margin would be lost by increasing lead time. The impact on the distribution network is a fairly direct one: the number and extent of distribution facilities and inventory are inversely related to customer delivery lead time. The choice seems clear: lose revenue and margin or maintain distribution assets. Most organizations tend to favor more distribution assets to accommodate customer demands for delivery lead time.

Current Service Policies

Where are service policies found? Whether good or bad, they are usually found in the hearts and minds of the people in an organization. Just ask one of the lead customer service representatives (CSRs). The answer probably will not be a surprise, or at least it should not be. Service policy should be well understood and communicated. It is hoped that the answer will be customer and product specific rather than a “blanket” response.

The question is usually less about how well policy is understood and acted on within the organization and more about how the policy was established. Ask the CSR a follow-up question: “Why is that the service policy?” The answer will be that the customer demands it, that has been our policy, or that competitors offer that policy.

But these responses have very little to do with the customer needs; at best they relate to customer “demands.” A demand is the external evidence of what the customer needs. For example, the customer may not really need product for several weeks after the production run starts, but planning processes may be ineffective and usually the customer calls in a panic requiring delivery within a day or so. The demand placed on the supplier for a one-day lead time is the result of the customer’s poor planning, not the real need in the business. Another example could be a retail organization selling over the Internet and offering same-day shipment. Does this mean that all customers require shipment on the day the order is placed? Probably not. It is a blanket policy that is easier to apply to all orders and customers rather than to ask customers and respond accordingly.

The implication of using external customer demands or blanket statements for service policy is trading distribution cost reduction opportunities for simplicity and ease. Consider the reduction in distribution costs if some customers could be shipped direct from the source or have orders better planned in relation to incoming replenishments. The more lead time and certainty available for customer orders, the more planning and cost that can be taken out of distribution. Distribution's main function as a buffer between customer demands and internal capabilities makes customer service policies as large an opportunity for cost reduction as any other initiative.

The real customer "need" must take precedence for service policy changes to improve distribution. Consider that most suppliers are several steps from the identification of the real day-to-day need due to planning and procurement processes. Therefore, the supplier is at the mercy of how effectively the customer's processes and organization operate. Some of the different environments to consider how delivery lead time relates to actual customer need include:

- *Dedicated, sole supplier for an ongoing process.* Lead time has little meaning. The inventory must be available when the customer needs. Lead time is a function of how effective the planning and replenishment processes are. Suppliers in this situation should seek as much ownership as possible for replenishment planning and execution to minimize disruption caused by customer processes.
- *Partial or "swing" supplier for an ongoing process.* This situation is a complication of the sole-supplier scenario. Depending on how the customer splits the business, a supplier's requirements may look like the sole-supplier case or the supplier may be the "swing" factor. With swing requirements, the supplier receives a portion of the requirements that varies based on how the customer's needs vary. For a swing demand, surge capacity may be the key requirement with the customer maintaining strict control over planning and replenishment. As the customer maintains control, separating real need from the customer's demands may be difficult.
- *Seasonal or promotional demand.* Lead time as a service policy may be a misnomer here since it is on lead time that many suppliers compete. Therefore, lead time is a function of capacity allocation rather

than commitment to deliver from finished inventory at a distribution center.

- *Spot purchases.* Service policy should ship in a quantity and time frame based on availability and convenience. Even if spot orders are the norm, taking that next order should be based on availability rather than commitment to deliver. Organizations do not like to lose revenue, so commitment is based on taking as many spot orders as makes economic sense.
- *One-time special order or product.* This situation is a lead time and capability-driven commitment. Supplier lead time is a function of operating capabilities and capacity availability.

Across all of these lead times, customers add some time as a safety factor to protect against delivery failure. The safety factor that any one customer adds to its “real need” is dependent on the customer’s experience with the product, suppliers, and internal operations. The last thing a buyer wants is a late delivery, so some amount of extra time may be added to be sure product arrives in time. Suppliers may also add a safety factor to commitments relative to their experiences with internal operations or changes customers historically requested. Unfortunately, many of these safety factors are built into the total lead time and are not easily identified, causing faster response than is necessary.

Dimensions of Service Policies

A starting point for service policy may be customer requirements contained in quality policies or specifications. A fundamental tenet of quality programs such as Six Sigma, ISO 9000, and others is to clearly articulate customer requirements to measure processes and compliance against. These quality documents may include customer requirements for service-level commitments and expectations.

Service policies must specifically identify the customer’s needs and operating environment. An agreement can start only with an understanding of how a customer operates and consumes product. Customers may disagree with this philosophy, stating that all a supplier needs to know is their need date. However, if customers ever change a need date and expect any level of commitment from the supplier to support changes, then the

argument takes on less meaning. Sure, there are antagonistic customers out there, or at least some of the buyers many suppliers must deal with are antagonistic; but the vast majority seek a reasonable relationship and need the supplier's help from time to time.

Documentation of customer service policies should include four points:

1. How the customer uses or consumes the product
2. The customer's market dynamics that cause schedule changes
3. Specifics of the customer's planning and replenishment processes
4. Declaration of how the organization intends to serve the customer

Understanding how product is consumed by customers helps a supplier to connect customers' requests for order handling and distribution to customers' internal processing. This is the starting point for understanding customers' internal operations and the reasoning behind their requests, especially for special packaging and handling requests. Seeing how customers receive, store, portion/issue, and ultimately consume product puts the picture together. By understanding customers' operations, a supplier may be able to identify improvements or alternatives for some of these requests that are beneficial for both parties.

For both parties, understanding the dynamics of customers' operations is critical to tightening the supply chain linkages and improving response. For example, matching container and shipment quantities to those the customer uses. Depending on the frequency and variability of customer processes, directly and exactly replacing quantities used may be necessary to minimize variability. Conversely, container sizes and shipment quantities cannot be roadblocks to fast response and tight linkage.

A tight set of linkages is fundamental to success with Lean as the two organizations work more closely together and eliminate unnecessary costs and buffers. The links cannot be tightened if each link operates independently. To increase interdependence and coordination, steps must be taken to link replenishments from a supplier to specific events at the customer's operation. The tighter the links, the more coordination is necessary.

Tight links benefit the supplier as well as the customer. As was demonstrated with the bullwhip and snowball effects, eliminating planning-induced variation in the supply chain benefits all participants. The supplier is successful only when the customer sells product and that product is ulti-

mately consumed, so temporary increases in sales and/or shipments only increase costs.

It is critical to understand the customers' consumption process of a supplier's product in light of the overall supply chain. For suppliers that view shipment to or receipt by customers as the end of their supply chain, it is time to reassess. A supplier may successfully ship product to customers and record revenues using generally accepted accounting principles (GAAP), but this does not eliminate the inventory and cost risks associated with the product. Everyone recognizes the warranty risks, and even GAAP has ways to set up financial reserves as partial "protection" of current profit from future claims. But the risks that are seldom reflected in most financial statements are the risks that customers will not require product for some period of time and will delay current orders or even return product previously shipped. Or conversely, customers have over consumed product and will require additional deliveries on short notice.

Suppliers must understand the customers' market dynamics that ripple back through to them. Customers must contend with possibly unique market characteristics that cause disruption in the supply chain that can be reflected in ordering and replenishment requirements back to suppliers. Every industry has different conditions and possibly unique characteristics that suppliers should recognize in order to support close linkage with their customers.

Suppliers also need to understand processes customers use to plan and manage product flow. Understanding how customers plan and why they take the actions they do can shed light on the best approach to operate in support of the entire supply chain. Some of the types of customer processes that may be encountered include:

- *Lean Manufacturing.* Customers operate using Lean practices, speak the language well, and understand how their actions impact suppliers. Efforts are made to tighten links and increase total supply chain effectiveness. The key challenge may be to continue supply chain improvements that are productive and mutually beneficial.
- *Enterprise resources planning (ERP).* While even Lean manufacturers will have ERP systems, the traditionalists operate ERP from the forecast on down and use the planning parameters discussed in Chapter 5 that cause the snowball effect, so suppliers must be prepared. Lean

practices are not recognized or valued. The key challenge will be the variability of orders, order sizes, and customer demands to focus on due date compliance.

- *Vendor-managed inventory (VMI)*. Customers may have negotiated on-site inventory owned by the supplier with customers taking ownership as product is moved into and consumed in production. There may be various approaches to managing the VMI, from customers planning and controlling replenishments to the supplier working to data provided by customers. Here the key challenge depends on who operates replenishments. The best case is for the supplier to utilize Lean practices for replenishments; the worst case is for the supplier to own the inventory and customers to plan it using traditional forecasting and planning techniques.
- *Manual reorder point (ROP)*. The Lean supplier may be able to create the processes and take more responsibility similar to a VMI operation. The key challenge and limitation may be the availability of computer-based information from customers.
- *Promotions and seasons*. Planning and replenishment for seasonal merchandise and special promotions can be drastically different and cause Pull to break down or not be utilized. Here the key challenge is the organizational resistance to Lean due to the forward planning necessary for a season or promotion. Unfortunately, the error inherent in forecasts that drive these processes can be at least partially accommodated by a Lean Pull approach.

Finally, the customer service policy must document how the supplier intends to support the customer's needs. This is really the crux of the service policy, which should be different for each major customer, product, or groups of customers or products. A frequent response is to "give the customer what they want." Although this may sound good on the surface, in real practice not all customers need or are willing to pay for the ultimate level of service. Most customers are willing to take more service than they pay for, and high levels of service compensate for flaws in planning and replenishment processes, but at some point maximizing profit to enable investment for growth requires tough negotiations and decisions about service.

Delivering high service does have a price, particularly for “blanket” policies. With Lean that price is much lower than with traditional methods due to the lead time, lot size, and flexibility improvements. As Lean improves operations, inventories and many other costs go down or service can be improved. Delivering high service is a decision to be made that relates to competition, customer requirements, and investment priorities. But by passing on all lead time reductions to all customers, a supplier is giving benefits to customers possibly without obtaining any benefits in return. The first supplier to reduce lead time creates a situation where all remaining suppliers must follow, which levels the field again, and only customers have benefited.

When Lean implementation is combined with adjusting service policies, the cost savings are tremendous. Consider the lead time reduction for customers that are currently shipped from stock: if lead time can be reduced below the customers’ lead times, then their orders can be made to order. Although this may not happen for many customers, any lead time reduction improves the chance to adjust operations and respond to that specific order. Due to the natural variability in all customer demands, providing some time to respond reduces inventory and last-minute expediting.

As lead times are reduced, suppliers must seek to obtain advantages from customers that create the “win-win.” Customers should be willing to give up something that costs them little to nothing in return for lead time reductions. The natural reaction is to ask for a higher price, which may be the right answer for a lead time competitive environment. In most cases, however, a supplier should ask a customer to assist in tightening the supply chain links as the offset to reduced lead time. Consider a customer that is offered shorter lead time: it is great, because the planning and forecasting errors can now be corrected much easier. Does that help the supplier? Probably not; it depends on how the customer plans replenishments and whether the customer exhibits bullwhip and snowball effects. The benefit customers can provide a supplier is embracing Pull for replenishment; doing so should cost customers nothing, but provides significant benefits to both customers and the supplier.

SEGMENTATION

The starting point for service levels is defining how markets and customers are segmented into categories for different levels of service. Multiple

segments are required to relate groups to the alternative service policies. In some environments, service policies may be defined down to individual customers and products, but most organizations may find that too cumbersome for everyday operations.

Because all customers were not created equal, many organizations use revenues or the size of the customer to group or prioritize. This approach yields a bigger-is-better scenario that does not relate well to the dynamics of product consumption and replenishment cycles. The paradigm that customers with larger revenues are easier to serve may primarily be that higher volumes tend to have more stable demand. That paradigm, however, may be speculation and not a good foundation on which to build a service policy.

Segmentation must be based on differences in customers' operations, supply patterns, and service needs such that a supplier can construct relevant service strategies. Figure 6.2 is a framework for considering where various customers or products fit into an overall segmentation approach. The approach is based on the necessary elements for effective Lean supply link-

FIGURE 6.2 SEGMENTATION FRAMEWORK

| | | |
|---|---|--|
| High Strength of Linkage | <ul style="list-style-type: none"> • Strategically buffer • Commit to service and flexibility • Flexibility is the key to cost reductions and service <p style="text-align: center;"><i>Collaborators</i></p> | <ul style="list-style-type: none"> • Reduce variation and buffers • Weld links together • Share the wealth of benefits <p style="text-align: center;"><i>Partners</i></p> |
| | <ul style="list-style-type: none"> • Consider make to order • Buffer groups of products and/or customers • Stabilize with varying market commitments <p style="text-align: center;"><i>Planners</i></p> | <ul style="list-style-type: none"> • Internally buffer • Drive benefits back into internal operations • Leverage flexible operations to cherry-pick markets <p style="text-align: center;"><i>Buyers</i></p> |
| | Low | High |

Demand Stability

ages: the combination of highly linked supply chains and demand stability. One without the other is a recipe for disaster. Stable demand does not necessarily make implementation of Lean easy, and variable demand does not necessarily preclude Lean implementation. A combination of the “will” (strength of linkage) and the “way” (demand stability) is required.

Segmentation Types

The customer type names from Figure 6.2 should provide some indication of the relationship between customers and supplier. To determine where a specific company’s relationships lie, one should assess customers and products across the will and way dimensions to draw conclusions for service approaches.

- *Partners.* These customers should have the easiest time collaborating due their high demand stability. When working with partners, one should check to see if they have taken steps to level out and stabilize demand or whether such stabilization is a natural state of the market they are in. Look at the actions being taken to weld together the supply chain, which should be much tighter than any other chain. Reducing “policy-inflected” variability should be the key focus, and any improvements should automatically ripple through the links to create benefits. Freezing schedules or taking other artificial means to level out demand should be avoided.
- *Collaborators.* Collaborators are customers who demonstrate trust and commitment, in other words a true sense of partnership across the supply chain links. Clearly, these customers see benefits for themselves in partnering and tightening the links: improved response to their variable demand. One can always differentiate collaborators from planners or buyers by their single-minded focus on product supply rather than cost reduction or any other benefits. Collaborators seek a source of confidence that product will be available no matter what their market throws at them.
- *Buyers.* Their market and operating environment should enable tight linkages, yet there is no visible support for Lean. Could they be unaware of Lean concepts, practices, and benefits? Or do they artificially level out their operations, thereby insulating suppliers from market

variation? Despite the high stability of demand, it can be dangerous to tighten linkages with organizations that do not understand and embrace Lean concepts.

- *Planners.* Planners are preoccupied with using the forecast and their schedules to manage incoming materials due to the highly variable nature of their requirements. It is difficult for them to give up control, and so at times Planners micromanage supply plans. They keep and justify high buffer levels due to their market and operating environment. Consumption variability may be increased due to operating practices that push product into finished goods or the market, meaning planners do not pull into their market.

Moving customers to the upper right quadrant of the segmentation framework requires attention on the two axes to build up the will and find the ways for tight replenishment and Lean excellence:

- *Strength of linkage (will).* Most suppliers start with the answers their customers seek or the topics that are top of mind: reduce price, change logistics, modify schedules, and so on. These are answers to deeper questions; some are straightforward, such as requests to reduce prices so customers can be more competitive or more profitable. The source for other requests may not be so obvious. Either way, the supplier is reacting to the visible issues customers are raising and may not be delving into deeper issues to help customers see the connections to Lean. Asking the right questions is often a simple but effective approach to find the ways Lean practices can address customers' root issues of customer service and cost reduction/profitability.
- *Demand stability (way).* There are many ways to reduce demand variation: first in replenishment ordering, then in order quantities, and finally in container sizes. Any variation that is "self-induced" into the natural market variation should be eliminated. A good starting point is to compare customer order, container, and usage quantities to identify differences. Order and container sizes frequently exceed usage quantities due to efforts by customers and suppliers to reduce cost or be efficient. Many of these changes can be made by policy rather than by physical changes—for example, an ordering policy that requires shipping full truckload quantities to obtain advantageous pricing.

All customers may not be ready or willing to take the Lean trip to improve Distribution. Whether the market dynamics are just not right or the company is not able to embrace Lean concepts, the supplier will need to determine what service strategy to have and how to tailor internal capabilities to meet customer needs.

SERVICE STRATEGIES

Service strategies are critical specifications of the supplier's approach and commitments to meet customers' requirements. In a typical scenario, customers expect that all requirements will be met as they "collaborate" by providing forecasts and then issue purchase orders. As the supplier agrees to the purchase orders, customers are confident of delivery. Or at least that has been the historical process.

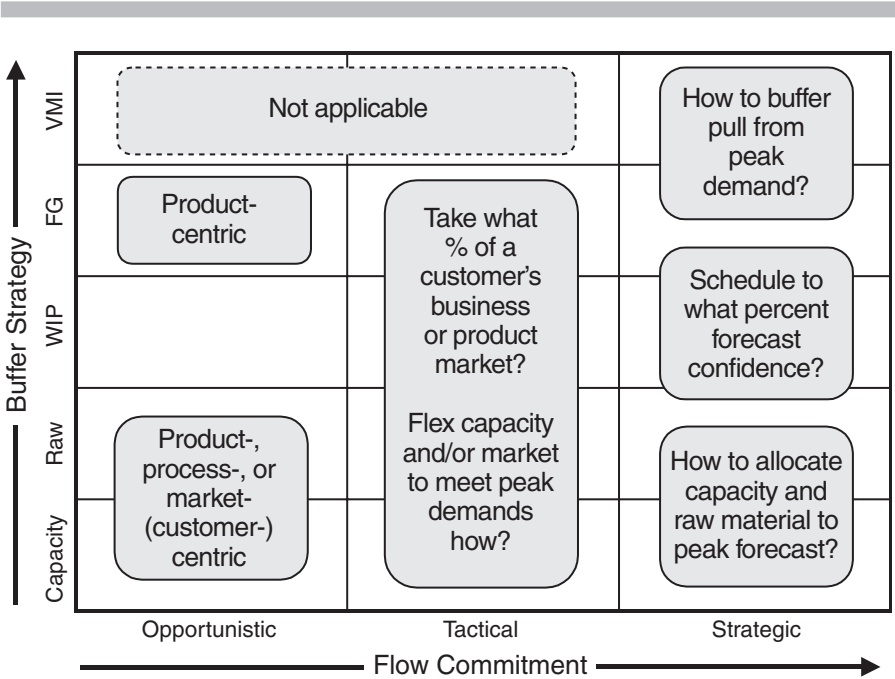
But are customers really confident? How much time do customers and suppliers spend changing order dates and reconfirming delivery schedules? Scheduling and rescheduling seems to be an ongoing and never-ending task for both parties. It seems as if Pull-based replenishment would alleviate a lot of time and confusion. But the price for a supplier with Pull is the assumed delivery commitment, despite changes in forecast and short-term schedules. To move forward with Pull and eliminate or at least minimize the focus on customer order due dates, service-level strategies will be critical both internally and with customers.

Flow Commitment

Moving to Lean-based pull brings this assumption to fill all needs, working to actual demand, but that is not a definition of service. Service is defined by what extent of flow is being committed and how quickly the response will be made. A rather simple way to picture this is in Figure 6.3, where the service strategy is encapsulated into two critical dimensions: where and how to buffer variation and what extent of demand to fulfill. This graphic assumes that the supplier has limited capacity, or at least cannot flex capacity with any and all market swings, so decisions must be made on customers and markets.

If a supplier can flex well beyond that required by the "main" customers, then Figure 6.3 would primarily revolve around the "strategic"

FIGURE 6.3 SERVICE STRATEGY CONSIDERATIONS



column. The entire network and distribution approach could be optimized around capacity flexibility. For example, lead time for replenishment of the source inventory would be the critical variable, enabling vastly reduced inventories and faster response across the entire chain. However, this is not realistic for most organizations due to limited capacities compared to the wide swings possible in customer demand.

Here are some broad definitions of the commitment to a customer's total material flow, which is one of the key drivers of the level of service.

- *Strategic.* Customers are crucial to the long-term success of the business and will receive the highest level of commitment to meet their total demand. This may be less than 100 percent, depending on the company strategy and characteristics of the customers' market and demand fluctuation.
- *Tactical.* These are important customers that will receive consistent service on their forecasted demands and some ability to flex actual Pull within some established limits.

- *Opportunistic.* These are customers or markets where orders are taken as capacity or product is available. These customers can be very “strategic” in the need to generate revenues for capacity not required for the remaining customer base.

For organizations that attempt to “sell out” capacity, the service strategy must address how total capacity and materials will be committed and then consumed across the various products and markets. These three categories of markets—strategic, tactical, and opportunistic—are representative forms, but not the only ones a successful firm might pursue. The key concept is how strategy addresses the balancing of total market demands, peak demands from strategic accounts, and buffering approaches. A buffering approach is a short-term way to meet peaks in demand and should not be a way to serve trending markets past operational lead times.

SUMMARY

Customer service policy cannot be assumed or taken for granted. Customer needs are paramount, but also must be articulated properly for success. If customer service need is defined as the lead time to ship from a particular distribution center where inventory currently is held, then few options to improve distribution and customer service may be possible. This is not a definition of customer need; it is a declaration of how the customer has been historically served.

An explicit service policy that describes customers’ operations and service processes is necessary for the organization to understand and provide excellent service. A statement of expected delivery lead time just does not support an advantageous connection with customers. The service policy should contain a description of customers’ consumption and planning processes in order to tailor Lean practices to customers’ needs.

Segmentation of customers and/or products into various groups for different service levels is one specific step toward improving service. A customer segmentation framework should differentiate the linkage and demand stability for various groups. The four main groupings of these relationships are:

- Partners
- Collaborators

- Planners
- Buyers

Each group has different characteristics and should be served differently. The strength of linkage can be referred to as the “will” to make the total supply chain effective. Demand stability relates to the patterns for usage and is called the “way” to supply effectiveness. Customer/supplier relationships with both the “will” and the “way” require different service strategies and policies from ones with little will or way.

A Lean approach can be developed to meet nearly any customer need and delivery parameter. The greatest improvement from a Lean approach is to leverage shorter cycle times and better replenishment capabilities to streamline and optimize distribution. However, blanket service demands rather than articulated customer needs will reinforce the current distribution operations and leave little opportunity to improve service and costs.



Buffer Strategy

Murphy says: variation happens, so don't self-inflict it

Mountaineering provides an analogy for working toward Pull. Each person in the line is connected, yet all are working at their own pace and ever mindful of the next person in line both uphill and downhill. There is some slack in the line between each mountaineer, but not enough to provide much time to prepare for a fall: everyone must be prepared at all times. The lifeline symbolizes interdependence and with it safety, yet it is confining to the extent that one's pace must be increased or decreased with the team.

Lean Distribution seeks to directly connect with customers and suppliers in ways that are mutually beneficial. Like the mountaineers, each link in the chain must be ever mindful of the entire team, but especially the person directly upstream and downstream. They must all act and work as a team, moving at the same pace with only a small amount of slack between. With Lean, producing far ahead and holding inventory may not help the effort: it could very easily be the wrong products at the wrong time. Producing ahead misallocates valuable resources by possibly storing the wrong product that can result in excess inventory, space and costs. The shorter the total chain, the more beneficial it is for all involved.

Developing the Lean supply chain requires training and team building similar to a mountaineering effort. Consider the basic skills that everyone must master: the key principles of Lean. The entire team must speak the same language, utilize practices together, and operate in unison. Although

a Lean team member may not have to overcome a fear of heights like a mountaineer, each member company must understand and “know” all of the other companies up and down the chain. All members in the Lean team must have the confidence and knowledge that the entire team can respond to changes in demand.

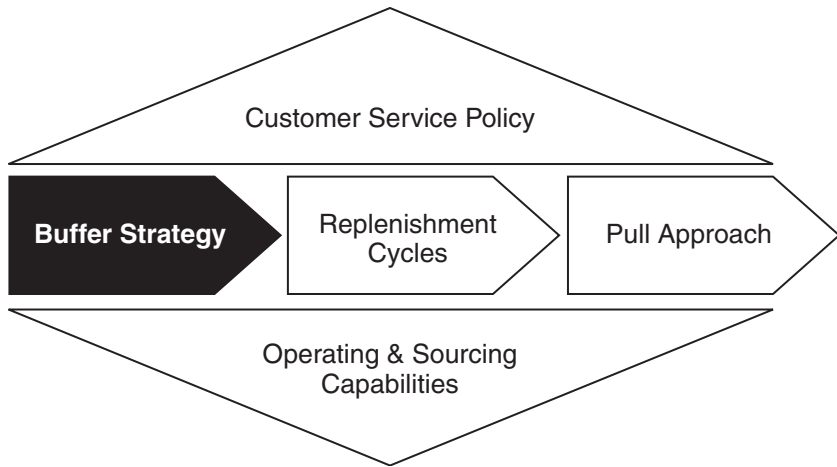
Lean practices are designed to bridge between customer requirements and internal operating capabilities. A fundamental component of the bridge is the buffer strategy that identifies how customer needs will be met despite demand and other variation inherent across the entire supply chain. The buffer strategy is shown in Figure 7.1 as the starting point for Lean design to designate that buffers are strategically placed to meet customer service needs and then replenishment and Pull practices are developed to connect with customers.

BUFFER STRATEGY

Buffer strategies are critical linkages in maintaining smooth flows to customers. There will always be variations in market demands, customer consumption, internal operations, and supplier deliveries that require buffers. These buffers may be in the form of inventory, capacity, or time. Organizations primarily utilize inventory as a buffer, because it is by far the easiest to quantify, track, and control. However, capacity frequently can be a more effective and lower-cost buffer. Time is not a long-term strategy to buffer, because it degrades service by making customers wait. Service strategy must specify the buffer strategy in order to ensure that peaks are properly supported. The downsides of an inconsistent or omitted buffer strategy can be higher costs and inventories and/or lower customer service.

Developing a buffer strategy starts with assessing the areas of flexibility to leverage. Using Figure 6.3 in Chapter 6, one should draw circles in the areas where the supply chain has the most flexibility. Then one should consider how much that flexibility is leveraged currently to respond to market fluctuation rather than using inventory. Then one should draw Xs in the areas where the buffer exists. Are buffers in the right place and leverage the appropriate combination of inventory and capacity? An effective strategy leverages as much flexibility as possible with inventory buffers limited and tightly managed.

FIGURE 7.1 LEAN DISTRIBUTION FRAMEWORK



An example of combining inventory and flexibility that frequently does not work is an automobile dealer network. The intent for most dealers in the United States is to have the car a customer wants on the lot, ready and available for sale. (In other markets, nearly all cars are ordered to customer specifications.) If the customer wants an option or color not in inventory, then a search is conducted across local dealers to swap cars. If searching local or regional dealers does not find the right car, the last resort is to have one built by the factory to the customer’s exact specifications. Anyone who has gone through that process knows the dealer is highly motivated to sell a car on its own lot first, then find one from another dealer or, as a last resort, special order one from the factory. Why? Because swapping with another dealer may increase costs, and ordering a car has a long lead time. The cars on the lot are the result of forecasts and decisions several months in the past, which can be accurate only in total number of cars sold at best. The end result is pressure and/or incentives placed on the customer to accept a car in inventory rather than exactly to his or her specifications.

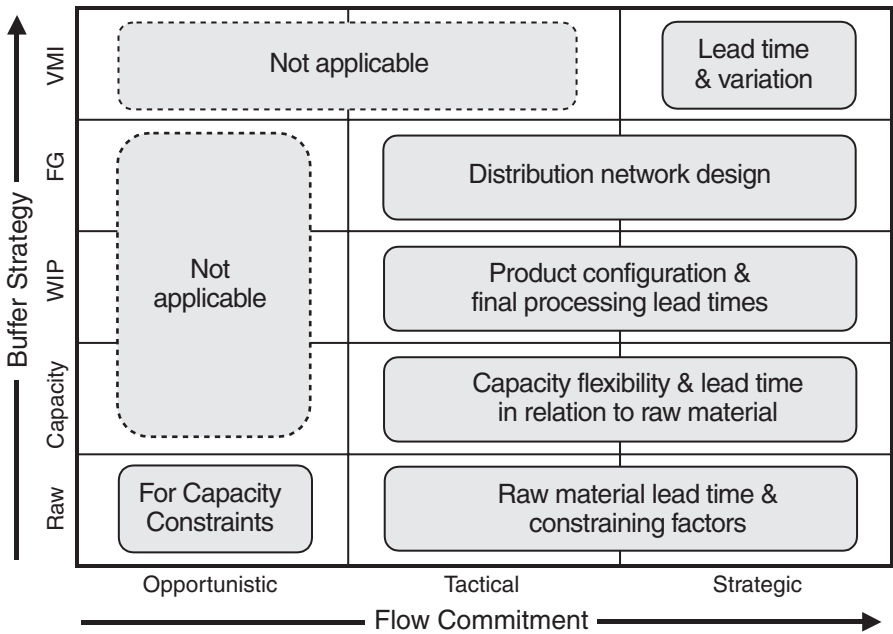
The alternative for the automotive dealer network is to eliminate most of the dealer ordering and operate to pull between the factory and each region and to reduce the cycle time for special orders. This would greatly reduce total inventory in the system, provide customers faster access to

exactly what they want, and reduce reliance on sales incentives to move cars. The dealer's role would be to set floor stock levels, forecast sales volumes, and forecast sales of some particularly popular but limited options. The barrier? A lack of flexibility in the ordering process and at the factory. With the typical 90 to 120 days of new cars in the distribution network, dramatic savings could offset some costs to increase flexibility. This new car inventory is expensive and leads to more lost margin on sales than may be realized.

Inventory buffers should be second-class citizens in a Lean world. But the reality is that most companies view inventory as an "asset" and good for customer service. This "reality" can be a fallacy. Inventory costs money, freezes decisions, and becomes obsolete. Except for art, fine wine, and other collectibles, inventory degrades over time and with some products quite rapidly. Inventory "embodies" the set of decisions made from forecasts or operational plans and casts them into concrete. These decisions cannot be remade, despite the fact that forecasts are inaccurate and customers change orders. Therefore, any product in inventory is the result of the best decisions made at some point in the past, but everyone knows decisions made with more current information will always be better. With more focus on flexibility, operating decisions to create inventory are made later and on more current data, resulting in less obsolescence and other inventory costs. When all of the costs of inventory are tallied, there are few cases to be made for inventory as a more effective buffer than flexibility, with seasonal buffers a possible exception.

Variation occurs across the entire supply chain and is the main "need" or problem driving a buffer strategy "solution." If there was no variation, then buffers would be extremely limited and driven by lot size and lead time factors. Therefore, the buffer strategy must align with places where variation can be best managed and customer service protected. These places should be where high variation and high flexibility intersect. An example could be a plant finished goods inventory for a product packaged in many different ways, say, vitamins. Buffering every package type (100-count, 250-count, 500-count bottles) and all of the various blister pack combinations would require many significant inventories due to the large peaks in orders for those products. If the packaging line could be operated to Pull, then the largest inventory would be maintained in bulk tablets and each specific package configuration finished inventory would cover the

FIGURE 7.2 SERVICE STRATEGY BUFFERS



number of days until the packaging line can replenish. The variability at the tablet level would be fairly small compared to the order variability at the finished package level. In a more Lean process, the packaging line flexibility would be the critical focus to enable many line changes so all bottle-count packages could be replaced daily. The resulting buffer strategy would be primarily tablets, labels, and bottles.

The buffer strategy considers the levels of variability and flexibility to assess where to best “place” buffers along the supply chain. In Figure 7.2 the stages across the supply chain are shown with considerations for placing the main buffer in each. Starting with capacity at the bottom and moving through raw material and ultimately to vendor-managed inventory (VMI) at a customer’s site, the stage to best place buffers includes some of these considerations.

- *Consignment Inventory (VMI)*. Placing VMI at a customer’s location by definition provides the customer with an uninterrupted supply. The supplier may place limits on VMI inventory usage, but the typical

arrangement allows a customer to consume on demand, and the supplier is responsible for replenishment. The replenishment lead time, demand variation, average demand, and container limitations determine the target inventory levels. Unless replenishment lead time is very short and fluctuation is low, these inventories become large quickly. There are a variety of ways to set up and manage inventory at customers, from consignment that is managed by the customer to full VMI that is the responsibility of the supplier. Many of these differences result in more or less inventory, depending on how it is managed.

- *Finished goods (FG)*. Finished goods can be placed at distribution points based on the service requirements for customers. Similar to VMI, the inventory levels will be a function of variation, average shipments, and replenishment time. There probably are multiple customers served from the same inventory, which will increase the effective turn rate for these inventories compared to VMI. The distribution network will determine where the “surge” inventory is placed. As was discussed in Chapter 4, surge inventory should be placed far back in the network as close to the source as possible. In some networks, there may not be a flow of the same product from the source to multiple regional distribution centers and then warehouses, so surge inventory may need to be placed farther out.
- *Work-in-process (WIP)*. This is where Lean practices excel and increase flexibility. The added flexibility to switch between products and adjust volumes can be leveraged to respond to changing market demands as long as key inputs, such as raw materials or components, can be available. The leverage point in WIP may be where the product diverges, such as with the packaging line for the vitamin example, or may be where processing times and operating flexibility kicks in.
- *Raw material and capacity*. The buffer options for raw material and capacity are usually one or the other. For process industries, raw material may be more readily available, but capacity is inflexible. In batch blending and other similar chemical operations, capacity can be flexed, but particular raw materials may be the constraining factor. It is usually a matter of finding which one is the bigger constraint and then allowing for the other.

In some cases, buffering customer demand is not necessary compared to the service-level commitments. In Figure 7.2, the “not applicable” boxes highlight areas where buffering variable commitment demands by definition is a waste. For the “tactical” customer group, it is expected that all demand peaks would not be supported; therefore, placing consigned or vendor-managed inventory at the customer’s site would imply the opposite to the customer. In the “opportunistic” customer group, commitments are made based on availability, so buffering would be proactive for a reactive market. There might exist some small level of inventory associated with opportunistic customers/orders based on orders being delayed or internal sourcing being early, which are natural variations in the process. There should not, however, be buffer inventory maintained proactively for opportunistic accounts, meaning having it available when the customer might decide to order it.

General Buffer Placement Rule

The vitamin example and buffer strategy considerations display a general rule for placing buffers: closer to the customer requires much more inventory. The fluctuation of demand for a single stock-keeping unit (SKU) at a customer site is always much higher than the fluctuation for a group of customer demands for that same SKU, say, at the warehouse feeding that group of customers. This general principle is statistically sound, but can be difficult to act on due to the urgency of customer service needs.

The buffer should be placed as far back as possible in the total supply chain. The closer the buffer is to the source, the less total variation there will be and the better capability there will be to flex to major swings in demand and absorb variations within the supply chain. Consider a black paint supplier to a major automotive company. For any one day, some but not all of the assembly plants might be painting cars black. The demand for black paint on that day will be high for some plants and zero for others. Consolidated demand for each day’s black paint total demand will be much more stable than the demand at any plant. At the plant making black paint, “seeing” the consistent total demand allows for more stable scheduling and planning.

With the main buffer next to the source, operators can better manage production, sourcing, and buffer inventories. Buffers placed physically in front of the producing operation can have a powerful effect on operators

to manage levels. An operator can visually work to keep the buffer full by adjusting schedules based on seeing the status of all the buffers to be maintained. As one buffer inventory fills, there can be physical limitations on the buffer size, further reinforcing the Lean concept of Pull.

DETERMINE SERVICE STRATEGIES

Combining all of the customer and supply-related input to determine a set of service strategies requires fitting customer needs into organizational capabilities and moderating commitments based on market strategies. There simply is no easy way just to ask customers for their desired lead time as the service requirement. Customers primarily communicate what they want, not what they need. One must be careful what one asks of buyers, because they may just say what they think one wants to hear: how quickly they want orders delivered.

Their real needs get confused in the day-to-day processes of ensuring an adequate supply and working to reduce costs. Consider what is on the mind of the buyer: the purchase price variances for the product and the lead times used in the planning system to ensure supply. Aside from quality measures, these are the basic planning and control parameters used in nearly every business, so seeking other answers may be cause for frustration and misleading tales of woe.

The true questions become: How are customers operating and how can a supplier be successful with Lean Pull? To answer those questions requires assessing how a Lean approach can smooth internal operations and improve service to customers, which may deliver benefits to both customers and supplier. These benefits must relate to the very deepest issues within each business rather than the superficial price or delivery questions of the day.

Suppliers must first determine their own capabilities and then match those against customer needs. By honing internal compatibilities, suppliers avoid the trap of over-promising and under delivering and then building up large buffers to ensure delivery.

Internal Lead Time

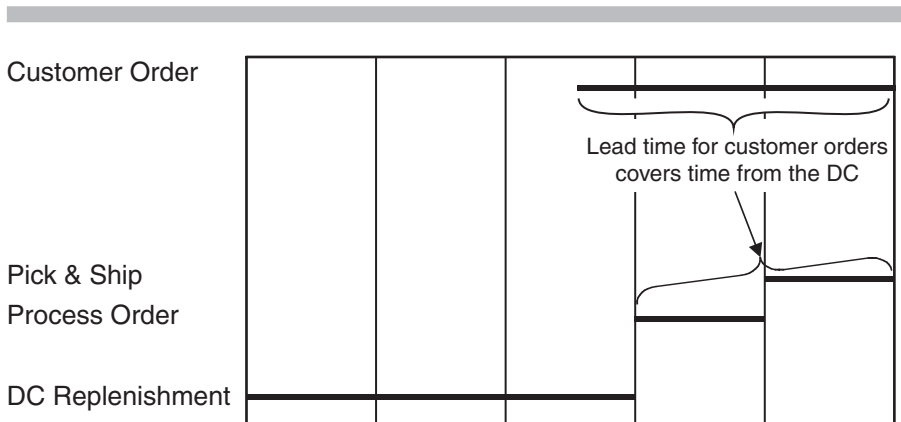
The total time to process customer orders or replenishments is an excellent starting point to assess internal capabilities prior to assessing customer ser-

vice policies. If internal processing times are long, service will be a challenge and buffers must be placed close to customers. Buffers should be back near sourcing or producing points rather than close to customers to maximize flexibility and stabilize schedules, so lead time is the enemy of effective buffer strategy and customer service.

The internal time required for orders paces where an inventory buffer may be required. For the example in Figure 7.3, the customer lead time is too short to allow shipments to the distribution center (DC) from the source prior to shipping to the customer, thereby requiring buffer inventory at the DC. This is a common situation where the customer order lead time is barely sufficient for internal order processing, pick/ship, and transportation from the DC. As orders are processed, variation that may impact timely delivery can be most readily seen in expedited or higher-cost freight. Expedited freight can reduce the transportation time and make up for lost time in order processing and the warehouse. Higher-cost freight can result from less lead time provided to carriers for load scheduling. Loss of the appropriate lead time in transportation for both of these cases is the natural condition of the variation in the first two process steps.

Many organizations have applied Lean practices to front office business processes, such as processing customer orders to eliminate waste, reduce lead time, and improve reliability. Limited customer lead time places pressures on internal processes to continually respond faster. Although some internal process steps, such as order processing, may be ripe for improvement,

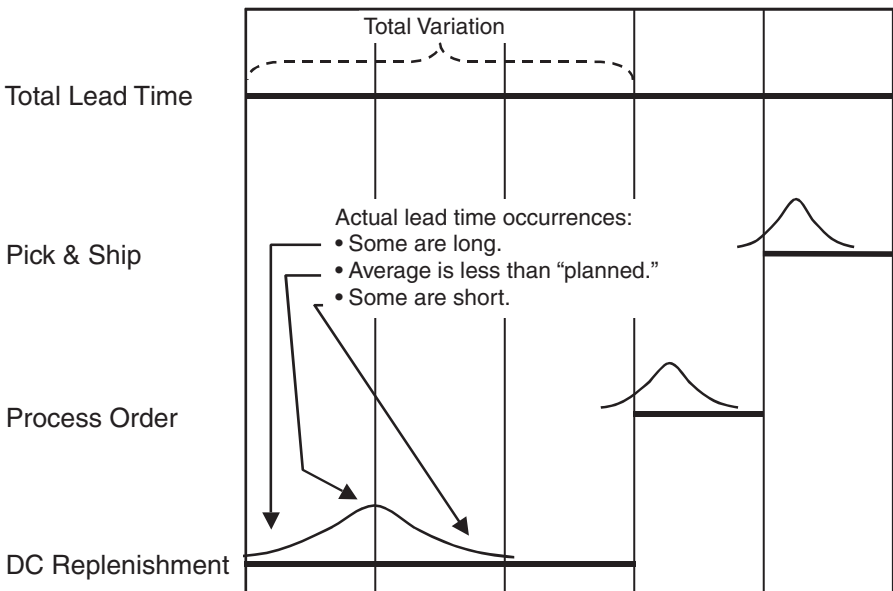
FIGURE 7.3 INTERNAL LEAD TIMES



transportation may be at the other end of the scale and have the most pressure for added lead time, particularly advance notice for loads so carriers can plan and schedule.

Process variation may be as important as lead time in assessing the requirements to meet service commitments. Variation is measured as the distribution of actual lead time for each occurrence (i.e., one specific order) of a process step. Figure 7.4 displays a curve over the length of the planned lead time bar to show how variation at each step requires the lead time to represent the longest time required, rather than the shortest. The height of each curve shows the number of occurrences for that actual time. For example, the DC replenishments could actually take anywhere from one week to over three weeks, depending on a number of factors. Very few replenishments only take one week, just as very few take over three weeks. Most of the replenishments take two weeks. So for planning purposes, a three-week lead time is used. As the variation for these three steps is totaled, the overall lead time for the steps means lead time can vary between two and five weeks—quite a difference!

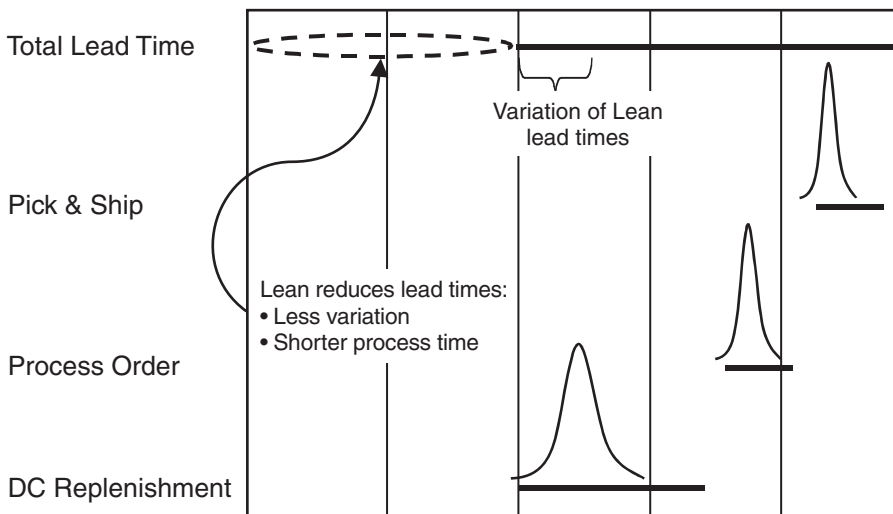
FIGURE 7.4 VARIATION INCREASES PLANNED LEAD TIMES



For the example in Figure 7.4, if the reliability and lead time of each step could be improved, the total lead time reduces and becomes more consistent. With more consistent lead times, Pull can be operated effectively and the overall lead time shrinks. Applying the shorter and more consistent lead times to this example, the resulting new service profile is shown in Figure 7.5. Now the customer lead time is nearly sufficient to ship from the “surge” inventory at the source (plant, master DC, or supplier) directly to the DC and then the customer. This shorter lead time enables direct shipment from the source, cross-docked shipments, and other service approaches. If the customer has highly variable demand, then the surge inventory location meets more of the peak customer demands, creating huge advantage with savings in inventory and schedule stability. In addition, for the largest peaks, it may be possible to ship directly from the surge inventory location to the customer, providing fast response and keeping the inventory balanced across the entire supply chain.

There are many sources for the statistics of variation and strategies to reduce process variation. Quality initiatives such as Six Sigma provide numerous tools that are additive to a Lean initiative to improve processes, especially using statistics and defect reduction. The key issue is to recognize

FIGURE 7.5 LEAN REDUCES LEAD TIME



that planned lead times must be based on the vast majority of occurrences and high process variation creates long times. If variation is not measured for a given process, then chances are that variation is fairly high. Statistical control and measurement are necessary to tame variation.

Service Requirements

Internal lead times and capabilities do not define customer service requirements. An accurate assessment of customer requirements independent of internal capabilities is critical to optimizing service. If the current best-case internal capabilities become the commitment to serve all customers, there can be no opportunity to segregate service and limited opportunity to use process improvements to improve distribution costs.

Obtaining an unbiased view of a customer's service needs can be extremely difficult. Most customers have been "surveyed" too often, so asking for input once again can be a dangerous endeavor that leads to quoting industry norms, competitors, or past experience. Asking internal sales representatives may bring bias as well: What salesperson wants longer lead time or perceived less service for customers? And past history is not a good indication as numerous internal and external conditions may have driven the past actual times for orders.

Customers who are asked may refer back to lead time and order quantity parameters in their planning system. A short lead time for customers' planning system and order release is not relevant to their "need" but represents the time necessary to meet current "expectations." These lead times will also include padding to cover the customers' perspective or history with variation in service delivery from the supplier or a group of suppliers. Although it is important to meet and exceed customers' expectations, it is also critical to point out and deliver cost reduction opportunities across the entire supply chain, and meeting service needs at a lower cost may be preferable to exceeding service needs.

Current warehouse locations may not indicate service needs. Decisions on warehouse locations may be heavily weighted by customer service needs, but customer demographics may have changed dramatically without changes to warehouse locations, providing customers with service above or below their actual need. Service below their need would probably be raised as an issue; however, service above their needs may not.

Only the characteristics of customer consumption and operational processes can specify service needs. These are the “real” needs. All else are opinions and objectives to meet concerns and protect adequate supply. The customers’ processes can provide more facts about consumption, such as the rates of consumption, frequency of production runs for the product, typical schedule patterns, space for storing inventory, and historical consumption profiles. Unfortunately, suppliers rarely have this direct information, but only have the “external” customers’ ordering and their own shipment patterns. Unless the supply chain is perfectly synchronized with all variability and lot sizing removed, the data suppliers have probably will not directly correspond to customers’ consumption characteristics.

Customers’ willingness to provide and work to actual consumption data may be the clearest indication of their strength of linkage. Referring to Figure 6.2, the strength of linkage and the variation in demand can be utilized to segment customers into categories relative to Lean-based service strategies. The collaborators and partners should display a strong desire to share the data necessary to link and work to actual consumption requirements. Buyers and planners would communicate objectives for lead time, comparisons to others, and the parameters their systems use. Clearly, those customers displaying “wants” rather than consumption and actual demand “needs” provide a basis for segregation of service policies.

Demand Data

Customer demand patterns must never be confused with how orders or forecasts are provided to suppliers. Customer orders are nearly always out of sync with actual consumption of the product: the quantity consumed is different from the quantity and timing of ordering. The bullwhip effect, the snowball effect, and current distribution processes discussions in Chapter 4 showed how customer’s order processes add variability to demand patterns. In a few rare cases, customers with a deep Lean Pull capability will have a fairly good connection between consumption and replenishment. Yet even those cases may have lot size differences that should be known.

The challenge becomes finding the real demand and linking to it. The primary source of demand data is the customer. In the retail industry, this is represented by point-of-sale (POS) data provided by the retailer to suppliers. Retail is an industry that has the natural source of data for consumption

due to the transaction processing required for consumers paying for their merchandise enabled by bar codes. But even in retail, other sources of consumption, such as breakage and “shrinkage,” may not be recorded accurately or timely. It is easy to understand that shrinkage can be reported only when it is discovered, such as when a shelf is replenished or at inventory time. It is hoped that the combined impact of shrinkage and breakage is low; say, less than 2 percent.

Consumption data in other industries range from as definitive as that in the retail industry to no daily tracking. In the medical field, consumption should be easy to track, because patient accounts are billed for many of the drugs and materials as they are issued from a stocking area and prescribed. However, with some manufacturers, particularly process companies, daily consumption may not be measured; it may be reported only through back-flushing or periodic inventories.

Customers’ information systems may also enable or limit data accessibility. Customers with mature or antiquated systems may not have effective capabilities to track and report demand data. For the more current enterprise resource planning (ERP) applications, data can be tracked and reported, but the customer may not elect to track that detail. Some of the ERP capabilities that restrict detailed daily demand data include:

- *Floor stock inventory.* Typically this inventory applies to low-cost and high-usage items such as fasteners that are kept next to assembly areas, but not tracked to any specific production orders per day. These inventories may just be refilled when empty with the inventory transactions of the container quantities out to the floor stock area, making the process look like lumpy demand.
- *Back flushing.* Materials are structured in the bills of material (BOM) for the product, but are not picked when the production order is started. Quantities of materials are automatically recorded and deducted as the finished product is recorded into inventory. Additional usage of material due to scrap or yield issues should be recorded at the same time as the finished product. Periodic inventories may be used to identify usage that was not recorded.
- *Shop schedule tracking.* Commercially available applications provide the capability to track each production order or run; however, at times

companies elect not to track orders. If the production orders are not individually tracked, the only consumption data may be the issues from material stores, once again depending on how material is issued.

- *As-required BOM quantities.* Some materials may not have the requisite data in the bills of material to track actual usage to orders and specific days. If no “quantity per” is included in the bill of material for the finished product, then material issues most likely will resemble floor stock transactions made periodically as physical inventory is conducted or large containers are issued.

Even companies that track consumption daily may hesitate to share the data or to invest the effort to extract data from the ERP system. Sharing data goes back to the “will” issue and may be best addressed by connecting Pull to the issues of most concern to the companies. Extracting data from customers’ ERP systems may be another matter. For commercially available applications, extracting data should be a straightforward task, although one requiring some time and effort. The data required are the consumption for each product each day. This should be an easy request for sole suppliers of products, because it only requires extracting and summarizing the inventory “issue” or “pick” transactions for each day by product SKU. Product supplied by several suppliers requires significant formatting to determine how daily consumption is meant to be split among the suppliers.

Demand Patterns

Obtaining actual demand data is the first half of the battle. Analyzing demand data is critical to understanding customers’ consumption patterns and needs. Data speak more plainly than opinions or emotions on the topic of replenishment approaches, so the focus must be hard data.

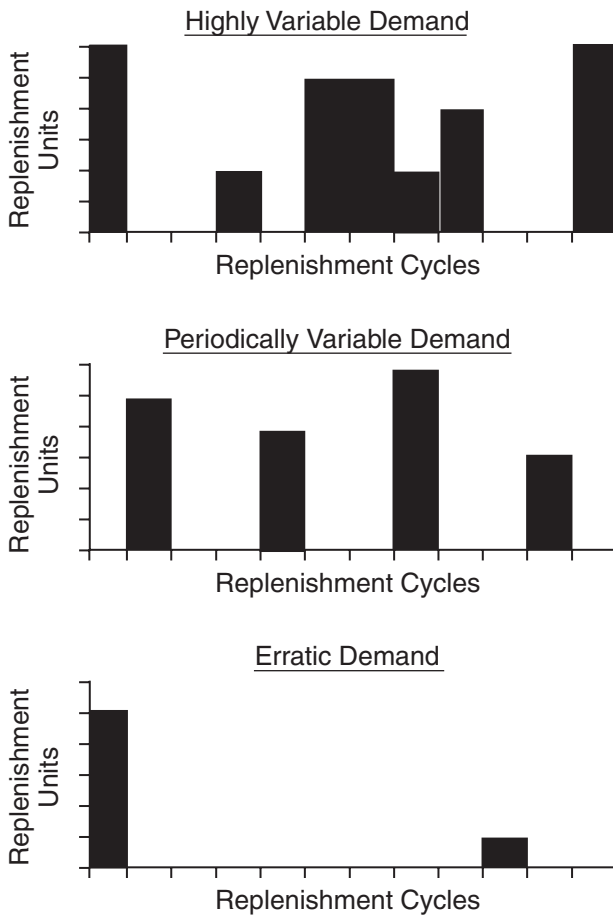
When hard data are not available, then the analysis may be based on observation and related data. Observations may be taken at the consumption site and documented over a relevant period of time. The observation seeks approximations for average and maximum consumption during replenishment time and the relationship between actual consumption and customer ordering patterns. Constructing a rough demand graph helps to envision the replenishment challenges and needs.

As actual or observed demand data is graphed, it can be advantageous to place as many customers and products into relevant categories. There are six primary demand pattern types:

- *Stable.* Consumption does not vary significantly. The specific extent of variation is dependent on the quantity consumed, ease of replenishment, and container lot size. All three should be compared to see if the replenishments will be highly variable.
- *Stabilized.* Customers schedule production, and consumption has been adapted to minimize variation. If the stable schedule does not benefit the customers' customer, then consider how to support a more variable demand since customers may need to adopt Pull with the customer at some point in the future.
- *Seasonal build.* The pattern grows as the production rate increases and then decreases. The seasonal build production rate rarely reaches the end customer's actual seasonal sales pattern, meaning that inventory grows until the season starts and then decreases as the seasonal shipments occur.
- *Highly variable.* Demand does not follow any decipherable pattern and varies in quantities larger than replenishment units. When demand is variable and significantly less than a replenishment unit, then the focus should be on ways to reduce the replenishment unit quantity.
- *Periodically variable.* Demand follows a regular schedule, indicating that customers operate in cycles, possibly one based on the number of products that are manufactured during each cycle. The cycle may not be as regular as shown in Figure 7.6, because it may be shortened or elongated by the quantities produced for each product.
- *Erratic.* Customers cannot predict or provide much warning for demand that far exceeds reasonable replenishment quantity and within the lead time of the supplier. This translates into inventory that is used very infrequently and possibly subject to a high obsolescence rate maintained at or near customers.

Figure 7.6 includes three different demand pattern types showing the quantity consumed (measured in replenishment units) during each period (replenishment cycles). Replenishment units are the smallest quantity of

FIGURE 7.6 DEMAND PATTERNS



product that is shipped to the customer. For some environments, a full truckload is the smallest quantity typically shipped to a customer. In other environments, the unit may be cases or some other quantity. Replenishment cycles are the cycle time to replenish the customer.

These examples of demand pattern types illustrate different approaches to Pull that may be required to ensure supply for the different and at times unpredictable demand scenarios. Obviously, demand patterns will vary

more discretely than shown in these examples within replenishment cycles and for amounts smaller than the smallest unit a supplier can replenish. In these cases, suppliers should leverage Lean concepts to reduce the required replenishment cycles and units. Suppliers shipping out full truckloads only (an example of a replenishment unit) should consider less-than-truckload (LTL) shipments for some customers to improve service and reduce total costs, despite the increase in some transportation costs. More discussion of this “Delivered Cost” trade-off is in Chapter 8.

Suppliers should seek to understand and to some point categorize demand patterns, but not stabilize them. As long as demand patterns represent the next level of demand, customers should likewise not attempt to artificially stabilize demand, because that invariably increases costs and may actually lead to worse service. Working to the actual demand patterns across the entire supply chain provides the most effective Lean replenishment approach.

SERVICE DISTINCTIONS

The reason to analyze demand patterns is to determine the appropriate service level and approach to meet customers’ specific needs. The key is a focus on customers’ needs rather than internal capabilities to specific service policies and approach. For example, how does providing the same great service to all customers relate to their individual needs? When dealing with customers in a mass marketing channel, this simple approach treats all customers the same. While a one-size-fits-all-strategy may appear to be the most cost effective, it tends to over- or under-serve the vast majority of the market.

Customers have unique requirements and demand patterns. Consider how many formal customer surveys and informal executive feedback requests are conducted. Many customers are over-surveyed, particularly consumers. Why so many surveys? Obviously to discover what customers want in products/service and how companies are currently performing. Current performance should be easily measured from internal data, such as shipping performance, but the surveys seek to hear whether current performance meets customers’ *needs*. Once again, the issue is to identify customers’ needs and then adjust as necessary.

Service Trade-Offs

A one-size-fits-all service approach is an optimal solution only for a homogeneous customer base. There are implications to over serving customers who are not willing to pay for the service: lost business, meaning customers may seek a lower-price product with less service. There also are implications to under serving: lost profits, meaning the price could be higher or costs lower. It can become a downward spiral as business is lost, service is improved (or price reduced) for all customers, thereby further reducing profit.

A nonhomogeneous customer base by definition would have varying degrees of sensitivity to price and service. Some portion of the market would pay more for “better” or “more” service, while other portions prefer little or no service and a correspondingly lower price. For example, companies may be offered a price discount to take additional shipments for product that is clearly not needed: that is an example of highly price-sensitive customers willing to take poor service in exchange for lower price. The opposite case to gain price increases for better service can at times be a very tricky business: too many companies have difficulty putting a tangible value on service and therefore may not readily accept a higher price. However, it is clear that service has been a differentiator used to gain or retain business that might have been lost.

Commodities are a good example of the price and service policy distinction. Prices are set for commodity products by commodity exchanges, creating a very similar price for customers in those markets. The difference between competitors can rarely be price, because market prices are so well known and set by the exchanges. Competitive differentiators can be service factors, such as consignment inventory, packaging alternatives, and fill rate agreements, which are service factors focused on customer-specific needs.

The question is how any one market responds to varying levels of service and how to provide different policies to meet the important market niches. One must look to the customers for the issues they are working to address or are confined by and seek out customer problems to find service solutions that can be proposed which will add value. Five such problems include:

- *Available space for inventory.* Customers with limited space may not be able to carry sufficient inventory for demand spikes. Suppliers that are

more flexible can respond to customer demand variation, which reduces customers' need for inventory space.

- *Demand variation.* Customers' markets may vary dramatically, making planning and scheduling difficult for all parties. A supplier that can leverage Lean Pull to improve response can add value to the customer, particularly if the supplier's product is critical for the customer's planning and schedules.
- *Linkage among inbound products.* Customers that source many products that must all come together at the same time and place provide an opportunity for suppliers. The supplier for one product that can pick up and deliver the others products at the same time in an organized "kit" ready for the customer offers better service.
- *Cost for carrying inventory.* For some customers, the cost to carry inventory may be high compared to other uses of working capital. For these customers, investing in inventories may limit growth due to their need to finance receivables, for example.
- *Difficulty tracking inventory.* In some environments, the supplier may be in a better position to track and manage inventories for the customer. In these cases, a supplier with effective replenishment mechanism and fast response can take more "ownership" for replenishment and the availability of product.

Suppliers seeking to leverage service policies must focus on customers' value equations and develop the appropriate service model to maximize customer benefit. The trick is to identify and quantify the customers' problems first, then develop the service approach and ensure that the supplier's internal capabilities fully enable the service approach. The last step is to present ideas to customers, starting with a confirmation of their problems.

Service Frameworks

There is no easy definition of service. For most organizations, service is defined by lead times, delivery accuracy, and/or fill rate. These measures take the customers' perspective on discrete orders placed. If the relationship between supplier and customer is based on the customer initiating "hard" purchase orders with an explicit delivery date, the measures may work

well. However, in the fast-paced supply chain of today, the date and quantity on a purchase order may change rapidly as markets and forecasts change, forcing traditional measures to track each revision prior to final shipment. Consider the examples of customer service policy shown in Figure 7.7: there can be multiple aspects of service and ownership of the processes to maintain a smooth flow of product.

There can be many variations on these service policies. For “make to stock,” the inventory may be held at the source, at regional distribution centers, or at a warehouse close to a specific customer to reduce lead time. The policy may limit swings in demand variation based on forecasts from the customer or allocations of capacity. The policies can be as tailored to customer groups as necessary to maximize the benefits for each service approach to the needs of both the supplier and customers.

FIGURE 7.7 SERVICE POLICY EXAMPLES

| | Make to Customer Order | Make to Stock, Ship to Order | Pull Replenish | Pull to Daily Demand | Drop Ship to Final Customer |
|-----------------------------------|--|--|---|---|--|
| <i>Service Policy Description</i> | Customers quoted lead time when ordering, based on capacity. | Supplier owns DC inventory and provides customer short lead time for orders. | Supplier replenishes to kanban signals generated by customer. | Supplier receives daily demand to trigger replenishments. | Supplier inventories and ships direct to consumer from customer's order. |
| <i>Service Guarantee</i> | On-time orders. Commitments to available capacity only. | Order fill rate. Commit to short lead time. | Fill rate and lead time for kanbans. | No stock-outs at customer location. | Order fill rate and time for shipment to final customer. |
| <i>Implications</i> | No distribution costs or assets required. Fills up capacity. | Customer orders may increase demand variation (bull whip). | Customer “owns” kanban process. | Supplier “owns” kanban process. | Supplier takes on direct-to-final customer shipments. |

A well defined framework is important to synchronize the overall customer service and supply chain operations. Everything for the supply chain and distribution flows from the service policies: how the network is optimized, where inventories are maintained, and how replenishment processes are operated. As decisions are made all along the supply chain, customer service comes first. Even when costs are being reduced or other compromises are being made, customer service is number one and trumps any proposed changes.

Delivered Profit

Customer prioritization and differentiation are key factors in defining the service policy framework. Most companies cannot provide the same amount of focus on each and every customer; there are just too many. Even for companies with only several hundred customers, prioritization is necessary to grow key markets and customer accounts. Differentiation can provide a tailored service approach to each group of customers to maximize the value added and minimize the supplier's delivered cost. Both perspectives are important to a profitable service approach to find the best mix of customer value from prioritization and then minimize delivery costs with differentiated service approaches.

Prioritization should be driven by the relevant importance and growth potential for various customer groups. How the company looks at its market potential and growth are most likely well known and understood. The traditional approach is to group customers based on sales revenues and growth. For example, the top five customers in sales revenues may garner the greatest level of attention. The main supply chain and distribution consideration for the traditional prioritization may be the impact on products and transactions in relation to the gross margin generated. Although this is not a statistically valid equation, a general principle can be stated that the delivered profitability ratio (DPR) for a customer or market segment can be represented by the "equation" shown in Figure 7.8.

Using the DPR enables segregation of large-revenue accounts that are extremely tough to serve from low-revenue accounts that are served easily. In general, the more transactions, products, and locations required to generate a given level of gross margin, the tougher the account is to serve.


FIGURE 7.8 DELIVERED PROFITABILITY RATIO

The problem:

- More products, transactions, and locations increase costs, yet they are key to increasing total revenues.

$$\text{DPR} \equiv f \{[(\text{Gross Margin } \$ - (\# \text{Transactions} \times \text{Cost})) \div (\# \text{Products} \times \# \text{Locations})]\}$$

Consider the possibilities:

- Cost of transactions is related to simplicity. 
- Product lines expand (# of SKUs) to growth.
- Number of locations is driven by service policy minus lead time.

The opportunity:

- The product and location proliferation “problem” for increasing revenues and can be addressed with Lean lead time, simplicity, and service policies.

For example, a customer buying one product from one DC should be much easier to serve than another customer buying the same revenues (gross margin) across a total of 10 products from 10 locations. The main objective is to steer away from total revenues and gross margin to prioritize customers and markets for the purposes of differentiating customer service policies for distribution.

The number of transactions can also be significant, but should be considered secondarily and evaluated in terms of cost implications. Transaction costs continue to decline and therefore should have less impact on comparing profitability streams than products and locations. Additionally, Lean streamlines processes and transactions to reduce the impact of transactions and increase the replenishment frequency, thereby increasing the number of transactions.

Significant DPR variation across customers or markets can be used to enable an effective strategy to meet profitability and not just revenue targets. Meeting a revenue target may not deliver the associated profitability target. The mix of products and customers plays a decisive role in determining the resulting profit. The DPR focuses attention on the products and customers that yield the most profit per unit of distribution complexity and helps to prioritize market efforts to achieve total profit as a more critical target than total revenues.

Flow Commitment

The results of the DPR supports aligning customers into the three service priorities: strategic, tactical, and opportunistic. This alignment defines the objective for how much of the customers' total demand or flow to support. The flow commitment is the "market strategy" that serves to delineate how the company plans to manage its own revenue and profit streams as the markets for different customers and market segments vary. As any one market or customer's demands changes, the flow commitment strategy communicates the actions expected in other markets to maintain total revenues and profits.

For different industries and customer channels, the ability to vary capacity and the available markets may be key constraints to the current flow commitment strategy. For cases with limited discretionary market available, the strategy may define the extent of market variation expected and how capacity will be matched to market conditions in the short term. Discretionary market means taking more or less of some customers demand and/or taking on other customers when desired to match total volume to capacity. A low-flexibility market is one where few changes can be made resulting in demands that vary directly with the existing customers. The capacity strategy becomes crucial for this low-flexibility market because market niches cannot be used to balance supply and demand in the short term. In the longer term, the strategy addresses how the company will seek more discretionary markets to better match markets to capacity at some point in the future.

For environments with flexible markets in the short term, the flow strategy can include more market-facing actions to achieve balance in supply and demand. Flexible markets may take many forms that allow a company to take or decline business. For example, some commodity products have efficient market exchanges where product may be readily sold in the short term. For other environments, varying commitments may be made to customers that buy from multiple sources, or commitments may be varied by product line as product markets vary. Whatever the market conditions, the flow commitment strategy must define how much of the market can vary and what actions will be taken to achieve total profit as flows to any one market, customer, or product line varies.

The time frame for the flow strategy is based on the relative lead time to adjust capacity and market commitments. The starting point depends on

which is easier to vary: capacity or market. Either way, the question is the time required to make adjustments or the time-based implications to the other component. Most organizations find it easiest to start with capacity and define the time frames and extent of variation possible. For others, maximizing capacity utilization is such a driving factor that starting with markets may provide a better perspective on what actions can be taken to balance.

Using these inputs, customers and markets should be assigned to one of the three flow commitments. For customers and markets with a 100 percent flow commitment, the implications become much more strategic to ensure a full supply as customer demands vary. The total variation must be identified and buffered with a combination of inventory and capacity, thereby making the assessment of variation and peak demands the critical component of planning. As little warning may be provided prior to a peak, these contingency plans are crucial to committing supply chain inventories and capacities to ensure the ready supply.

Planning for tactical markets must seek agreements for the level of flow commitment. The peak demands may not be critical to this process, if the agreement is based on total volumes or specifies peaks. Although this type of agreement may be acceptable to a supplier, it leaves a customer in the difficult position of filling the gaps. In many industries, this approach is taken without much regard for how the customer fills the gaps. In the high-technology industry, customers may be placed on allocation to limit the quantity of components available to them. This measure can also occur in retail for hot products, where the manufacturer may allocate product across the board or to higher-priority channels.

The opportunistic channel must identify the possible market demands and gaps. For example, can the company sell opportunistically to the tactical customers of a competitor? The opportunistic channel may need to survey many customers to prepare short-term commitments and the market potential in order to facilitate making plans to “allocate” future capacity to each market channel. These allocations can create an ongoing available-to-sell quantity for the opportunistic customer base that is revised with other market demand and production variation.

Each of these three strategies must come together as a complete picture of market potential and peak demands for capacity balancing. This has been the objective of traditional sales and operations planning (S&OP) processes

utilized widely within ERP environments. What the S&OP approach has lacked is the focus on peak demands and strategically limiting flow commitment. For the Lean supplier, segregating this level of commitment is crucial to ensure good customer relationships, because Pull would otherwise seek to fill all peak demands for every customer and product.

Buffer Strategy

Enabling the flow commitment strategy requires a combination of adjusting capacity and maintaining inventory to create a buffer against peak demands. Specifying where to place buffers, particularly inventory ones, depends on the service strategies and lead times across the supply chain. If the customer is willing to wait and accept some variability in delivery, then the buffer could be in raw material and capacity rather than finished goods. However, most customers will not wait for the full sourcing cycle time and require accurate delivery times, requiring significant inventory buffers.

The buffer strategy must start with customer expectations for response and the internal lead times. As shown in Figure 7.2, placing the inventory buffers serves to eliminate or reduce the lead times customers are willing to accept. The lead time differential is a straightforward difference between the two lead times with inventory as the separator.

In addition to a lead time buffer, inventory serves as protection against variation. The source of variation may be from demand, production, sourcing, transportation, or any other source that impacts the smooth flow of product. These variations could be accommodated with sufficient lead time, but given the constraint on lead times, they must be buffered with inventory.

Buffer inventory also is the hedge against temporary or seasonal demand imbalances. These “temporary” imbalances require a buildup of inventory over an extended period of time and then a fairly rapid outflow to customers. Capacity limits the ability to make as much as is shipped during these peak seasons, so inventory must be built over a long period of time. These peaks may be calendar-, holiday-, or promotion-related, but all are similar in that the peak is well known and lead times are long. Inventory serves as the capacity storehouse so production and sourcing have more stable schedules.

For each of these three reasons, inventory is a major component of distribution strategy. Identifying the location and parameters driving the

inventory buffers serves to delineate the distribution and customer service strategy. In a way, starting with current inventories, the customer service, variation, and capacity limitations of the entire supply chain can be inferred. The question becomes whether these current inventories match the objectives and reflect the optimal approach to serving customers and maximizing profitability. Therefore, the buffer inventory strategy is a key linchpin in managing the entire distribution network, but must be driven by well-defined service and operating parameters.

Tailor Service Approach

Customer service strategies as the driver of the entire distribution approach must be well defined and segmented. The service policy examples from Figure 7.7 show the variation in approach that could be accommodated within a Lean environment. The difficulty with all of these approaches is articulating how they apply to specific customers, market niches, and products. In the absence of clarification, service policy becomes clouded and the most stringent policy can be applied to all. In order to meet unique customer needs and leverage those requirements into internal and external distribution benefits, differentiation of service policy is necessary.

The differentiation approach should be driven by each customer's "willingness" to support Lean and Pull replenishment. Without support for Lean and Pull, suppliers will find it difficult to take the costs out of internal operations necessary to improve profit without impacting service. Going back to the segmentation framework (Figure 6.2), one must fit customers into one of the four categories and consider the Lean Pull service policies (Figure 7.7) to take:

- *Partners.* They embrace Lean Pull. The direction should be to move as close to Pull excellence as possible. Service policies of "Pull Replenish," "Pull to Daily Demand," and "Drop Ship" would be warranted. Both customer and supplier should enjoy cost savings and improved supply chain stability.
- *Collaborators.* The customers support Pull but have a difficult, unstable demand. One should utilize Pull practices to stabilize demand and reduce the lead times to replenish customer inventories. Due to variability of demand, the Pull approach must be tailored and inventory

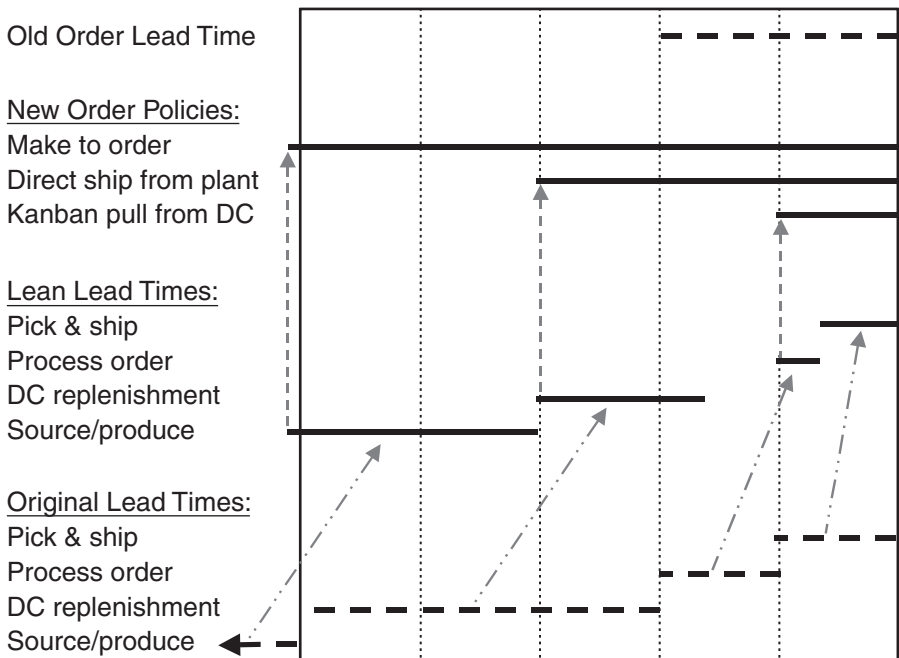
buffer location well defined. A service policy of “Pull Replenish” should be considered; for products across multiple customers that would stabilize demand variation, one can consider “Drop Ship” service models. Customer response improves with Lean, and the supplier’s costs and schedules stabilize.

- *Buyers.* Buyers are customers with stable demand, but little support for Pull or Lean. Here one should leverage Lean to drive internal benefits within operations. Buyers seem to work best to the “Make to Stock” approach that lets the customer initiate the Pull with a customer order. Lean lead times tighten the supply chain to improve the supplier’s operations and costs.
- *Planners.* Planners have a variable demand that they prefer to forecast and plan, frustrating attempts to stabilize with Lean. A “Make to Order” policy works well to synchronize the customer’s planning system with the Lean schedule. Lean provides the customer with more stable lead time.

Each service approach is highly dependent on lead times as well as demand stability. Demand stability can be improved by working to Pull and implementing many Lean practices, but lead times must be leveraged from a service perspective. As the current service approach for each customer is reviewed, the shorter lead times with Lean can enable changes and improvements in service. Figure 7.9 revisits the internal lead times (from Figure 7.5 shown as dotted bars) with an “after Lean” view. The new Lean lead times (solid bars) enable faster response by eliminating order processing reviews for the Pull replenishments, by reducing variation, and by reducing sourcing/production times.

Lead time reduction can be leveraged to improve service and reduce costs. Service improvements should be delivered to partners and collaborators by enabling faster response and tighter linkage. These increasingly tighter linkages will yield cost savings as well as service improvements, but service should be the key for these accounts. The cost savings will come from the tighter linkage across the supply chain as inventory is reduced, space is reduced, and schedules are stabilized. These improvements are enabled by transitioning from a customer-order-driven replenishment to the Pull with the lead time shown in Figure 7.9 as “Kanban pull from DC.”

FIGURE 7.9 SERVICE POLICIES ENABLED WITH LEAN



This lead time eliminates review and processing time for customer orders to make the links between customer and supplier as tight as possible.

Another example of the service and cost improvements are accounts that currently have a sizable finished goods inventory to serve their orders. Due to the relatively long internal lead times and shorter customer expectations for delivery, some inventory may be maintained as components, work-in-progress, or possibly even finished goods to respond to orders. The specific location of the inventory depends on the lead time differentials, and the size should be related to the magnitude and variation of orders. For these customers, shorter Lean lead times enable direct ship from the source, shown in Figure 7.9 as “Direct ship from plant,” meaning the new lead time is to ship the customer’s order from the source (plant) rather than from stock at a DC. By using direct ship, variability is reduced as multiple products and customer orders are combined at the source and the flexibility of inventory increased. Due to reduced internal lead times, this

customer should experience only slightly longer lead time, but with improved service.

For customers with the most erratic demand or special requirements, make to order can be a possibility. Once more, the lead time reduction in the plant and with internal process steps results in a five-week lead time to make the product to order (probably from components). Now some customers with highly variable demand or smaller order volumes can be served by making to order, further reducing inventory and stabilizing the entire supply chain.

In each example, the shorter Lean lead times enable service and cost improvements. These improvements can be leveraged to reduce inventories and move the buffer back toward the source. Every step buffers move back into the supply chain brings stability by smoothing demands from multiple customers and/or products. Stable schedules have been the goal of most operators and a source of cost advantage.

Accomplishing these changes takes confronting the service commitments to customers and pinpointing the real “need” rather than the “wants.” Lean lead times are more reliable, thereby decreasing the need for buffer time inserted by both customers or internal sales and service organizations. Eliminating the extra padding in lead times can drastically reduce lead times that enable the change in service policy. Customers not operating to Pull will be the most affected, because their orders are heavily lead time dependent.

It is tempting to give customers better service rather than to “confront” the possible change from shipping from a DC to the same orders shipped direct from the source, but better service may not be the profitability lever for the customer or supplier. Especially for non-Pull customers, providing more service without a commitment to Pull removes a possible lever to stabilize schedules and continue a win-win cost reduction.

SUMMARY

A buffer strategy is much more than specifying the location to maintain inventory. Buffers may be a combination of inventory, capacity, and time necessary to support customer demand despite internal and external variation. Inventory should be the last resort for a buffer, because capacity and other buffer strategies can be more cost effective and flexible. Inventory

buffers limit flexibility as demand and variation patterns change, resulting in excess or obsolete inventory.

Well defined customer service framework and flow commitment are the bridges between buffers and Pull processes to create effective linkage with customers. A tight linkage is highly desired to reduce “policy-based” variability such as the snowball effect and stabilize schedules with Pull. The customer service framework includes five approaches to meeting various customer needs and service commitments while enabling Pull.

Service policies are enabled by the shorter lead times and flexibility from Lean. As customers’ true needs are separated from their wants, Lean operations can respond to a variety of service policies. As the lead times decrease and service policies allow greater connection of the supply chain, variation can be reduced. By tackling both variation and buffer strategy, Lean eliminates costs that usually build up to compensate for customer demand variation.

Buffer and service framework approach comparisons can be more reliable by using a delivered profitability ratio (DPR). The DPR allows comparison of various customer flows for difficulty, distribution impact, and profit, enabling better service and buffer strategy decisions that cut across the typical gross margin profitability view.



Replenishment Cycles

Create distribution pipes and let replenishments flow

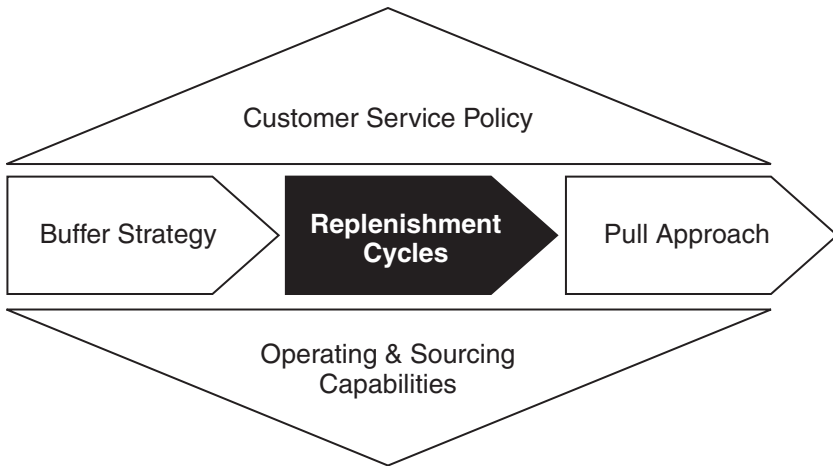
Replenishment cycles are the linkage between the selected buffers and actual customer demand. Replenishments must be determined to best meet customer service needs as well as continue to reduce costs and waste. The closer and faster replenishment connections are, the better; however, cost implications and other constraints can impact construction of the optimum cycle.

Developing the replenishment cycle depends on the constraints on demand, supply, and buffers. Each constraint must be assessed to determine what replenishment cycle meets the needs of customers and internal capabilities. The replenishment cycle binds together the buffer strategy and Pull components of the Lean Distribution approach, as shown in Figure 8.1. Components of the replenishment cycle that must be determined and specified include:

- Distribution pipes
- Replenishment time
- Delivered cost
- Demand patterns

As these components are developed, the replenishment cycle can be specified to meet the objectives for speed and responsiveness without creating undue costs in the distribution chain. In the ideal Lean world, the

FIGURE 8.1 LEAN DISTRIBUTION FRAMEWORK



cycle would enable near-instantaneous movement of replenishments out to customers after small increments of consumption. The faster, smaller, and more connected the replenishments are, the better.

THE PIPELINE APPROACH

Once the buffer and service policies are in place, Lean practices should be used to increase flexibility and reduce lead time for replenishments from the source out to each distribution point and customer location. With faster replenishments, inventories can be lower and response to changes in demand will be improved. Lean concepts have been extremely effective in accomplishing these objectives in plant operations and can be equally as effective in distribution. The processes and operations in distribution have been influenced by information technology optimization to reduce costs primarily by increasing lead times and lot sizes, so the time is ripe to refocus on increasing flexibility and reducing lead time.

As lead time is reduced and flexibility increased, there comes a point where customers' confidence in response reaches certainty. The certainty of replenishments is enabled by short lead times and consistent delivery. But how can this be accomplished with cost and other distribution realities

to contend with everyday? The answer lies in creating “distribution pipes” to deliver outstanding service, while maintaining low inventory and costs. Each “pipe” represents the delivery mechanism to specific distribution points and customer locations such that day-to-day cost trade-offs do not hinder effective response, lead time, and customer service.

The analogy for high certainty of service delivery is the water pipeline. Consumers have 100 percent certainty that when the sink faucet is opened, water will come out. Consumers are not concerned whether the water utility has planned sufficient supplies for their location. Consumers do not worry that replenishment orders are not being processed, may be delayed, or may not be filled 100 percent. The pipeline from the source to their location responds instantly and fully. Consumers do not worry about the pipeline from the reservoir to the processing plant and through all of the neighborhoods. They are assured of perfectly accurate response to the demands in each household and business.

Why does the pipeline analogy work for distribution of discrete products? It forms a visual of the objective. It provides a guideline for a quick response structure. It focuses the design and operation together for the benefit of the whole. The pipeline creates this visual imagery that solidifies how response must take precedence over local cost reduction in order to optimize all of distribution operations.

Immediate Response

The pipeline analogy brings to light the immediacy required to act on replenishments. As was previously discussed with enterprise resource planning (ERP) and distribution requirements planning (DRP) systems, replenishment orders are planned and evaluated prior to being released and fulfilled. For Lean and the pipeline approach to work most effectively, the lead time for replenishments must be short. Adding time to replenishment order processing for review, evaluation, and possibly approval increases the lead time and thereby the entire chain to the customer. The more time in the replenishment cycle, the higher inventories are and the more risk for service problems.

Daily replenishments would be ideal but are obviously not practical in many situations. In the pipeline analogy, as water is released at any one point, more flows from the reservoirs and down the pipelines, but the fixed

size of the pipelines restricts the flow to the exact amount being consumed. In distribution, the immediate response within fixed replenishment lanes brings the fast response, low inventories, and excellent service objectives of Lean. The closer each “lane” can get to the ideal daily replenishment, the better. Any diversion off this ideal process is a trade-off, probably driven by cost considerations.

Assessing individual orders increases lead times, but also diverts time and attention away from improving the process. For specific orders that are being questioned, there must be some aspect of the replenishment process that is not working. Rather than reviewing orders, the process parameters should be the focus and receive attention to continually adjust as market conditions change. The lead time, replenishment quantity, average usage, and variation parameters should receive the focus for ongoing adjustment. If these parameters are reasonable, then any adjustment of replenishment orders is strictly overriding the customer’s planned consumption levels and is akin to betting in Las Vegas: sometimes you win, sometimes you lose, but over time the house always wins.

Customers with known changes in demands should have replenishment parameters adjusted rather than replenishment orders reviewed. Advance knowledge about future demand changes, such as plant shutdowns, special promotions, and product life cycle changes, can be made within the Pull replenishment and should not require order-by-order reviews, except in unique or very temporary situations.

Guiding Flow

Working with discrete products and flexible transportation modes eliminates the “confining” aspects of the pipeline. For the water utility analogy, the size of the pipeline restricts pushing too much water out into the market, of course unless a pipeline bursts. For discrete products, ships, trucks, rail, and air carriers move product on demand. These modes of transportation have a great flexibility in volume, which enables bulges in inventory to flow out through distribution channels toward customers. If the bulge is intended, that is one thing, but frequently bulges are not intended and can divert resources and delay response to actual demand increases.

A good test whether bulges should be occurring is a comparison to demand fluctuations and sourcing. If demand is spiking, then bulges may fol-

low through distribution out to customers. This would be a good match of replenishments to demand patterns.

With plant operations, bulges can rarely occur. How frequently can a plant suddenly produce a large amount of product? It is a rare situation, probably linked to a batch operation somewhere in the process rather than a large jump in output across all operations. There may be spikes for a specific product but not for the total output of all products. Plant-driven output spikes are difficult to find and would not be the likely cause of bulges moving through the supply chain.

Inventory surges from sourcing should be the result only of seasonal or other special purchases. These surges are planned well in advance, and the impact to transportation and distribution should be anticipated.

Transportation management can restrict bulges from occurring. Transportation capacity should be matched to demand patterns. Like production and sourcing capacity, transportation can be impacted by the bullwhip and snowball effects, which are detrimental to its overall effectiveness. A more stable schedule for carriers brings cost and service advantages, which can be accomplished by eliminating the variability induced by planning and optimization efforts. As Lean-based Pull stabilizes transportation to that required for demand, there will be variability, but less than with traditional optimization efforts.

Transportation capacity can be a powerful measure and force for assessing and managing flow patterns across the overall supply chain. Transportation is the “pipeline” connecting all locations across the supply chain and should be treated as that critical delivery mechanism rather than strictly as a cost to be reduced. Clearly, reducing all aspects of cost is critical, but the most productive approach can be to minimize disruption in transportation rather than to induce disruption with attempts to reduce costs. As transportation is viewed as the capacity to link the supply chain, time and stability will be the focus as the Lean mantra is to eliminate variation and reduce lead times.

REPLENISHMENT TIME

The elapsed time to replenish inventory at any point in the distribution network is the critical driver for Pull success. The longer it takes to replenish inventory, the higher the buffer will be throughout the network

and more fluctuations possible (refer to the bullwhip and snowball effects). In order to minimize “internal” fluctuation and respond quickly to demand changes, the replenishment time should be as short as possible. Ideally it would be the next day; replenish today’s shipment the following morning. If next-day replenishment is not feasible, how fast is reasonable and what trade-offs should be made for the fastest “feasible” replenishment time?

Analyzing the current freight usage and replenishment times identifies where Lean Pull and replenishment strategies can bring improvement. As long as the total cost of distribution is the objective, these trade-offs should be made to serve customers better and enable a lower total cost. A major barrier encountered will be freight cost, which is viewed as an expense to be minimized.

Freight Analysis

The short-term trade-off for fast replenishment is usually freight cost. Replenishment time can almost always be reduced with premium freight or shipping multiple partial loads. Increasing premium freight is avoided due to the natural consequence of higher freight bills and budget overruns. This is a straightforward trade-off made nearly every day in distribution to meet service and financial objectives. Figure 8.2 shows an analysis framework that can be applied to the entire network as well as major portions to compare replenishment flows and service.

- *Distribution turns.* The inventory in the distribution pipes divided by the average demand per year (only for inventory in the distribution network).
- *Premium freight.* Internal replenishment shipments with partial loads or premium freight modes.
- *High value.* The product cost is very high in comparison to freight, making the freight expense small in comparison.
- *High weight/cube.* The product either cubes out or weights out a truck shipment long before the other parameter and/or the product cost is low compared to the freight expense, making partial shipments extremely cost prohibitive.

that pipe. Increase this total transit time by 50 percent as a starting point to compensate for demand variation. The resulting time of 13 turns (52 weeks divided by 2 weeks transit divided by 0.5) approximates the middle of the range for the distribution turns axis.

The premium freight axis may be best quantified by the lower end and middle of the scale. A good starting point for very low use of premium freight is 5 percent of shipments. In the typical environment, premium freight is an exception used to compensate for an error, problem, or unexpected customer emergency rather than used to balance overall replenishment time. The middle of the scale, which indicates a high use of premium freight, could be over half of all shipments, indicating that premium freight balances nearly all variation in the network. Keep in mind that little to no use of premium freight indicates that variation is near zero, inventories are high, or customer service is suffering.

Results of this freight analysis should drive efforts to improve utilization of freight as a balancing force and variable to optimize flow. If current freight is tightly distributed around the best mode (e.g., truckload quantities), then consider how some premium shipments could be used to respond to demand variation. Some level of premium freight is usually warranted to balance variation in a proactive manner rather than maintaining excess inventory and warehouse space.

Network Analysis

Complexity of the distribution network may be blamed for many service challenges and cost problems. Complexity is a natural reaction to the day-to-day operating environment where the conflicts of demand variation and reducing transportation costs create difficulties. This is especially true for complex networks, where small demand variation can be easily magnified. To focus improvement efforts in the right directions, it is necessary to understand the complexity of a network and how it is managed.

Network complexity is a function of the number of business process tasks and physical steps necessary to replenish all consumption points. These two factors are critical measures to segregate the difficulty to *manage* the network from the *complexity* of the network. Managing the network is the accumulation of every business process step, from forecasting to authorizing replenishment orders. The more steps and people involved in each

step, the more complex the task of managing the overall network. Likewise, the more physical moves, locations, and transportation lanes in a network, the more difficult it will be to manage; the network itself is complex.

The simplest network has a source where customers line up and wait to pick up product as it is produced. There would be no distribution costs or planning, just produce and load onto customers' vehicles. There would be no forecasting and planning: the production paces all flow, and customers are always waiting for product. This seems like a dream world with no distribution problems or costs, but the real question is: How close can the real network be made to look like this ideal?

The physical network configuration was addressed in Chapter 6 with the discussion of customer service policy. As customer service lead time decreases, networks become more complex and distributed close to customers' points of consumption. These shipping points in the network can be moved only with changes to service policy or alternative transportation that decreases shipping time in order to meet customer lead time. For a given set of service policies, transportation alternatives should be considered to reduce variation and total costs wherever possible.

Complexity of managing the network relates to forecasting, planning, and executing replenishments. The processes can become complex as the objectives to reduce costs and maintain service are addressed simultaneously. With no cost reduction concerns, planning replenishments would be a snap: take orders from each location and ship replenishments. Simplifying the replenishment process requires readily available inventory at the source or "surge inventory," as addressed in Chapter 7 on buffer inventory strategies. With the surge buffer, forecasting and planning can focus on total demands and not each location, reducing planning process complexity.

Difficulty to replenish can be further reduced with more frequent replenishments. As replenishment frequency increases, the size of inventory buffers at the points directly serving customers become smaller. Smaller replenishments avoid magnifying demand variation back through the distribution network. The point of diminishing returns for replenishment size is the smallest demand units. For example, inventory points for customers ordering in multiples of 10 units should be replenished in quantities of 10 or more. To send a replenishment of 5 units does not help an inventory of 0 since another replenishment order must be received prior to meeting the next customer order.

Once inventory is readily available, in order to be simple and fast, replenishment processes cannot be encumbered by cost restrictions. Cost restrictions, such as minimum load sizes, delay the replenishment and require time for assessment, modification, and possibly authorization. A minimum load requires holding some replenishment orders until the total is a full load, which obviously slows down the process. Although the cost reduction theme is critically important, reducing costs at the transaction level may be an attempt to optimize the last couple of percent of transportation or other costs.

Significant cost advantage may be driven by more fundamental assessment of internal replenishment points that increase network complexity. An internal replenishment point serves to reduce transportation and other costs between the source and the final warehouse that ships to the customer's location. These internal points may ship to some customers while also shipping to other internal warehouses. The internal shipments are discretionary and could be replaced with direct shipments from the source. Although changing these internal shipments may not always be prudent, such shipments should be scrutinized both to reduce the network complexity and to focus on the more significant costs.

The summary network analysis should provide the perspective for options on overall complexity to improve distribution turns. Managing the network with simple processes and replenishments may be the main thrust for business process complexity. Changes to speed up replenishments can adversely impact transportation costs in the short term, creating obstacles to change.

DELIVERED COST

Improving service and profitability with the distribution pipes approach encounters a major obstacle with functionally aligned cost reduction. Distribution as a function has readily quantifiable costs, which have been under scrutiny to be reduced. These costs can be tracked and monitored easily with financial budgets in each function or location for labor, transportation, expenses, and overhead. As orders are processed and loads are shipped, the budgets for distribution can be easily monitored and variances identified. Therefore, the main driving force across operations is the effort to reduce quantifiable costs in each of the functional budgets.

The unfortunate consequence of functional budgets is that they tend to slow down product flows. Due to efforts to reduce each functional or departmental budget, product flow becomes optimized around the impacts to budgets more than to the overall speed from source to customer. Gathering multiple orders for a wave pick in the warehouse is an example of an effort to reduce labor that tends to slow down orders. These efforts can be thought of as product flows running 200-yard hurdles compared to running a 200-yard sprint: Product flows faster with fewer budget-driven obstacles. The question becomes: At what point does the speed of product flow become a problem, despite the possible reductions in various functional budgets?

Delivered cost seeks the optimal view from a customer or product profit perspective across the organization rather than within any one function. This is a horizontal collection of costs rather than the vertical functional budgets, such as for a warehouse. Collecting costs horizontally has the advantage of providing the profitability view for customers or products either individually or in relevant groups.

Cost Reduction Strategies

Transportation costs are managed by maximizing load quantities and working to further reduce costs per load. Ship quantity optimization efforts reduce flexibility and increase lead time by holding or increasing the size of replenishments until the shipment quantity is attained. This may take the form of rounding up the quantity for existing replenishment orders and/or grouping orders into one shipment. Either way, both elapsed time and effort is required to create full-truckload quantities, which is valuable time needed to respond to replenishment signals. Even if the information systems perform the task, there can be elapsed time implications as some orders are held to wait for others to increase the ship quantity.

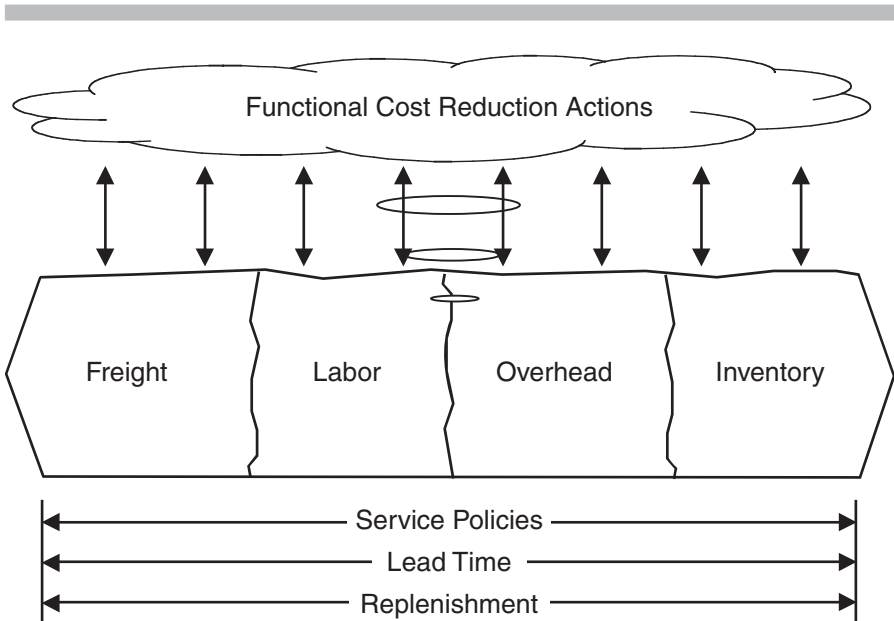
Another tactic to enable optimum load sizes is to set the replenishment quantity to the full-truckload size. Although this appears to keep the replenishment orders flowing quickly, the time between replenishments increases and thereby reduces the rate of response to changes in demand both at that specific location as well as at all others. As more inventory is “pushed” out to consuming locations, less inventory is available at the surge point and resources are diverted away from locations where demand

is increasing, causing shipments between customer or warehouse locations, higher carrying costs, and more obsolescence.

Reducing costs per load is the other half of the transportation cost optimization equation. Lowering these costs requires leveraging volumes and carrier schedules to improve pricing. However, taking the carriers' perspective shows that stabilizing schedules and providing more lead time for shipments is better than short lead times. Once again, increasing lead times to enable lower transportation costs may reduce flexibility and will increase the total lead times for replenishments.

The objective must be to reduce *total* costs rather than any one cost element, such as transportation. The total cost view enables the comparison of trade-offs across the entire distribution chain to make decisions that increase profit rather than reduce one element of cost at the expense of another. Actions taken to reduce some functional costs can have repercussions in other areas. Figure 8.3 shows a waterbed analogy to distribution costs where cost is represented by the total size of the waterbed. For the waterbed, cost reductions in one area may actually "resurface" as increased costs in another area. This is evidenced in the trade-offs to reduce freight

FIGURE 8.3 THE DISTRIBUTION "COST" WATERBED



that increase inventory and overhead (space). The total size or dollars of cost associated with distribution is the key target, rather than any one functional cost, leading to the need to focus on the cross-functional perspective of total cost.

There are three primary cross-functional drivers to manage total costs across the entire distribution chain:

- Customer service policy
- Lead time
- Replenishment

Each driver is the result of decisions and processes that impact distribution but are not controlled within any one area of the distribution chain. These drivers must be managed from a cross-functional perspective requiring very different actions for improvement across all distribution locations and other functions within the organization. For example, service policy is usually set by Sales and negotiated with the customer, despite its dramatic effect on distribution resources and costs. With sufficient leeway on time and service, an organization could totally eliminate distribution. This is not realistic for most companies but is illustrative of the impact service policy has on distribution.

Distribution's function as the buffer between internal lead time and replenishment capabilities and external customer service policies can lead to operating decisions and investment choices. Taking a cross-functional cost view of each major product or customer group enables decisions and actions on the three drivers to find the optimum balance between internal operations and external service requirements and commitments. Back to the service policy example, a more reasonable approach could be to find which customer groups or products should have service policy changes rather than attempt to change all. Finding these segments where the cost/benefit of, say, the trade-off in freight and service could be adjusted requires a view that aligns all costs around the three drivers.

Delivered Cost Assessment

This trade-off between service and transportation cost is difficult to assess when looking at just the cost dimension within distribution. The easy short-term answer is to reduce transportation, which is the most readily

quantifiable cost. However, increasing the lead time for replenishments creates service and inventory implications that can outweigh transportation cost savings. A total cost approach is required to completely assess this trade-off and make decisions that improve both service and profit.

Distribution costs accumulate as product moves through facilities and handling processes. At each process there is a fixed or variable cost created by the product movement, which should be associated with the product and customer driving the need. As the product accumulates these costs, the resulting total can be referred to as the delivered cost, which should include at least these components:

- Inbound transportation
- Receiving and put-away
- Storage, damage, and obsolescence
- Picking, kitting, packing, and shipping
- Outbound transportation

As the delivered cost is prepared, it is tempting to focus on individual products or customers, but many decisions cannot be isolated in that way and relate across many products and customers. So different distribution streams must be identified and used to decide the most cost-effective distribution paths or pipes.

Distribution pipes connect the source with each step across the entire distribution chain to customer locations. Each pipe determines more than just the transportation cost between locations; how the pipe is configured determines inventory and other aspects of delivered cost. The simplified distribution network in Figure 8.4 displays the many possible scenarios in building distribution pipes, which can be grouped into five types:

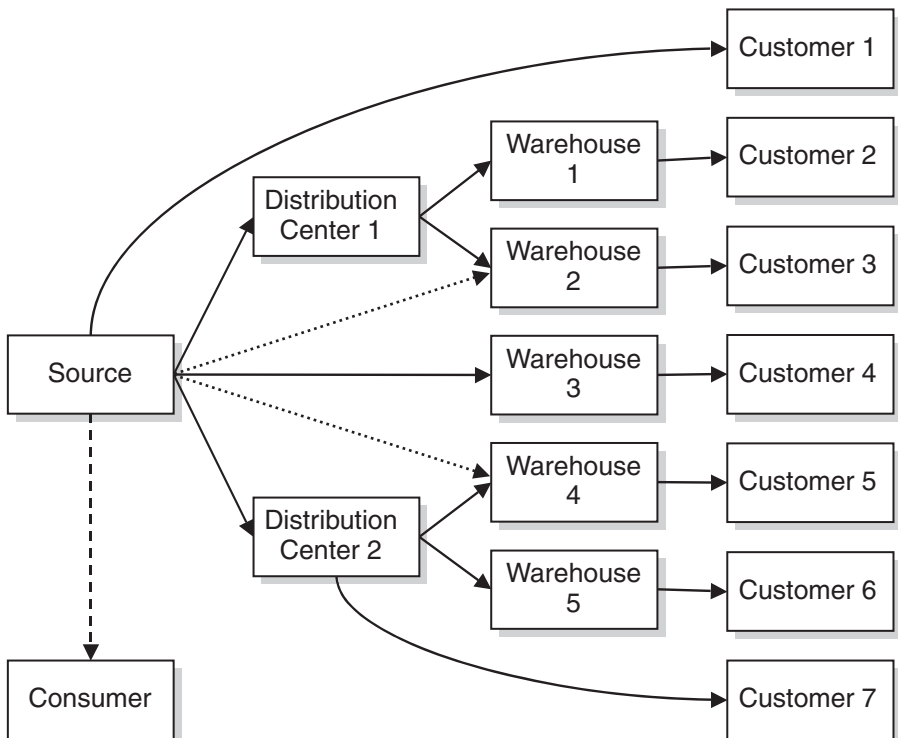
- *Direct to consumer.* Shipments go from the source directly to the customer's customer (consumer).
- *Direct to customer.* Shipments go direct from the source to Customer 1, indicating no requirement for distribution or warehouse costs. This may be a large customer with full-truckload quantity orders.
- *Direct to warehouse.* The pipe from source to Warehouse 3 indicates that the warehouse may be very large or close to the source (distribution center [DC] to customer pipe is similar).

- *Distribution center.* The DC serves multiple warehouses as a leverage point to reduce transportation costs and inventory levels.
- *Swing pipes.* Source ships to Warehouse 2 and Warehouse 4 for special promotions, peak demands, and to balance out other temporary peaks.

Total costs across these distribution pipes include all costs and investments in distribution. It may be tempting to focus on transportation and other costs reasonably traceable to customers and products, but the significant investment in assets and overhead costs should not be ignored. Adding these costs to the freight that can be tracked to specific orders provides a more complete picture of all costs associated with each pipe.

Allocations are required to reflect the appropriate amount of overhead and asset costs for each pipe to create an estimated total cost. As products

FIGURE 8.4 DISTRIBUTION PIPES



flow across the network, cost should be accumulated. For Customer 2 in Figure 8.4, the costs to prepare and ship replenishments from the Source to the Distribution Center 1 and costs in Distribution Center 1 to ship to Warehouse 1 must be added to the “local” costs within Warehouse 1 to service Customer 2 to complete the delivered cost picture for Customer 2. In this way, upstream costs at the source and DCs are collected and shown against the ultimate customer.

The total delivered cost can then be calculated and compared by the relevant customer and product pipes. Initially these might be groups of customers and products with similar characteristics rather than an analysis for each one. The analyses could then be further detailed within specific groups as required to identify customers with outlying cost profiles. Care must be taken to ensure that distribution pipe decisions are based on costs that can be influenced or changed. Be wary of how fixed costs are utilized, because the objective is to reduce *total* costs, a portion of which is challenging investments in fixed assets that could be replaced by more variable costs.

Delivered cost results provide the baseline for continued improvement in the configuration and operation of the distribution pipes. This is a step toward viewing distribution budgets in a more cross-functional and process orientation. The end objective is not to operate any one warehouse or DC better, but to operate each pipe and the total network to maximize results for each customer and the entire organization.

Cost Allocation

Delivered cost assessments require a substantial amount of cost allocations for overhead, fixed assets, labor, expenses, and inventory. Typically these costs are not tracked to individual products or customers and must be estimated or assigned for cost allocation purposes. As a customer order is picked and shipped in the warehouse, labor may not be tracked and measured against each specific order. At the end of each day, the total warehouse labor may be known for each area, but not each order. Expenses, overhead, and depreciation of assets also are not tracked to customers or specific orders. In order to obtain a closer estimate of the net margin for a specific customer or group of customers, the warehouse labor, expenses, and overhead must be allocated based on other known factors, such as orders picked and shipped.

For customer orders shipped, the time and effort to pick, pack, and process the shipment may be dependent on a number of factors, such as the number of order line items. This may be more representative than the number of customer orders if there is significant variation in number of line items and if the time and effort in this process varies with the line count. Figure 8.5 displays a sample set of activity drivers for major costs categories to the downstream location or customers.

Allocations are tricky because they may be challenged as not representative for particular situations or customers. Nearly every activity can be viewed as imperfect, an example being the number of order shipped to allocate shipping costs. Some customers or orders may be easier to ship than others. How significantly different they are must be determined to decide whether multiple activities are required, such as domestic order and international order. The key to determining how many activity drivers rests in the complexity to accuracy trade-off: the more drivers, the higher the impression of accuracy, but the complexity of the model and analyses also goes way up. The key is to find the relevant differences and add drivers

FIGURE 8.5 SAMPLE DELIVERED COST ALLOCATIONS

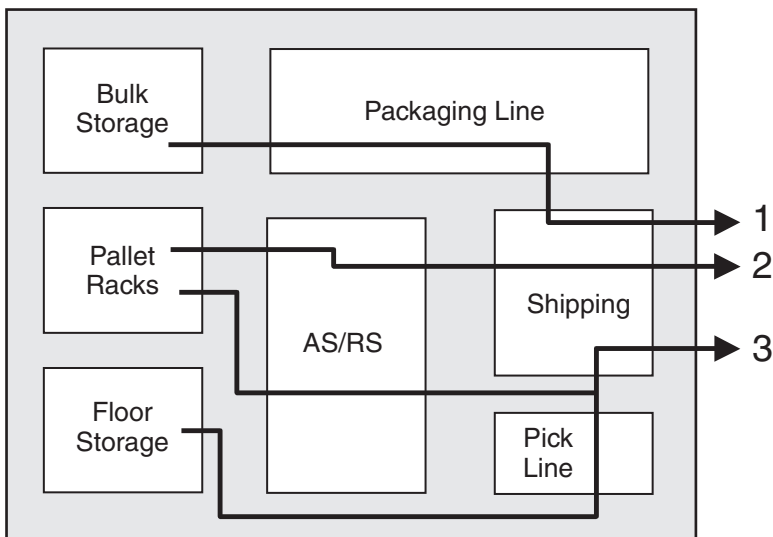
| | Source | Distribution Center | Warehouse |
|------------------|---|---|--|
| Outbound Freight | Freight billed or incurred to customer. | Freight billed or incurred to customer. | Freight billed or incurred to customer. |
| Labor | Replenishment order lines. | Replenishment order lines. | Customer order lines. |
| Space | Average product inventory. | Average product inventory. | Average product inventory. |
| Inventory | Average product dollars in inventory. | Average product dollars in inventory. | Average product dollars in inventory. |
| Expenses | Replenishment orders. | Replenishment orders. | Expense profile by product and order (2 activities). |
| Inbound Freight | N/A | Product receipts. | Product receipts. |

only for those differences. Relevancy can be tested by asking whether decisions can be made along the lines associated with the driver and the extent of difference. Ultimately, the most representative activity driver or small set of drivers must be selected. Accuracy in cost allocations is a misnomer, and attempts to achieve “accuracy” should be avoided. Any allocation mechanism can be challenged as misrepresenting “reality,” so the objective must be “directionally accurate” numbers for decision making and not absolute ideas of true costs.

Customer orders may take different paths through a facility and require different assets. Figure 8.6 shows three customer order flows that each uses various assets. Each area has a different cost profile due to the investment and costs to operate. The floor storage area is inexpensive, but takes up a lot of total warehouse space per unit of product. The automated storage and retrieval system (AS/RS) is a large capital investment, but maximizes storage density and pick efficiency. How the costs vary for each order may determine wide differences in delivered cost and the ultimate profitability view.

Allocating costs to customer orders and distribution pipes may not provide representative results. Consider the investment in distribution facilities and equipment. It would seem best to allocate these costs based on volumes

FIGURE 8.6 CUSTOMER ORDER COSTS ACCUMULATION



of transactions, sales dollars, or some other method. The difficulty lies in the fact that warehouses are located to meet customer lead time needs and to reduce total distribution costs, so any one pipe to a customer may not be the “reason” the facility exists.

As decisions are made to change pipes, allocations continue to spread the “same” asset and overhead costs rather than reducing them. If overheads are allocated to all orders, despite the best intentions of the allocation basis, then making changes to any one pipe results in more overhead allocated to the remaining pipes. This reallocation results in incremental decisions based on the false notion that costs can be decreased. It is only when a decrease in variable costs outweighs any changes to overhead that improvement is made.

Delivered Cost Calculation

After the activity drivers have been defined and quantified, a delivered cost matrix can be developed. A sample high-level matrix is provided in Figure 8.7 based on the distribution network from Figure 8.4.

The delivered cost matrix shows the four steps required to translate local costs to the delivered costs:

1. *Summarize local costs.* Use relevant categories to match local costs with the activity drivers identified to allocate costs to downstream locations and customers. Different freight modes may need to be separated if those modes have different activity drivers. An example could be parcels versus truckloads where parcels are shipped directly to consumers and truckloads to customers. The sample does not include this detail, which is required to match each type of cost to the associated activity driver.
2. *Allocate source costs.* The replenishment-related costs from the source are allocated to each next location in the network. For this sample, the source incurs \$10 million to hold, pick, and ship replenishments to the distribution centers and Warehouse 3. These are shown being allocated to DC1, DC2, and Warehouse 3 with \$12 million remaining costs associated with Customer1 and end consumer shipments. These allocations are shown with arrows from the source row.
3. *Allocate replenishment costs.* Combine the allocations of source replenishment orders (ROs) costs with the local costs and spread across the

FIGURE 8.7 SAMPLE DELIVERED COST MATRIX

| Source | Allocate Source RO\$ | | | | | Allocate DC RO\$ | | | | | Customer Order Delivered Cost \$ | | | | | | | | | | | |
|-----------------------|----------------------|----------------------|----------------------|-----------------------|----------------|---------------------|-----------------------|-----------------------|-----------------------|-----------------------|----------------------------------|-------------------|-------------------|--------------------|-----------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| | | DC 1 Allocated RO \$ | DC 2 Allocated RO \$ | Wshe3 Allocated RO \$ | Local DC RO \$ | Revised DC Total \$ | Wshe1 Allocated RO \$ | Wshe2 Allocated RO \$ | Wshe3 Allocated RO \$ | Wshe4 Allocated RO \$ | Wshe5 Allocated RO \$ | Allocated D RO \$ | Customer Order \$ | Revised "Local" \$ | Consumers | Customer Group 1 | Customer Group 2 | Customer Group 3 | Customer Group 4 | Customer Group 5 | Customer Group 6 | Customer Group 7 |
| Warehouse 3 | 4 | 4 | 2 | 0 | 2 | | | | | | 2 | 4 | 6 | 8 | 4 | | | 6 | | | | |
| Distribution Center 1 | 4 | 4 | | 4 | 8 | 4 | 4 | | | | 4 | 4 | 8 | | | 8 | | | | | | |
| Warehouse 1 | | | | | | 4 | 4 | | | | 4 | 4 | 8 | | | | | | | | | |
| Warehouse 2 | | | | | | | 4 | | | | 4 | 4 | 8 | | | | 8 | | | | | |
| Distribution Center 2 | | 4 | | 4 | 8 | | | 3 | 3 | 3 | 2 | 4 | 6 | | | | | | 7 | | | 6 |
| Warehouse 4 | | | | | | | | | 3 | | 3 | 4 | 7 | | | | | | | | | |
| Warehouse 5 | | | | | | | | | | 3 | 3 | 4 | 7 | | | | | | | 7 | | |
| Total Cost | 22 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 54 | 54 | 54 | 8 | 4 | 8 | 8 | 6 | 7 | 7 | 6 | 6 |

warehouses receiving replenishments. For DC1 this is straightforward as the RO costs are split across Warehouses 2 and 3. For DC2 this is more complicated due to the allocations required for shipments to Customer Group 7. These allocations are shown with arrows on the Warehouse 3, DC1, and DC2 rows.

4. *Develop delivered costs.* This last step takes the costs at each customer order shipment point and allocates to customers. In the example, allocations come from all locations except DC1, which does not ship directly to any customer. These allocations can be the most complicated as the more representative activity driver is sought and then as numerous drivers may be used due to the variation in types of customer order fulfillment processes. These allocations are shown with dotted horizontal arrows for all five warehouses.

The results are the total delivered cost at the bottom of each customer group column. Summing all of the delivered costs equals the \$54 million total cost for all of the “local” expense budgets, showing that these are a new view of old costs. These totals must match to show that all distribution costs are being reflected in the ultimate cost per customer group. If there are other activities occurring in distribution, such as returns and rework, then these costs must be segregated and noted. A proper accounting for all costs is necessary for completeness and accuracy.

For simplicity, activity drivers were not shown in the sample. The activity drivers are used in each allocation for the four steps and would make the sample matrix too complex to read. There should be one to four drivers for each allocation arrow above, making the allocations a complex portion of the matrix. For simplicity, all customer groups were assumed to have similar replenishment order, customer sales order and shipment volumes, except the consumer group. Allocations became equal splits in most cases rather than the complicated calculations seen in actual practice.

Delivered Cost Analyses

Reviewing the delivered costs matrix results highlights several common themes. The delivered costs vary among the seven customer groups and the consumers group. Variations should not be based on volumes in each but on the characteristics of the flows represented by the activity drivers.

Proper allocations should allow equivalent comparisons despite differences in sales volumes, number of orders, average number of line items on orders, and other factors. The total distribution costs are driven by each customer group and should be considered in assessing profitability for each group. The themes that may be behind these differences in delivered costs for each customer group may include:

- *Large differences in delivered costs between groups.* These may be caused by distance or other easily identifiable factors. The extent that differences cannot be explained or do not agree with “gut instincts” may indicate the need to further understand activity drivers and their relationships to the various groups and locations.
- *High cost to deliver impinging a group’s profitability.* Comparing the delivered cost results to gross margin calculations may lead to dramatic differences in resulting profitability, where some customer groups become much less profitable than previously thought. This is a natural result of moving from a gross margin view to total cost.
- *Significant variation in activity drivers.* Surprising results for the cost profiles and usage of each activity driver may also be cause for further analysis. Differences in the warehousing costs for activities shown in Figure 8.6, for example, may identify concerns for pricing and customer service policy changes.

As the delivered costs matrix is further analyzed, the parameters that can be changed or better managed should be in the forefront. Categories of these costs may include:

- *Order characteristics.* Some customers are easier “to serve” than others. The delivered cost analysis should distribute more cost to those with difficult service profiles: less volume per order, more line items, pick time, packaging requirements, and many other aspects of orders that may require more time, expense, or space. Order policies may be a critical driver of these requirements.
- *Freight versus overhead.* The distribution network probably was modeled to minimize total costs by strategically locating DCs. This may not result in the lowest delivered cost for each customer group. The freight costs for one particular group may be less significant than the

allocation of overhead, creating differences in the delivered cost. As overhead becomes a larger factor than freight, more direct shipments may be appropriate.

- *Inventory requirements.* Inventory costs can be invisible and elusive until the delivered cost calculation forces allocations. The allocation points out the levels of inventory to support customer groups. The real drivers of these different inventory levels are lead time, replenishment process, and variation.

Going back to the waterbed analogy in Figure 8.3, the three factors of service policy, lead time, and replenishment may be the keys to addressing concerns. How each of these three factors is managed can frequently deliver more cost reduction, enhanced service, and profitability improvement than focus on functional costs such as freight.

SUMMARY

Distribution networks historically were designed to meet customer service requirements and minimize freight costs. The networks were operated to those objectives as well as to reduce all remaining distribution expenses. Yet the cost waterbed scenario applies to distribution: pushing one set of costs increases others or impacts customer service. The goal must be to lower the total water level, meaning lower total costs.

Network designs rarely consider variability and are planned to always use the lowest-cost freight. Variability is the main driver of customer service problems and cost exceptions, yet it is not well integrated into network designs, operations, and expectations. How variability is addressed may be found in the current levels of inventory and nearly single-minded emphasis on lowest-cost freight. Some level of expedited or partial freight is necessary to properly accommodate variability in order to retain stable transportation schedules that enable the lowest-cost freight for the remainder of shipments.

Distribution pipes are designed to enable smooth replenishments while minimizing *total* distribution costs. This total cost approach is described as delivered cost to emphasize the customer focus to the total cost equation that integrates the customer service policy and buffer strategy into replenishment cycles design. With a well integrated approach, total costs can be reduced and the waterbed scenario can be avoided.



Pull Approach

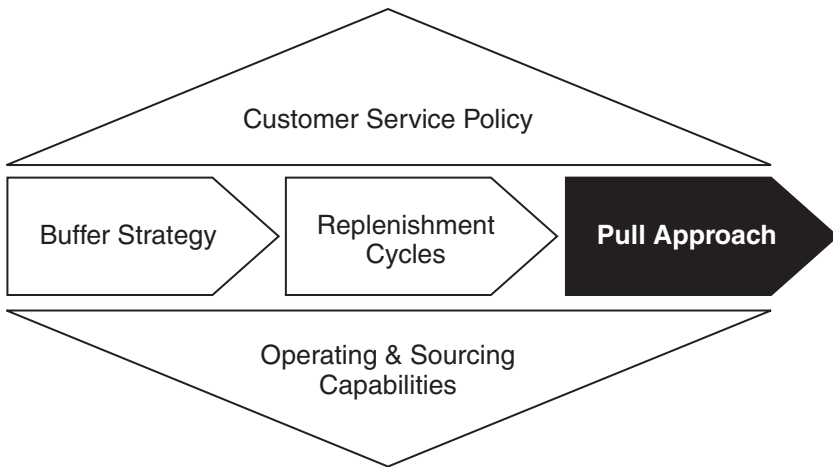
Customer orders are rarely Pull demand

Pull approach is the final link between customer requirements and internal operations and suppliers. This link is both a physical distribution of products and services as well as the information to connect and synchronize operations. Although the link must be fast and responsive, it must first be built on solid data that are representative of demand and characteristics of flow in order to replenish most effectively.

The starting point for Pull data is demand, which frequently may be confused with sales or shipments. Demand data relate to the actual consumption of product rather than an interim shipment or transfer. For example, shipments to a customer's distribution center are not the same as the customer's consumption despite being treated as "sales" in financial records. The difference is replenishment processes within the customer's operations that can cause bullwhip effects; therefore, Pull must be driven by demand data.

Demand data can be combined with the customer service policy, buffer placement, and replenishment cycle to establish the Pull approach that links with the customer. As shown in Figure 9.1, Pull completes the linkage by leveraging operating capabilities to meet customer service requirements. The right combination of these components results in smooth replenishment of inventories and fast response to changes in demand required for excellent customer service. The Pull approach is specified by the trigger for replenishments, replenishment order process, inventory targets, and measurement processes.

FIGURE 9.1 LEAN DISTRIBUTION FRAMEWORK



Pull should synchronize upstream flows to actual demand and initiate replenishments to the consumption point. In a Lean world where waste is eliminated, as each unit is consumed, another is fed into the replenishment “pipe” for delivery to the consumption point. This linkage should be tight with as little delay or lag time as possible. Time is the enemy of fast response and excellent customer service, so Pull must focus on speed and incremental replenishment.

Incremental replenishment relates to matching replenishment and consumption quantities. For example, shipping a replenishment order (RO) today for the quantity consumed yesterday would be incremental replenishment. In today’s environment, an incremental replenishment approach encounters challenges from the policies intended to limit cost or impacts to operations. Shipping full truckloads to customers may reduce freight but is an impediment to replenishing as consumption occurs. These policies and trade-offs were addressed in the delivered cost analysis, the results of which should guide considerations in setting replenishment quantities and policies.

Response time involves many aspects of the total cycle for replenishment of physical consumption. Time starts when consumption occurs and ends with the receipt of the replenishment at the consumption point.

Within an ideal Lean world this would be the transportation time to the customer; however, there are many steps required to identify, initiate, and complete a replenishment, which must be considered. Time delays occur for a variety of internal and external processes, not the least of which is identifying when consumption occurs.

PULL TRIGGER

The first step to synchronizing flow and initiating replenishment is determining when to trigger action. In a pre-Lean world these replenishment orders were triggered by the customer's systems that tracked inventories and forecasts, but with Lean the trigger can be driven by actual demand. Identifying when demand, or consumption, occurs and how much was consumed is the starting point for triggering replenishment.

Developing the trigger process includes more than just obtaining demand data. This is the starting point and one for customer and supplier to initially agree on, but the remainder of the process is critical. How and when the customer provides data may be constrained as well as how prepared a supplier is to use the data. Last, all parties must agree on the approach to initiate the replenishment to maintain a high level of confidence in how the process will provide excellent customer service.

Define Demand

Consumption, demand, customer usage, and sales are just some of the terms that describe the customer's actions to put a product into use. Each term may have a different meaning and could create confusion about the trigger point. A clear definition of demand is a mandatory first step to specifying the trigger point and capturing data to synchronize flow. In most cases, a company's sales will not be the same as the customer's demand. Time phasing, order policies, and many other factors create a difference between the demand for a particular day and the supplier's sales to that customer for that same day.

Flow synchronization should focus on a specific and agreed-on point where customers transform the product in their process, which is called consumption. That point represents an irreversible step in the flow that is directly connected to final consumer consumption. Consider movement

of inventory through a distribution center (DC) that may be related to increasing inventory at a stocking point rather than to replenish consumption. The supplier may or may not be required to replenish the DC inventory, depending on whether the DC target level has changed in relation to that at the consumption point. So shipments out of a DC probably are not triggers for replenishment, but net changes to inventory target levels are.

It may seem counterintuitive to think of DC shipments as not being “consumption points,” because the DC may be the next step in the supply chain flow. For our pipeline example, it would seem that each shipment from a DC must be replenished, but the assumption with a pipeline is that inventory cannot be increased or decreased along the pipe. Because inventory is consistent across the entire pipeline, each movement represents consumption at the very end of the pipe. The possibility for movement to be caused by inventory changes is one of the clearest signs that a specific point may not be the most representative of consumption.

Defining the consumption point requires assessing how it impacts the overall supply chain flow past the customer. Some of the characteristics of a consumption point include:

- *Irreversible.* The customer would have great difficulty moving the product back into stock and returning it to the supplier for credit.
- *Impacts total supply chain flow.* If a stock-out occurs, then total flow to the ultimate customer is impacted.
- *Measurable.* It can be reported daily in the normal course of events. These may be estimates based on an actual measure of final product production, such as using back-flushing to estimate raw material usage.
- *Ownership changes (usually).* The customer has taken legal ownership of the product, although some contracts may postpone this until the customer ships the final product to its customer.

Defining the consumption point must also consider the supply chain and Lean aspects of flows past those influenced by the supplier. An example could be a customer that builds significant finished goods inventory and then stops buying materials or requests to return materials. These and other indications that the customer’s production or distribution is not synchronized with the market should be addressed in the service policy to determine whether Pull replenishment can be achieved.

Obtain Customer Data

The availability, source, and accuracy of data may be limiting factors in both identifying the consumption point and obtaining actual demand data. A preferred consumption point may prove to be unworkable due to data constraints. If the data are not available or accurate, then another point may need to be selected. Although this may be suboptimal, the pragmatic aspects of moving forward with Pull may outweigh the time and cost to collect and report demand at the point most desired.

With the preferred consumption point identified, the process to obtain demand data may be developed. The optimal solution may be a daily electronic transmission of demand between information systems, although this may also create the most complex process and data requirements. A proper balance among complexity of the process, availability of data, and timeliness is crucial to effective replenishment.

For customers with reasonably current enterprise resource planning (ERP) applications, obtaining demand data should be fairly straightforward. The data structure and definitions should be assessed to determine consistency with the characteristics of the consumption point. The depth, accuracy, and timeliness of data depend on how the ERP application was implemented and tailored, indicating that the proper relationship to the physical process cannot be assumed. Some of the ERP-related conditions and limitations to be aware of include:

- *Back-flushing.* Material consumed in the process is not tracked and entered into the system for each production lot. The output of the process is tracked and then raw material is “assumed” to be used in the quantities designated in the bills of material. Adjustments are made periodically as physical inventories are conducted for each of the raw materials and reconciled with the system.
- *Floor stock.* Materials are stored in open containers on the floor and are not issued to specific production orders. Actual consumption is reported similar to back-flushing.
- *Stockroom issues.* Discrete issue transactions are performed for materials leaving the stockroom for production. These issues may precede actual production as material is kitted and staged. For some products in large containers, an entire container (e.g., a 55-gallon drum) may

be issued with the expectation that only a portion will be consumed and the remainder returned. These issue and return situations may cause additional variability in demand data.

- *Yield and scrap factors.* These may be separate quantities used to adjust planned requirements and issues for production or could be included in the bills of material quantity per unit.
- *Inventory accuracy.* Changes to inventories from cycle counts and physical inventories must be included in adjustments to targets or consumption.
- *Unit of measure conversion factors.* These are automatic conversions from supplier to inventory or issue units of measure. A supplier may ship in cases, and the customer may inventory and issue in units of each.

These factors should be taken into consideration in interpreting data from the customer's system. Extracting and properly formatting the right data are crucial to avoid synchronization or computational errors.

Replenishment Trigger

Transitioning from customer-planned replenishment orders to demand-driven Pull is the preferred method to initiate and manage flow. The customer's order preparation logic nearly always inserts variability into the actual demand profile, which is a source of waste, inventory, and disruption. But customers may be comfortable with current ordering processes and the knowledge that inventory has always been available. For situations with current service concerns, a transition to pull may be easier than one that is currently operating smoothly. In each case, the Pull process must demonstrate a superior approach to replenishment through faster response and surge inventory.

A transition to Pull with the customer must be based on a mutually agreed-on process and parameters. Working with the customer on the process provides clear and articulated steps everyone understands. These process steps may be different for various accounts due to the availability of source data and the unique operating conditions at the location. Some of the conditions to be aware of that may require tailoring the Pull approach may include:

- *Flow commitment.* The service policy for a particular customer may limit the commitment for volume that must be included in processing to limit total replenishment quantities over the specified time horizon.
- *Inventory constraints.* The customer may not have space or facilities to store sufficient inventory to cover demand variation during the replenishment lead time. This situation may require more frequent replenishments, despite transportation trade-offs. Facilities may also have upper limits such that replenishments can only “fill up” the vessel or space.
- *Demand relationships.* Demand may be linked to other processes within the customer, suggesting that inventory should be ordered based on the downstream operation schedule. Doing this requires assessment of the stability of schedules to determine whether replenishments could be triggered based on starting a production run rather than after consumption.

There are other reasons to tailor the Pull approach, but these are the main differences that may be encountered initially. Customers may raise a variety of issues and concerns regarding Pull with the intent to maintain control over the replenishment orders. Efforts by customers to control replenishment should be investigated in order to address the real concerns and enable support for Pull.

As the approach is tailored, the main emphasis should be on the direct connection to actual demand rather than forecasts or plans. Going back to the service policy discussion, if plans can be developed in order to generate future orders for product, then that customer probably should be on a make-to-order basis rather than Pull replenishment. As a make-to-order account, the customer would plan and generate the orders with sufficient lead time for the supplier to make to order.

The Pull trigger may be performed in three primary ways. Figure 9.2 shows the three main approaches along with some positives and negatives for each. These three approaches may be described as:

1. *Daily Demand.* This provides the actual demand data to the supplier for analysis and action. The supplier owns the replenishment process and provides the customer with an advance ship notice, using

FIGURE 9.2 REPLENISHMENT TRIGGERS

| | Daily Demand | Customer RO | Physical Kanban |
|-------------|--|---|---|
| Description | Customer communicates actual demand quantities each day. Supplier determines and initiates RO. | Customer and supplier agree on replenishment parameters customer uses to generate and issue RO. | Material handling or shipping container used to control pull (returned empty bin initiates RO). |
| Positives | Replenishment trigger may be easily modified as demand patterns change. | Provides customer with confidence RO are initiated when necessary. | Simple and effective process. Physical and visual. |
| Negatives | Supplier may need to maintain inventory and demand data separate from sales. | Changing RO process is more difficult and time consuming. | Requires container return. Lag time for return. Limited demand visibility. RO limited to container size. |

agreed-on parameters. Suppliers are able to monitor demand to quickly adjust replenishment process parameters. Daily demand should be the preferred approach to make demand transparent for suppliers that have the information systems to separate customer demand data from shipments and sales data.

2. *Customer RO*. The customer uses the agreed-on replenishment processes and issues replenishment orders (ROs) to the supplier. Customers with inventory ownership and having the information systems capabilities may be well suited to generate Pull ROs.
3. *Physical Kanban*. The kanban may be a card, container, or other device that signals inventory is required. The kanban process is simple and visual, so it works well for companies with limited systems support or that desire to implement prior to systems capabilities being available. The main disadvantages relate to the accumulation of demand into the kanban quantity and the elapsed time and handling required to return the physical kanban.

These three approaches differ in the lead time, communications mechanism, and responsibilities for the RO generation process. The characteristics to evaluate when comparing and selecting one of the approaches should include:

- *Lead time.* Response time may be significantly increased with one of the alternatives, posing risk to smooth flow. The longer the replenishment lead time, the higher inventory and average replenishment quantities will be magnifying demand variation.
- *Information systems.* Customer and/or supplier information systems may be unable to support the data collection and transfer.
- *Ownership.* For inventories owned by the supplier, a higher responsibility would naturally be warranted for the replenishment process; the only concern for the customer is a continuous supply of product.
- *Flexibility.* As demand patterns change, so must replenishment parameters. The time and difficulty to modify the Pull replenishment parameters may reduce responsiveness for situations with changing demand patterns.

As each alternative is assessed, the focus should be on optimizing the total flow and maintaining fast response. Kanbans may be used initially to pilot the process or as a temporary solution as systems are put into place, but whatever approach is used, the intent needs to be working toward communicating and acting on each demand occurrence.

REPLENISHMENT ORDERS

Whatever Pull approach is utilized, some type of replenishment order will be needed for the supplier's and the customer's systems. These orders serve to track inventories, prepare shipping documents, and record sales for the supplier and track the purchasing process for the customer. ERP order processes have some inefficiencies and time delays that may be the major concern from a replenishment viewpoint.

Actual demand triggering Pull orders is another difference with traditional replenishment orders, which creates some confusion in some ERP applications. Because ERP planning operates from forecasts, there should be a series of planned orders being "pushed" that might collide with the

Pull replenishment orders. This collision of orders must be confronted and resolved to minimize confusion.

Order Processing Steps

The total replenishment cycle time, including replenishment order time, determines the speed of response, which is a critical factor in service. Referring back to Figures 7.3 through 7.5, the lead time for replenishment order preparation and processing may be a significant and highly variable portion of the total replenishment time. Therefore, the order process should receive the same attention and flow mapping as production processes. Figure 9.3 provides a summary view of typical steps in an order process to highlight that a value added analysis can be an appropriate step to streamline order processing.

Once mapped, the order process steps should be improved and controlled similar to production processes. Eliminating non-value-adding (non-VA) and automating value added steps should focus on the time factor to

FIGURE 9.3 REPLENISHMENT ORDER PROCESSING STEPS

| Process Step | Value Added (VA) | Non-VA |
|------------------|------------------|--------|
| Enter | ✓ | |
| Validate | | ✗ |
| Price | | ✗ |
| Check credit | | ✗ |
| Commit inventory | | ✗ |
| Commit delivery | | ✗ |
| Pick | ✓ | |
| Build load | | ✗ |
| Ship | ✓ | |
| Track & report | | ✗ |

continually reduce total replenishment cycle time and decrease variability in the time to process orders.

ERP Processes

ERP driving orders by push and replenishment orders triggered by Pull can result in “collisions” at order release time. Inventory planners and customer service representatives may be in the middle of these collisions as an ERP report indicates one set of orders for release while Pull creates others. Collisions should be avoided.

Figure 4.4 shows the ERP planning logic that pushes orders to release. As each order moves closer to the current time (week 1), an ERP action message will be issued to release the order for picking and shipping. But the process must wait for a Pull to trigger the replenishment rather than allowing ERP to release a replenishment order, so the planner will continue to receive ERP release messages until the Pull or another action is taken. The question then is: What action or approach can be taken to eliminate these distractions?

A reaction may be to ignore or turn off systems planning programs and rely solely on Pull. The short-term collisions could be eliminated, but enterprise-wide longer-term planning would be eliminated as well. The fact that there are many critical uses for these plans in Purchasing, Customer Service, Finance, and Operations suggests that another approach is needed.

The collisions occur due to the mismatch between the ERP plans and actual customer demand. Plans and demand will always be out of sync because forecasts will always be inaccurate. An approach to mitigating the collisions is to continually adjust the forecast as actual demand and replenishments are obtained. In this way, the forecast is “consumed” by the Pull replenishment orders that have taken the place of customer orders. If Pull exceeds the forecast, then the service policy determines how to address the extra in order to keep the overall plan in balance. Conversely, if the Pull quantity is less than the forecast, decisions may be required to reallocate the forecast to other customers.

Using the Pull approach, the role of a planner shifts from order release to monitoring Pull and keeping the plan in balance with the changing forecast. The planner’s role shifts from merely reviewing and releasing orders

to managing the overall flow. Flow management requires more business decisions and judgment, yielding a better plan and enabling the balance necessary to maintain operations that work to Pull.

INVENTORY TARGETS

Pull requires sufficient inventory to meet customer service lead times and buffer against variation. These two factors were considered when establishing customer service policy and buffer strategies. A level must be calculated and maintained for Pull to complete the tightest possible linkage with customers, which requires a lean but sufficient inventory. If there is too much inventory, waste will undermine Lean disciplines and extend lead time. With too little inventory, stock-outs or excessive expediting occurs. The proper balance must be sought so Pull operates effectively and enables the ongoing elimination of waste.

Setting and maintaining the target levels for these inventories is a critical ingredient for Lean success. The level of inventory should be set to instill confidence and allow adjustment as operational parameters change. The connection between parameters such as lead time, demand variation, and customer's usage patterns are paramount to setting consistent inventories and making modifications to levels over time.

Target Calculations

Calculating inventory targets should enable consistent results for the service policies across all products and customers. For many companies, inventory levels are set using broad averages across many products. Although this may seem to provide the same great service for all items, each product and inventory location has unique demand patterns, lead times, and replenishment needs that make generalizations suboptimal. In order to provide consistent customer service, the unique aspects of replenishment and demand must be incorporated into the calculation for each product's inventory.

Faced with setting inventory targets for many hundreds or even thousands of product/location combinations, historically some rule of thumb has been used. The rule may have been a number of weeks to maintain in inventory, which made calculating a target for each product/location straightforward using an average demand. Unfortunately, these simple calculations

assumed that the key drivers for inventory across all products were similar, which is rarely the case, especially in regard to demand variation.

Simplicity of calculation needs to yield to the rigors of statistics and quantitative methods to improve the match of inventory for the desired level of customer service. The inputs to calculating targets for lead time and demand variability are unique for each product and location. Unique quantities must be used in the calculations for inventory rather than a general average applied across many items to yield an inventory target by product/location. These unique calculations then can be updated as Lean practices improve operations or demand variation changes.

The target formula applies all of the replenishment and demand parameters into a rather straightforward calculation shown in Figure 9.4. In this formula, variation provides the “safety stock” necessary to cover peaks in demand. If there was no demand or supply variation, then inventory could be the exact amount necessary during the replenishment time. Variation may be initially set to 0.5 (representing 50 percent variation) when no quantification is available. This has proven to be a reasonable value for many environments and can be modified as actual inventories are monitored.

Some of the factors to consider when calculating inventory targets:

- *Maintain a consistent definition for “days.”* For average shipments per day and replenishment time, ensure that either workdays or calendar days are utilized for both.
- *Quantify demand variation.* Use statistics to calculate variation that incorporates 96, 98, or another percentage of the occurrences.

FIGURE 9.4 TARGET INVENTORY CALCULATION

$$\text{Target} = \text{Demand} \times \text{Lead Time} \times (1 + \text{Variation})$$

Where:

- Demand = average consumed per day
- Lead Time = replenishment time in days
- Variation = factor to reflect all variation (typically >0 and <1)

- *Segregate supply variation.* The quantity and lead time to replenish have some variation, which may be significant. Replenishing a warehouse from a distribution center may present minimal variation with fixed transportation schedules and readily available inventory in the DC, but replenishments from a supplier or plant may vary sufficiently to categorize and track.

The target calculation formula may be expanded further to reflect the actual complexity of the operating parameters. Starting with the simple formula overcomes some resistance to change by using data that are more readily available or can be estimated, but still instills the critical dimension of specifying lead time and demand variation. Complexity should be added as more data are available for the operating parameters, particularly for variation.

An initial expansion would be to split variation into supply, lead time, and demand. These three factors relate to different aspects of the replenishment cycle and can be quantified separately. The variation in each of these components requires different actions to manage and reduce, so separating them improves the target calculation and enables more detailed monitoring. The downside is added complexity and effort to gather data that may not be currently available.

BUFFER MANAGEMENT

Once target levels are set and replenishment processes are operating, the ongoing work begins to manage the inventory buffers. With Lean-based Pull processes, the planners should be able to spend less effort on the day-to-day replenishment orders and can focus more on managing the total replenishment process, which is called buffer management. The key ingredients of buffer management entail adjusting the inventory target levels and replenishment process parameters in order to maintain expected customer service levels.

Target-level setting is not an exact science and requires tweaking to fit the service levels and operations for any specific environment. The operating parameters and variability factors will never be perfect; levels must be monitored and adjusted. It is better to start managing the buffer levels with the expectation that adjustments are necessary, rather than to attempt to

find the perfect factors and level. Time and effort will always be required to monitor and adjust levels as conditions change.

Variability Considerations

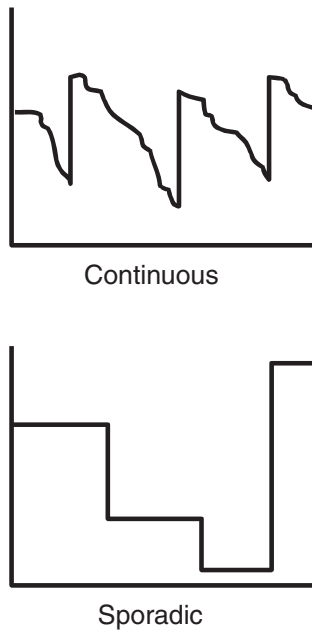
Because variability is a major driver, it should be quantified using statistics rather than emotions, gut instinct, or rules of thumb. The statistics initially may be crude, such as highs, averages, and lows, but over time they should become more sophisticated to improve service and take the guesswork out of the buffer-setting process. By setting a numerical value for variation and tracking the actual, even initial crude quantities can be revised to be moderately representative.

The next step in managing target levels is to define what is different about the requirements and operations for each unique product/location combination. Each customer probably does not have the same type, size, and configuration of equipment and would have different ways to schedule and operate, causing major differences in consumption patterns.

- *Continuous operations.* For these operations, the product is consumed or used very frequently, often enough that peaks and valleys in usage are manageable—say, less than 30 to 40 percent swings for average period-to-period usage.
- *Sporadic runs and usage.* The operation runs or uses the product sporadically based on market and operating conditions. Usage appears to be near binary, meaning it is on or off, but little in between.
- *Make to order.* Usage must be scheduled and planned in advance or the product would be outdated or unusable. Schedules must be linked rather than linking actual usage with replenishment.

A method to better visualize these differences is by graphing inventories. One should try to picture an inventory sawtooth graph for a particular customer or product where the daily inventory position is plotted over time, usually by days (quantity in the vertical axis and time on the horizontal axis). That graph will tell a lot about replenishment processes and consumption in order to identify how well the customer is currently being served. Example inventory graphs are shown in Figure 9.5. These are graphs of inventory at the consumption point. If these types of data are not available,

FIGURE 9.5 INVENTORY GRAPHS



then the linkages in the chain are very loose. There cannot be tight linkages without a clear view into point-of-use data.

For distributors, the usage patterns are for sales and shipments, because they may not perform any conversion. For example, there would be a big difference between a product that is purchased in 55-gallon drums and sold one gallon at a time compared to one purchased in drums and sold in full drums. Why is there a difference? When a product is sold by a distributor in much smaller quantities than purchased, the timing for replenishment may be a consideration, as may be reducing the container size. For the supplier, the same may be true because selling larger containers may cause unnecessary production spikes.

Environments where the replenishment quantity is much larger than quantities sold, as in the continuous example of Figure 9.5, provide excellent opportunities for simple replenishment and extensive cost improvement. Lean replenishment cycles should flatten and lower the sawtooth to both reduce costs and lower inventory, while responding to demand peaks faster.

As demand changes become more pronounced, as in the sporadic example of Figure 9.5, simple replenishment processes may be challenged if not balanced. There are two factors working against any replenishment model with sporadic demand: the factors driving the quantity and time between spikes. The objective must be to understand the drivers and then modify supply characteristics to match usage. Accomplishing this may be tough for most organizations, because they are focused on their own operations and not those of their customers.

Buffer Zones

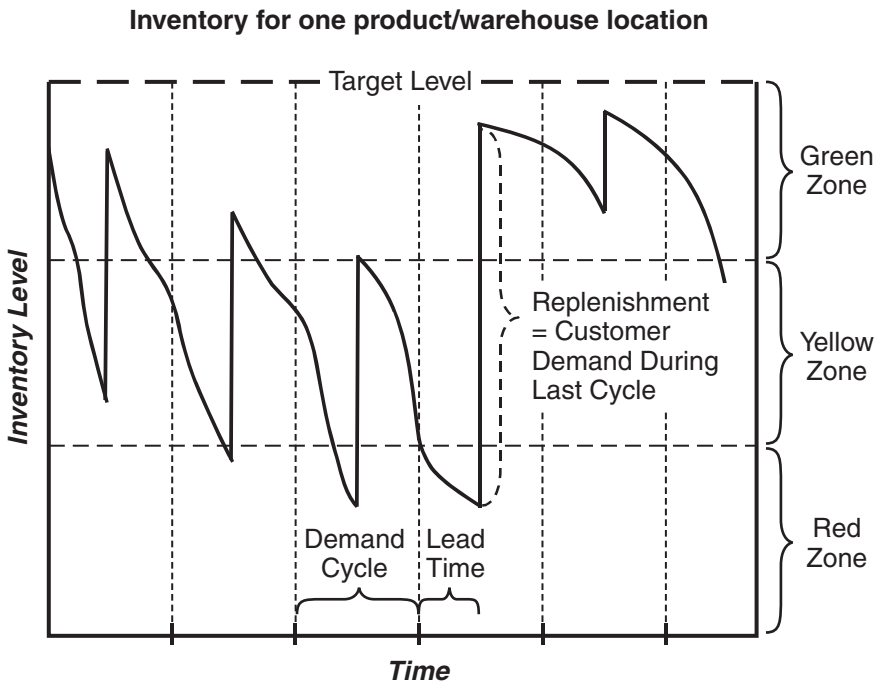
Buffer inventory can be split into three zones that segregate the total inventory target for monitoring and action. Similar to a street traffic light, these zones can be represented by the colors green, yellow, and red to indicate whether action is required. Like a traffic light, green is full speed ahead, yellow indicates caution, and red indicates that a stop is imminent.

Actual daily inventory levels should progress through all three zones over the course of several replenishment cycles. As normal demand replenishments occur, inventory will naturally dip into the yellow zone, but in most cases a replenishment order should arrive prior to reaching the red zone. However, products should at least occasionally reach into the red zone, or inventories may be too high. Figure 9.6 shows a sample inventory graph where the level dips into the red zone as demand spikes during two replenishment cycles.

The three zones can be described as:

- Green “*demand*” zone is typically “good,” but not always, because products that are too frequently in the green may have too much inventory. This zone represents the quantity required to meet demand prior to a new replenishment cycle. Demand quantities are significant when production runs consume sporadically.
- Yellow “*replenishment*” zone is a solid working level that shows demand has consumed inventory and replenishment is required. This quantity is driven by the replenishment lead time.
- Red “*variability*” zone is not necessarily “bad,” just an area where replenishment should be in process or may require monitoring. It is set to accommodate the variability in demand.

FIGURE 9.6 WAREHOUSE REPLENISHMENT CYCLES



Initially these definitions may seem complicated, because they may not be easy to identify separately. The important point is to recognize the individual components of the target zones and work to refine the calculations over time.

An initial approach to zone setting is to use the rule of thirds. Each zone should be set to one-third of the target level. This approach is not scientific but does yield zones that can be monitored and modified as actual demand and supply patterns emerge. In actual practice, this approach has proven to be a worthwhile starting point for the buffer management process.

Zone Measures

Once the zones are established and can be tracked, the daily status for all products across these zones can be used to monitor overall inventories and the health of replenishment processes. The inventory at each product and location combination is meant to move through all three zones over time,

so on any one day, the actual distribution of all the products by zone should be indicative of the replenishment process's health. If there are too many in the green zone, inventories may be high or demand may have slacked off. Conversely, too many in the red zone may indicate problems with replenishments or higher demand across the board.

In an ideal world with no variation, the red zones would be very small. For such a case, inventories for all of the products would be in the green and yellow zones. However, until that ideal world of no variation is reached, the red zone will be important and inventory will regularly dip down into the red. The question for the monitoring activity to answer is whether there are too many products in the red zone.

Summarizing and trending the snapshots for all of the daily inventories by product and location can be zone measures. The summaries are of the number of products, the inventory investment, and/or the quantity of product in each zone, depending on which measures are most relevant. The counts of products and quantities across all of the products can be in some of these forms:

- *Time in a zone.* The length of time a product has been in one zone may indicate need for action. Products in the red zone longer than the replenishment order cycle require expediting and follow-up. It may also indicate a peak demand that was not contemplated when setting the red buffer level. Products that are in the green zone longer than a replenishment cycle may have the opposite issues.
- *Products within a zone.* The number of products, dollar value, and other aggregate measures of inventory by zone can be measures of the overall health of total inventories. These totals and the time-based trends for each indicate whether replenishment processes are working effectively. For example, the fact that half the inventory dollars are for products in the yellow zone may indicate that the replenishments are occurring well for the vast majority of total inventory flow.
- *Impacts of zone measures.* One should measure stock-outs and order backlogs due to low inventory (red zone). These stock-outs may be caused by any one of the components of the target inventory but are evidence of replenishment failures. Then one should compare the lost sales to inventory investment and determine whether inventories are set too lean or whether the replenishment processes need work.

These are measures of how well inventory is flowing through the system and whether replenishment is matching demand. The Pull replenishment approach enables a smooth flow across the entire network to avoid product delays or overages at any points in the distribution network. Monitoring each target level through the three zones provides a crystal-clear measure of this health and condition of flow as baselines are established and trends identified.

SUMMARY

The customer demand necessary to drive Pull should not be confused with customer orders, sales booked, or replenishment orders. Demand must be defined in specific terms to eliminate misunderstanding on this key driver for Pull and inventory replenishments. Demand relates to actual consumption rather than orders or requested needs and may not always be tracked by the customer or reported to the supplier. Clearly articulating and operating to demand is the fundamental tenet of Lean in order to resolve the bullwhip effect and reduce demand variation.

Once actual demand is well defined, the replenishment process is defined by the trigger and Pull process. The trigger may be one of three basic types: daily demand, customer replenishment order, or a physical kanban. Depending on the replenishment cycle, one of these may be the preferred approach, with shorter replenishment cycles better. As these replenishment options are evaluated and implemented, inventory results can be tracked and monitored with the three buffer zones:

- *Red* to protect against demand variation
- *Yellow* to allow replenishment cycle to operate
- *Green* to enable the customers' consumption

Inventory targets are calculated from the replenishment cycle times and demand characteristics. The targets include factors for demand variability, supply variability, cycle time, and consumption patterns. The calculations may initially be estimates but should become more specific and quantified for each factor. For Planners, the shift to Pull requires a shift in responsibilities away from replenishment order planning and processing toward target inventory calculation and monitoring.

Results for target inventory monitoring become a critical measure of the replenishment process. Maintaining the right inventories despite changing and possibly challenging demand conditions is the critical measure of Lean Pull replenishment health. There exist various measures and reports to assess how the process is performing for the various products, locations, and customers.



Conclusion

Lean enables simplicity

Lean Distribution is a journey from the complexity and rigidity of forecast-based optimization to the simplicity and flexibility of market-driven Pull. The Lean approach enhances the benefits of forecasting and optimization for longer-range decisions and commitments, while enabling the execution excellence of Lean. Quite simply, the benefits of a forecast are most pronounced far into the future and diminish close to the current month; Lean benefits are in execution for customer service and replenishment each day to lower total costs. One can visualize overlapping benefit streams from forecasts in long term with business planning and Lean to service customers and operate distribution every day. It is a marriage of opposites, but opposites that attract.

Implementing Lean Distribution may challenge many existing norms and policies. In fact, if the implementation does not challenge some existing practices, then the team may not be examining current operations closely or Lean practices are already thoroughly embedded in distribution. An initial test of whether Lean is embedded can be the extent and the strength of Pull from customers through distribution and back to the source. If shipments are based on customer orders and the customers' actual consumption cannot be clearly linked with shipments, then Lean is not present. Even in a seasonal or fashion industry, when actual customer demand occurs, replenishment should be driven by Pull, not forecasts or planned orders.

The benefits from Lean Distribution are in customer service, the total cost of operations, and asset utilization. These cost reductions are not quick fixes: Lean works to create flexibility and the ability to execute reducing infrastructure as well as operating costs rather than to just short-term cost reductions. Cost reduction efforts, such as finding cheaper freight, typically entails increases in other costs, such as inventory. Cost reduction can be like the waterbed: pushing down in one spot raises others.

With the Lean Distribution approach, benefits streams can be determined based on operating levers, such as service levels, cycle time, flexibility, and lot size. As these levers are improved, the distribution savings can be readily identified and taken to the bank. Lean practices in distribution link these operational levers to replenishment, pull, buffers, and customer service policy, enabling a completely new view into the drivers of cost, asset utilization, and inventory. Benefits can be substantial when Lean practices address all aspects of distribution from customer service policies to replenishment and pull. Distribution requires a comprehensive view, one that challenges many existing policies and practices but yields simplicity and reliable execution.

THE SIMPLICITY CHALLENGE

Distribution operations have been getting more complex, not less. One can consider the degree of change inherent in distribution operations as customers seek more:

- Improvement in the entire distribution channel (lower costs)
- Flexibility to changing market conditions (less forecast commitment)
- Better service (supplier ownership of inventory)

These objectives seem contradictory, so how can service and flexibility be improved while costs are reduced?

The answer to improving distribution operations is to eliminate the fluctuations due to planning, forecast changes, and other sources. Although well intentioned, many of the optimization and planning processes are based on forecasts that change frequently, creating “waves” of change across the entire distribution channel. As change occurs, the disruption makes cost reduction efforts difficult and can at times increase costs. Disruptions can

extend all the way back to the source—a supplier or the manufacturing plant—creating increased product costs. A more stable schedule for the plant or supplier can have a dramatic impact on costs that extend out beyond distribution.

Simplicity works by eliminating the bullwhip and snowball effects created by forecast and customer order change. These effects magnify small variations in forecasts, customer orders, and schedules to ripple large waves of changes across all operations and disrupt schedules. Their cause: the many planning factors intended to reduce costs as operational plans and schedules are developed. These plans aim to reduce costs by making full-truckload shipments, creating efficient schedules, and buying in low-cost quantities.

Recognizing that distribution may never be “simple,” how can simplicity realistically be achieved? Lean changes the primary focus in distribution and operations to replenishing daily customer demand. Lean streamlines business processes and operations such that low total costs are achieved without additional focus and attention. For example, Lean capabilities to replenish more effectively enable more frequent shipments from the plant to the distribution center and customer. With more replenishments, distribution can worry less about when shipments must be planned or whether inventory will be sufficient. The system “just works” as long as the cycle time, replenishment approach, and other key fundamentals of the Lean design are maintained. Low costs result from how distribution replenishment and customer service processes were structured. Execution becomes the key and the enabler of simplicity: a single-minded focus on the execution thread and letting everything else follow.

PLANNING TRANSFORMATION

Distribution operations are predominately driven by forecasts and optimization planning processes as technology improved over the past 20 years. Information technology applications are commercially available for nearly all aspects of distribution: network planning, warehouse operations, transportation, customs, and so on. With these applications, a company is able to purchase at a reasonable price and install software across distribution to optimize warehouse labor, freight expense, and space utilization.

Despite these improvements, most distribution organizations seek additional answers to the growing trend of challenges from both customers and

company executives. As organizations seek to improve shareholder returns, costs always seem too high, service improvements are being requested by customers, and assets are under pressure. It can be a never-ending cycle where improvements are quickly “taken to the bank” but are not the only “deposit” expected.

The cost and service challenges go to distribution planning to determine optimum plans. As planning optimizes from the customer forecast on down, the result can be to a need for more accurate forecasts. As the starting point for the planning process, the forecast may take the heat as too inaccurate or not sufficiently detailed to provide plans with lower costs. It will be argued that without accurate forecasts, any optimized plan will not be worthwhile or will change before it can be implemented.

Forecasts are limited to the accuracy and stability of the market. Even the best marketing crystal ball will have difficulty improving accuracy to the level of detail and over the time horizon needed for current planning systems. There are just too much data about too many customers, too far out into the future. To get an idea of this complexity, one can multiply the number of items in the forecast times the number of months in the forecast times the number of customers, which should yield a very large number for even a small company. For larger companies, the numbers are mind boggling. The effort to truly develop market intelligence and customer-collaborative forecasts is significant, taking valuable time from salespeople, who should be selling.

Even with accurate forecasts, variation within internal operations and suppliers will continue to disrupt plans and require continual revisions to an optimized plan. Production operations and suppliers will not deliver 100 percent on time; some orders will be early, others will be late or partial, all of which will require adjustments to the remainder of the plan. Even early shipments may cause disruption as added space is required for storage that may not have been planned. Within distribution, variation can occur as deliveries are late and customer order volumes or workload spikes. Even with a near-“perfect” forecast, there can be sufficient variation from other sources to whipsaw plans and schedules.

Without accurate forecasts and a stable plan, the planning process should refocus on key decisions and commitments rather than on building a detailed and comprehensive set of schedules and replenishment orders. These decisions relate to capacity allocations, supplier agreements, and market

commitments, which are critical to attaining the company's overall business revenues and profits.

The technology transformation for planning and optimization provides many benefits in service, cost, and asset utilization. The next level of benefits comes from stabilizing plans. A plan that is developed with the best available data and logic has limited value when it changes frequently and is difficult to execute. The “marriage” between forecasting and planning with Lean Distribution is to allow Lean to execute the day-to-day business while forecasts drive overall business commitments.

LEAN DISTRIBUTION BENEFITS

The Lean Distribution approach provides an operational foundation for service excellence and low total costs. A combination of service and cost performance is what differentiates how a Lean approach both simplifies the business and delivers results. Service and cost are typically considered to be conflicting objectives where trade-offs must be made, but Lean focuses efforts on changing the dynamics of this trade-off by reducing cycle time, improving reliability, and increasing flexibility. These changes deliver benefits in customer service, total costs, and asset utilization.

Customer service benefits accrue from improvements in service policies and value provided to customers with Pull. As service policies are formalized and segmented with the Lean Distribution approach, benefits relate to service delivery for customers grouped into segments with various levels of service. By formalizing service policies, improvements result from:

- Providing differentiated levels of customer service
- Improving execution of service delivery
- Examining and segmenting customers for price/value
- Directly linking (Pull) with customer usage to improve the customer's material flows

Within Distribution operations, Lean improves the flow of products to mitigate fluctuations in customer demand. With buffer strategy developments, Lean takes inventory placement and management from a just-in-case approach to a proactive setting of inventory to ensure service excellence. The buffer “shock absorber” is consolidated, lowering total inventories and

protecting against variation. This reduces the pressure to maintain inventory availability so Distribution can focus on executing replenishment to customers and the critical elements of cost.

Benefits also accrue across “downstream” operations both internally and with suppliers. As Pull with customers improves the connection with actual demand, the disruption in planning and customer orders can be decreased, eliminating the snowball and bullwhip effects created as small changes in forecasts and customer orders are magnified. Operations (and supplier) schedules are stabilized by insulating the market variation with the strategic buffers. As schedules stabilize, Lean practices further improve flexibility, reliability, and costs without the distractions of daily disruptions to meet spikes in demand.

The planning function also benefits from a Lean Distribution transformation. Often the attention and effort required to update forecasts and revise plans lessens as forecasts and planning become more strategic and less tactical. Planners spend less time managing the plan and internal replenishment orders and more time determining and supporting longer-range decision making. The total time required for the Planners may not be less, but certainly more value added time.

Lean benefits may seem counterintuitive to traditional measures; however, they are quantifiable. As Lean takes hold, benefits can be quantified along key measures of performance and cost:

- Inventory reductions across the entire supply chain as buffers become strategically located and managed
- Distribution cost reductions as customer and distribution center replenishments become distribution pipes designed using delivered costs
- Customer service readily measured against segmented policies and expectations
- Operations schedule stability as measured by the disruptions to schedule within the window of time for a specific operation

These and other benefits can be linked back to key operational parameters and improvements. Cycle time is an example parameter that improves with Lean and can be related to inventory and service costs. As cycle time is reduced, the improvements in inventory and costs are readily apparent.

These relationships make Lean benefits more transparent and linked with day-to-day operational improvement efforts and measures.

SELLING THE LEAN DISTRIBUTION VISION

At times, benefit claims should be taken with a grain of salt. Numerous improvement initiatives, books, presentations, and software solutions claim similar results for customer service, inventory, and operating costs. It can be confusing to separate the real claims and benefits that can be counted on from those that may be mere sales pitches. In taking the lead to sponsor an improvement initiative, the risk for delivery of the benefits can be a major source of hesitation. Who wants to be out in front of (or associated with) an initiative that is not delivering results?

The Lean Distribution vision should be built on a solid definition of business needs linked to paradigm and operating process change. The Lean Distribution paradigm shifts are well documented and related to how change improves operational results. A clear cause-and-effect linkage exists between change and benefits. The cause-effect relationships are critical to selling the Lean Distribution vision, because they enable the organization to hear, debate, understand, and agree with the change. Lean methods avoid the “black box” approach that do not describe how change will occur, articulate the implications to various organizational units, or say what the business will look like in the future. With Lean, the paradigm shifts are clear, the process approaches are well tested, and what remains is tailoring Lean practices to a specific market and operating environment.

Once the paradigm shifts are agreed, the main concern in developing the benefits case for a Lean Distribution vision is assessing and quantifying key performance metrics, especially those impacting the business the most. Figure 10.1 provides a list of barriers to improvement and metrics that may be used to quantify Lean benefits. The starting point is assessing, quantifying, and agreeing on the barriers to improving the business. By taking the barriers first, the business needs are well documented and agreed to. If agreement cannot be reached on these barriers, then no solution is required or can be determined. The business needs must come first and be well defined and documented, not left to gut instinct.

FIGURE 10.1 LEAN DISTRIBUTION BUSINESS CASE

| Barrier | Implications | Lean Distribution Approach | Metrics to Quantify Barrier |
|--------------------------|--|---|--|
| Customer Order Forecasts | A major barrier to improvement, resulting in demands for revisions and better accuracy. | Lean reduces reliance on forecasts yet improves customer service with defined service policies and buffer strategies. | Forecast accuracy (by SKU, not \$). Lead time to revise the forecast. Time and effort to revise. |
| Customer Demands | Customer demands are increasing making distribution more complex and challenging. | Excels at replenishing actual demand quickly, making the customer's planning easier and less constrained. | Pull, VMI, SMI, etc. Shorter order lead time. Less (or no) forecast commitment. |
| On-Time Order Deliveries | Inventory is increased to improve service, but snowball and bullwhip effects disrupt schedules. | Lean simplifies processes, increases responsiveness, and reduces reliance on forecasts improving customer service. | Fill rates. Lead time and on time delivery. Customer order lead times. |
| Schedule Stability | Planning and forecasting changes disrupt schedules which increases all operating costs. | Improves flexibility of operations and designs replenishment around demonstrated capabilities. | Schedule changes and disruptions. Lost capacity or output. |
| Inventory Quality | Too much in one place, not enough in another. Internal shipments between warehouses. | Pull with customers and across warehouses maintains the target level of inventory, despite demand variation. | Excess or stock-outs in aggregate. Pockets of excess or stock-outs. Cross shipments to balance. |
| Inventory Investment | Inventory is inexpensive in trade-offs with other costs until the total dollars or space becomes too high and must be reduced. | Creates a buffer strategy to maximize leverage and deployment of inventory that reduces total dollars and space. | Sales discounts and special deals. Obsolescence. Cost of warehouse space. |

Gut instinct can be a wonderful thing: somehow it tells us that change is necessary, but the direction may not be so clear. It is a barometer of discomfort with the current situation and environment. An executive “listening” to gut instinct senses that the status quo is not working by observing the conflicts in current measures and performance. For example, if customer service is deteriorating despite inventory increasing, there clearly is a message for change. In other scenarios, the conflict may not be as pronounced, and it may be more difficult to sense that change is necessary. The trick is to know when gut instinct can be trusted to determine that change is necessary.

Agreeing on the need for change does not set a course for a workable solution. Deciding what solution to embrace can be equally as difficult as agreeing on the business need. For a Lean approach, it can help to describe how current policies and processes result in the barriers being observed. For example, if inventory is increasing and customer service is decreasing, a thorough examination of how inventory and service are behaving will build confidence in the Lean approach and processes. These causes and effects provide the organization a basis for understanding the differences with a Lean Distribution approach.

IMPLEMENTING LEAN DISTRIBUTION

The Lean Distribution journey requires functional organizations and measures to take more of a process and product flow focus. The measures of cost for an individual organization create barriers to product flow. Reducing transportation expense can have large impacts on other costs, as was seen with the Distribution Cost Waterbed analogy. Pushing down on transportation may not lead to reducing total costs; inventory, handling, and other costs may rise in order to reduce transportation.

Transforming actual organization structures, reporting relationships, and performance measures can be a challenge, but it is not the primary obstacle to accomplishing these improvements with Lean. Although the organization and performance measures are the subject of entire books, it must be recognized that a focus across traditional lines is necessary in order to increase the speed and flexibility of product flow. This focus can be difficult to embrace due to the deeply rooted drive to take actions that reduce cost; however, in many cases, cost reduction efforts within any one organizational

area encounter the waterbed scenario and most likely increase costs in another area.

One must start by examining customer service policy and existing practices. By assessing policy from the customer view first, commitments can be formalized and aligned with internal delivery capabilities. In some cases, service commitments may be more than capabilities, but in many cases, new and enhanced service options should be presented with Lean capabilities. As policies become more structured and segmented, customer commitments can be aligned with total delivered costs to attain target profitability.

Then one can move to a total product flow focus, showing how operational capabilities are improved with Lean. Operational parameters are the foundations for customer service and effective cost containment, so care must be placed on understanding relationships as well as values. Examples of the parameters and relationships include:

- *Cycle time.* The driving parameter for replenishment cycles and inventory levels. Cycles are determined by how and where product flows as well as the policies associated with product flow.
- *Batch size.* The amount of product produced or acquired at one time. Smaller batch sizes help reduce variation, cycle time, and total costs.
- *Demand variation.* The actual customer demand may be difficult to obtain, much less measure its variation. Steps may start with internal views of customer demand and progress to consumption measures at the customer's location.
- *Reliability.* Measures of quality and operational excellence. The ideal is a Six Sigma approach and set of measures to ensure that when production is required, product will be delivered.
- *Flexibility.* The scheduling window required for operations to be effective. A small window and significant variation in volume is preferred over long lead time and fixed capacity.

Broad-based understanding of these parameters and their relationships to product flow, costs, and customer service can be half the battle. Spreading the understanding across organizations can help bring the focus to the product flow necessary for Lean to succeed. As product flow becomes the goal, past cost reduction actions and the forecast barrier to further improvements

can be seen as less important than leveraging fundamental change to operational practices.

The Lean Distribution journey means traveling on the road of discovery and relationship building meant to cross and bind together the enterprise for product flow and customer service. Each new discovery of how key operational parameters relate to maximizing flow can lead to bottom-line improvements. Confidence in taking more steps will build with the growing sense of these relationships and the power to drive change through operational capabilities.



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