Applying lean principles to design effective supply chains: lean management principles can be applied to inventory and supply chain management to reduce inventories and improve system performance

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Whether the task is managing an individual warehouse or developing an international supply chain, a few key principals can help to streamline operations, create additional capacity, reduce costs, and improve the bottom line. Businesses, nonprofit organizations, and even military supply chains often are hampered by waste in their systems that affect more than just financial costs. Waste reduces overall supply chain performance. Here are some fundamental principles that can be applied to refine any logistics operation.

Those who design, manage, or merely intend to improve supply chains can look to Lean manufacturing principles and apply a corresponding supply chain process. Lean manufacturing focuses on seven primary types of waste. These are listed in the chart on page 45 alongside their supply chain equivalents.

Organizations must conduct continual analyses and improvements in order to ensure that their operations, logistics activities, and supply chains are as effective as possible. When applying Lean management principles, the value of reducing inventory is obvious. Reducing the amount of material in storage means that less capital is tied up in inventory. If less space is required for housing inventory, then a smaller amount of property, plant space, and equipment is required to store and manage inventory. Reductions in inventory reduce the cost of storage, increase the amount of inventory turn, and can reduce overall expenses. ["Inventory turn" refers to how fast a business uses up its inventory. An increase in inventory turn means that the business is using up its inventory faster.]

Measuring Operations

This cause-and-effect relationship sounds simple enough, so how is it done? It all starts with validating current systems and getting an accurate measurement of operations. Supply chain managers must begin by mapping the chain and the processes that make up the chain. They also must establish valid performance measures in order to ensure that they have an accurate assessment of the activities they are measuring. Establishing appropriate performance measures is important enough, and complex enough, that entire books are dedicated to how they can be established and what they should entail. In fact, Robert S. Kaplan and David P. Norton have written numerous articles and books on the "Balanced Scorecard" and how metrics can be developed to measure performance and translate an organization's strategy into operation. However, measurements alone are insufficient if they only focus on individual processes or systems within an integrated supply chain.

So how can management use measurements to improve their supply chain? How is knowledge applied to increase velocity and reduce inventory? Take, for example, a simple formula for determining the amount of a given item a manager should keep in inventory. This amount usually is determined by establishing a quantity to stock that reflects other key variables. That is, how much of a given item should be maintained on hand as operational inventory (OI) to last until the item can be replenished? This quantity is determined by establishing a requisitioning objective (RO) that includes the quantity desired on hand, plus the quantity needed during the time required to receive the item, plus some amount of inventory known as safety stock (SS). The time required to receive an item after an order is placed is known as order ship time (OST). The addition of safety stock is intended to ensure that sufficient quantities of inventory remain on hand to meet customer demands in the event of changes in shipping times or in forecasted patterns of customer consumption. When expressed in an equation, the computation for a requisitioning objective is: RO = OI + OST + SS. [OST in this equation represents the quantity of the item that will needed during the OST period.]

Analyzing Reactions Within the Supply Chain

Analysis of most supply chains shows that inventory tends to be determined by successful activities within a variety of geographic zones and at multiple nodes of activity. These separate activities combine to make an integrated system, or an integrated supply chain. Activities that take place at one node of the chain will impact activities within other nodes and overall supply chain performance. As an integrated system, a supply chain reacts much like Soldiers running in a military formation. This is also what logisticians in commercial industry refer to as the "amplification," or "bullwhip," effect.

When the unit initiates its running movement, all participants know the direction, perceive the intended velocity, and can see the activities of those immediately to their front. Despite all this information, the results are very predictable. A runner in the front row takes off; immediately, this activity is transmitted, row by row, throughout the column, and the effect grows as it transits the column from front to rear. Runners throughout the column go through a series of sprints and shuffles attempting to damper the amplification, or bullwhip, effect. This effect can only be controlled by having the entire column act as one. Military units control this by singing a cadence. The cadence allows all participants to anticipate each step throughout the column at precisely the same time.

Commercially designed supply chains attempt this by integrating "point of sale" information throughout multitiered, or echeloned, supply chains. These supply chains continually integrate usage forecasts to better anticipate consumption, manufacturing, and distribution requirements. One of industry's most noted models is Dell Computers, which is known for updating manufacturing requirements every 2 hours. Many multitiered businesses employ practices that fall far short in forecasting supply demand and subsequently fail to synchronize requirements with production. In fact, multitiered organizations that rely exclusively on "pull" systems that operate on forecasted demand alone tend to be the most susceptible to amplification. On the contrary, Wal-Mart has integrated point-of-sale technology in which the activity of processing a sale can trigger the manufacturing of a replacement item.

Ensuring Inventory Accuracy

Decreasing the amount of time required to incorporate knowledge of demands shortens the amount of time needed to integrate that information into replenishment forecasts. Reliable information about the location of inventory in the supply chain also enables supply managers to determine accurately the status and availability of inbound replenishment items. This knowledge, coupled with shortened OSTs, can decrease the amount of safety stock required. These improvements can reduce overall inventory on hand, reduce storage space requirements, result in higher inventory turn ratios, and translate into significant cost savings. ["Inventory turn ratio" measures the number of times an organization turns its inventory in a year. This is computed as cost of goods sold divided by average inventory.] Because inventory commonly comes from a variety of vendors, through a variety of transportation nodes, and in numerous configurations, organizations must look beyond the walls of individual warehouses and validate operations throughout their respective supply chains. Of course, maintaining accuracy of inventory on hand is a fundamental prerequisite for any initiative to improve inventory management.

Therefore, efforts to ensure accurate on-hand balances should precede improvement initiatives to gain better in-transit visibility or to expedite the velocity at which inventory flows. Once inventory accuracy is established, tracking and measuring shipment times of inventory as it travels from node to node can reveal more than just transit times between nodes. Although accurately measuring OSTs can improve predictability, many other considerations may not be captured in that metric alone.

Focusing on only one aspect of operations often results in suboptimization--making one link in the operation more efficient without considering the effect that change might have on other links. Avoiding suboptimization requires analysis of individual processes and systems and how they all interact or affect each other. Warehouse internal issues, such as how the items move through a given warehouse, can yield opportunities for reductions in average customer wait time. For example, stock picking, consolidation, packing, and preparation for shipment can take days at a given facility. Internal warehouse improvements that increase velocity at one node may actually add time at another. Take the selection and packing of all like-items together. This may increase the velocity at which those items travel through the warehouse. However, the items may need to be separated at another location and transferred to a different means of transportation before moving on to the final destination. The initial modification of packing all like-items merely transfers the workload of separation to another location in the system and might slow down the overall process.

These challenges can be compounded by the presence of inaccurate inventories; untrained inventory managers; excessive nodes of activity; redundant operations; unnecessary or redundant processes; variance in transportation carriers, processes, or schedules; or unpredicted variance in workload volume. All of these problems contribute to supply chain inefficiency. So the underlying challenge becomes creating an integrated system to get items from point of origin to point of consumption with the least amount of time. Often, simple efficiency increases effectiveness.

Many of the factors described above combine to create requirements for additional storage at supporting nodes. For example, inefficient management of inventory close to the point of consumption will cause the supporting activity to order, receive, store, manage, pick, pack, consolidate, ship, and track unnecessary quantities of supplies. Of course, having more than one supporting node of supply will cause these redundant activities to take place at more than one location and can increase the stockage quantities of those items at each node. This amplified effect degrades overall supply chain efficiency and limits the chain's overall effectiveness by adding excess inventory. This concept demonstrates the amplified impact of higher reorder points and increased safety stocks through the chain, illustrating the mechanics of "Little's Law." This law states, "The average number of things in the system is the product of the average rate at which things leave the system and the average time each one spends in the system." This simply means that, "as velocity increases, storage requirements decrease." As velocity increases, OST decreases and, subsequently, reorder points and safety stock requirements decrease. Slower ship times, combined with the factors listed above, add waste in the system.

Mapping the Supply Chain

Many opportunities exist to improve a given supply chain's velocity and performance. Some can be executed in the short term and may offer significant cost savings in terms of personnel required, quantities of inventory stored, and overall workload reduced. Other improvements may require more investment in information systems in order to convert existing pockets of data into integrated supply chain knowledge. Mapping a functioning supply chain and applying Lean manufacturing principles provide several opportunities to improve supply chain processes.

Lean manufacturing is nothing more than the compilation of various manufacturing and industrial engineering practices to systematically eliminate waste. Of course, the easiest way to eliminate waste is to eliminate unnecessary tasks or processes in the system. To do this, the process should be mapped using some form of network diagram. Once diagrammed, system designers realign processes based on their relationship to other required processes in an effort to shorten the overall system time requirement. The time associated with the overall system reflects the system's critical path or the longest path through the network diagram. For example, the chart on page 46 shows a sequence of processes performed sequentially with finish-to-start relationships. Completing these processes in the current configuration results in an overall system time of 45 hours.

Although each system comprises eight processes ("A" through "H"), changing the relationships among these processes--so that some processes can be performed simultaneously--reduces the system time from 45 hours to 26 hours. Once the optimal sequence of processes and relationships is identified, the focus turns from critical path management to "system crashing" (reducing the process times associated with each activity along the critical path). Crashing the critical path (or reducing overall system time) generally is accomplished by combining tasks within processes or adding more resources in order to shorten process cycle time. Continued refinement of the overall system can be achieved by looking for redundant tasks within each node, lead times of precedent requirements, cycle times associated with each task, and their relationships in order to reduce the overall process time within that node. This same concept can be applied to designing large supply chains. With supply chains, eliminating a single node can save millions of dollars in unnecessary infrastructure and overhead. For many operations, this can result in freeing up critically required space for other uses, reducing manpower requirements, and creating additional system capacity.

Increasing Efficiency of Nodes Within the System

Unfortunately, most supply chains are much more complex than shown in the charts. Reducing the number of processes, tasks, or even communication channels can have an overall positive effect on improving system effectiveness and quality. For example, if 5 people, or "nodes," are involved in a process and each must call the other to coordinate, the result will be a total of 10 communication channels. (See chart on page 47.) This result is derived by using the formula [N x (N - 1)] / 2, where N is the number of nodes in a system. If one of the 5 people involved in that process is removed, and all of the remaining parties are still capable of communicating with each other, the number of channels is reduced from 10 to 6.

Why is this important? Every additional physical, or communication, node in the supply chain makes the system exponentially more complex. Each additional node in the supply chain provides an additional opportunity to increase the amplification effect. This increased complexity also applies to each physical or virtual node, where either material transits or electronic data interchanges take place. Each of these junctures provides an opportunity for producing errors. Quality engineers refer to this as "rolled throughput yield (RTY)."

The chart above shows an example of overall quality output based on four or five process nodes. For example, system 1 has five processes in the system. Despite a relatively high rate of success at each node, combining the success rates for each process results in an overall system yield of only 59 percent (.90 x .90 x .90 x .90 x .90 = .59). The reduction of only one process node from the system increases output yield to 66 percent.

When components, supplies, or even information must transit several channels through several nodes, each activity offers an opportunity for error. The greater the number of activities means more opportunities for errors and a lower productive yield. The reduction of a single node can significantly reduce the number of system channels and activities, resulting in significant increases to productive output.

For example, for manual systems where materiel release orders are printed for stocked items to be picked, prepared, packed, documented, and shipped to a customer, numerous steps must be accomplished by human effort. Human performance is far from perfect and often results in errors during one of these functions. Often, when a customer finds errors with his order, he processes a discrepancy report. This results in a less-than-satisfied customer and creates additional workload in the system to remedy the error.

The simplicity of these principles sounds intuitive. However, supply chains often evolve at one node without consideration for what is taking place at another node. In fact, this evolution tends to be common because of the specialization of different organizations in providing a given good or service. Many hospitals, for example, focus on healthcare and rely on staff materiel managers to meet their supply requirements. These materiel managers often rely on vendors that have contracts with different storage and transportation services to provide their supplies. This pattern is also common in various industries where the entire supply chain operates in fragmented components. It is no wonder, therefore, that independent business processes generally evolve until problems arise that require crisis management or until a collaborative effort is applied to improve the interests of two or more parties.

Supply chains for most industries are extremely complex and have numerous physical and informational interfaces. In order for supply chain participants to truly realize the optimum potential of their operations, they must be willing to collaborate with other supply-chain stakeholders. When that time comes, the application of Lean manufacturing principles can be translated to supply chain fundamentals and used to simplify processes, eliminate waste, and improve overall effectiveness.

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