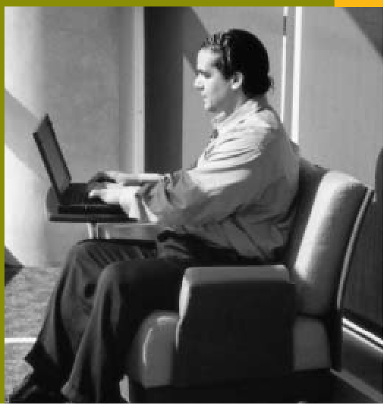
SAP Solution in Detail
SAP xApp Lean Planning and Operations



SAP® xApp™ LEAN PLANNING AND OPERATIONS

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EXECUTIVE SUMMARY

Pacing production. Synchronizing supply. Even in traditional lean manufacturing settings, these two pillars of demand-driven production are difficult to manage. So how do you enable lean manufacturing when you're dealing with demand volatility and variable volumes and mixes? Or when you're looking to move from an early-stage lean transformation to a corporate-wide deployment? With the SAP® xApp™ Lean Planning and Operations (SAP xLPO) composite application – a real-time production management and scheduling system – you can address the two critical requirements of lean manufacturing:

- Production leveling at pacemaker operations
- Synchronization to create stability in the upstream supply chain

A powerful new addition to SAP's offerings for manufacturers, SAP xLPO supports an integrated approach to lean production management. This approach directly links production to actual consumer demand, while maintaining the stability required for consistent, reliable, waste-free factory and supply chain operations. SAP xLPO fills the gap between enterprise-level systems and visual factory controls and enables factory personnel to do the following:

- Establish pacemaker production schedules that are leveled over the shift, day, and week to absorb demand variability with lot sizes as small as possible – small EPEI (every part every interval)
- Properly size and monitor inventory buffers, kanban loops, and supermarkets that minimize carrying costs and enable 100% customer order fulfillment
- Send level, stable requirement projections and buffer replenishment signals to upstream operations and suppliers
- Monitor actual production and changes to underlying demand volatility to adjust finished goods, work in progress (WIP), and safety stock target levels as needed

SAP xLPO helps create and monitor demand-driven production schedules that are as level as possible, and as mixed as possible – given your production process at any point in time. The software enables you to maximize responsiveness and minimize waste at all stages of transformation and operation.

ACCELERATING LEAN TRANSFORMATION, SUSTAINING LEAN OPERATIONS

SAP xApp Lean Planning and Operations is a demand-driven production management system based on the principles of lean manufacturing. With SAP xLPO, all your production operations become highly responsive to your current and projected customer demand. Unlike conventional scheduling systems, SAP xLPO manages strategically placed material buffers and uses material pull signals to create a highly agile and responsive production environment.

SAP xLPO was designed to accelerate, scale, and sustain lean manufacturing processes within an enterprise. Its functionality and configurability allows it to extend lean manufacturing to most production processes – build to replenishment, assemble to order, and build to order.

Finally, SAP xLPO is a real-time, shop-floor control tool that embodies the principles of lean manufacturing: user empowerment, planner control over the system, system usability, and rapid speed of deployment. Based on the concept of a single point of schedule, SAP xLPO does not require detailed modeling for most of the production environment. As such, the system's output is less dependent on the accuracy of the mathematical model or on the predictability of the manufacturing process. Material pull is a process of production scheduling based on actual material consumption that is simple and forgiving of model or data inaccuracy.

Optimally Managing Material Flow

SAP xLPO manages production and material flow by precisely aligning a pacemaker process with customer demand – or *takt* time – and then synchronizing all other processes with the pacemaker by using material pull signals. The pacemaker process should be the only point of scheduling in the supply chain. Consequently, it is the only relatively intricate process encompassing high-performance, real-time scheduling that is coupled with the intelligent management of material buffers. All other processes are based on material pull. They are "signaled" to remain in perfect synchronization with the pacemaker. In spite of its elegant simplicity in managing production, SAP xLPO offers capacity management, production batch sizing, and material-buffers management at every node in the supply chain.

Enabling Agility and Responsiveness

Lean manufacturing is a process that is highly sensitive to customer demand. SAP xLPO extends that sensitivity by providing an environment that is highly agile and can rapidly respond to change in demand or to unplanned production problems. Several elements contribute to that agility. One element is the speed at which factory personnel can reschedule the pacemaker process and realign it with demand. A second element is the creation of strategically sized material buffers throughout the production environment. The system effectively utilizes these buffers for instantaneous response. Finally, there is the dynamic nature of the material pull process – kanban – that trades off long-term scheduling for short-term responsiveness.

BUILDING ON THE TWO PILLARS OF LEAN MANUFACTURING

Lean production management is based on two fundamental processes – pacing production and signaling to synchronize the supply chain. SAP xLPO completely supports your efforts to smooth out material flow and synchronize your supply chain.

The pacemaker work center – the point where the pace of production is established – is the heartbeat of the lean factory. You schedule the pacemaker process to meet customer demand and maintain inventory targets while smoothing material flow throughout the supply network. In order to smooth out your material flow, the pacemaker enables you to build products at a constant rate and to use the smallest batches that constraints will allow. Moreover, the pacemaker process is the only scheduled process, and consequently is the only process that requires "detailed modeling."

The pacemaker is also the point at which you set and execute production strategies and advanced inventory management. For example, if demand exceeds your capacity in the future, should you build early or consume your safety stock? Building early could prove to be the wrong strategy if the demand is highly volatile. Consuming your safety stock is also a risky proposition. However, once the pacemaker calculates the production plan – based on the selected strategy – then the rest of the supply chain follows in tight synchronization. Figure 1 illustrates the elements of lean production.

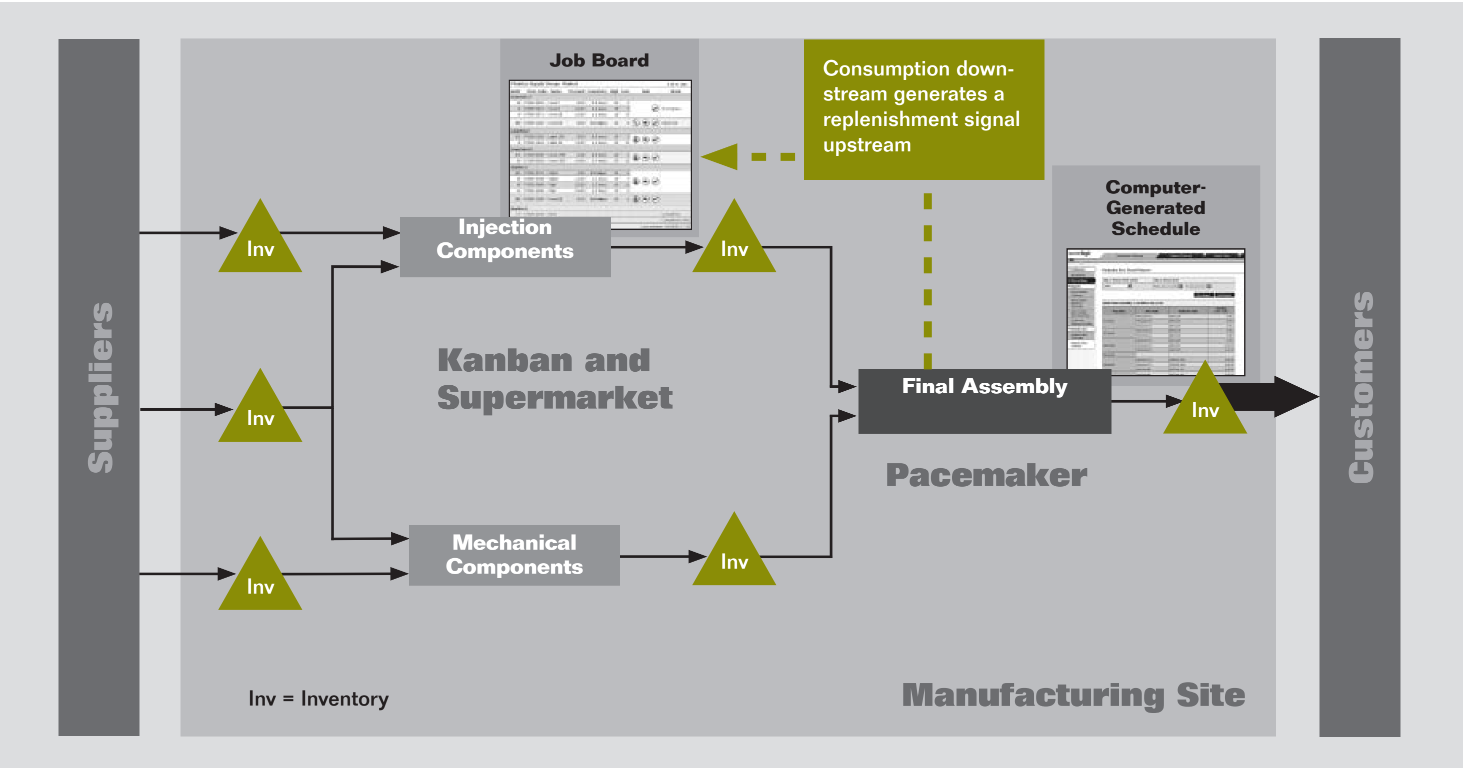


Figure 1: The Lean Supply Chain

In its simplest form, signaling is a process of consumption-driven replenishment. Whenever a downstream process consumes a standard pack, a pull signal is sent to the supplying work center(s). That pull signal does not necessarily trigger replenishment – for process efficiency, a manufacturing trigger point must be reached before replenishment is requested. Prior to replenishment, the batching or grouping of pull signals can occur across a family of products having common characteristics – for example, products with similar changeovers.

Unlike pacemakers, signaled work centers are not provided with a system-calculated long-term schedule. They do, however, have a prioritized list of replenishment orders based on the material consumption of their customers (downstream work centers). A signaled work center, in order to accomplish its task, needs the following information:

- A list of jobs to execute
- A sense of urgency or priority for every job
- Grouping and sequencing of jobs with similar attributes
- A measure of lateness and capacity problems

Another type of consumption-driven replenishment is the "supermarket" – a centralized warehouse that provides an inventory stocking and replenishment location for multiple customers that have complex, low-agility supplying work centers. Although the supermarket serves multiple customers, the signaling principle remains the same. In other words, the downstream consumption of material similarly generates a pull signal at the supplying work center.

Production at all signaled work centers is triggered based on the actual consumption of material. Lean production scheduling, therefore, can be viewed as both real time and execution based. The goal of this kind of scheduling is to keep the factory in perfect synchronization with minimum effort.

PACING PRODUCTION FOR SMOOTHER MATERIAL FLOW

The pacemaker planning functionality in SAP xLPO works to even out the production of items over time and to use all available capacity to maximize the number of runs of each item. This production leveling process is sometimes called "heijunka" in lean manufacturing.

The input that flows into the pacemaker process comes in the form of demand signals from the factory's enterprise resource planning (ERP) system. Often, these demand signals represent the raw customer demand. The demand signal is unleveled, variable, and can change from day to day as orders are adjusted, canceled, and rescheduled.

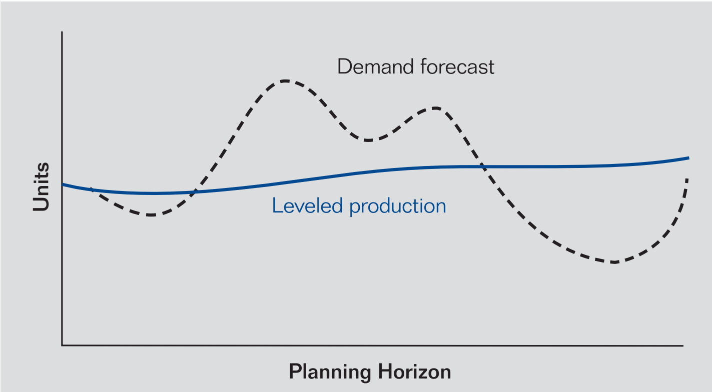


Figure 2: Demand Variability and Production Leveling

By pacing production and using downstream inventory buffers as a shock absorber against demand variability, a company insulates its factory from this chaotic demand. See Figure 2 for an illustration of how production can be leveled in spite of fluctuating demand.

To determine the amount of production required to meet demand and maintain inventory levels, the pacemaker planning, scheduling, and leveling logic considers inventory targets, demand signals, and real-time information about actual production records. The algorithm then chooses work centers, computes changeover time, balances loads, and maximizes use of the available capacity to ensure that all products either meet their requirements or come equally close. The result is an even distribution of production runs throughout the schedule's time frame.

Finally, the pacemaker creates a detailed production plan and schedule. The schedule shows which items each work center should build, in what quantities, and in what sequence. Once approved by the production planner, the leveled production schedule is sent as output from SAP xLPO and is available to external systems. Depending on the manufacturing process, the planner can send the schedule to a shop-floor execution system, forward it directly to suppliers, or send it back to the ERP system for inclusion in other factory information systems.

EMPOWERING USERS WITH EASY-TO-USE CONTROLS

In alignment with the principles of lean manufacturing, SAP xLPO focuses on user empowerment and control. In contrast to manufacturing in a system-driven environment, lean manufacturing holds users responsible for the performance of their work centers. To carry out their responsibilities, users need to make their own build or buy decisions. Accordingly, SAP xLPO empowers users by providing a friendly and intuitive user interface architecture. For maximum ease of use, the interface integrates complex tasks into a single screen and allows the user to completely override the system logic, if necessary. Users benefit greatly by having at their disposal this convenient cockpit where they can navigate easily to the controls they need (see Figure 3).

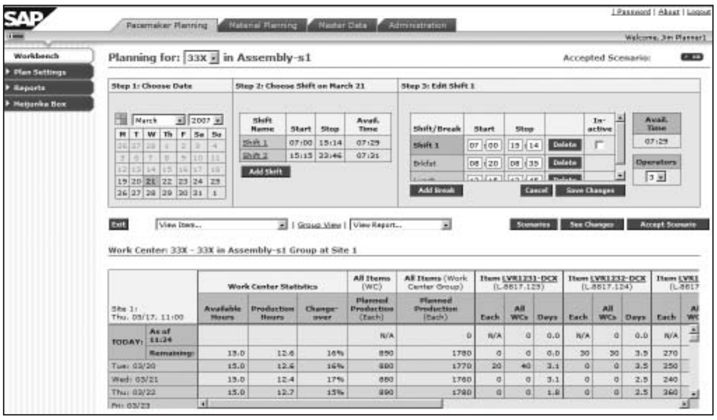


Figure 3: Control Cockpit for Team Leader of the Pacemaker Work Center

Ultimate control over the production plan always rests with the user. Consequently, SAP xLPO provides controls that help the production planner to adjust the way the system creates its plan and schedule. The following controls are the most important.

Managing Production Processes and Meeting Inventory Targets

The pacemaker process can manage both build-to-order and build-to-replenishment processes. In the case of build-to-replenishment, the safety stock buffer can be expressed in either units ("We need 1,000 on hand") or in terms of days of coverage ("We need to have 1.5 days worth of shipment on hand"). In the latter case, the system automatically adjusts the production plan as average demand changes. The actual inventory on hand rises and falls naturally, staying consistent with the 1.5 days of coverage.

Controlling Production Sequences

The user can control the order in which a series of items will be produced – the system always arranges the schedule to create as many runs of the sequence as possible. For an example, see Figure 4. If "ABCDE" is the preferred production sequence, the resulting schedule might place runs – with minimum and maximum sizes – in the order shown. Items with low demand (like "D" and "E" in the example) may not appear in every repetition of the sequence, but the requested build order will be maintained.

Figure 4: Level Schedule Taking into Account Small Lots and Preferred Sequence

The sequence represents a reconciliation of production constraints and the overriding aim of keeping production batches as small as possible. The system always respects the minimum and maximum run sizes for each item as set by the user. In the example above, if "A" can be produced in batches with a minimum of four items, the run will factor in that requirement. Item "B," however, might have a maximum run size of one item. The resulting production run will take this into account too. This reconciliation process ensures efficiency by producing items in multiples of their standard package quantities and by constraining run sizes in cases where longer runs lead to increased scrap factors or require operator intervention during the run.

Splitting Production and Loading Work Centers

Though the system will intelligently assign production of items across the available work centers, the user still has control over how the assignments are made. The system understands the distinction between preferred and secondary work centers, and uses secondary capacity only when necessary. The system can also be configured to distribute production of each individual item across as many or as few work centers as possible.

Managing the Product Life Cycle

As a product passes through the stages of its life cycle (through introduction, ramp-up, maturity, and retirement), the appropriate replenishment method changes. For mass production, planners mostly use the build-to-replenishment approach. However, as demand decreases and becomes sporadic, the build-to-order approach is better. As an item's start-of-life and end-of-life dates arrive, the system can automatically switch between the two modes.

USING SIGNALING TO SYNCHRONIZE THE SUPPLY CHAIN

Signaling is the process that keeps all other work centers in synchronization with the pacemaker. Material pull is a process of replenishment that is triggered by actual material consumption.

In a pull system, a kanban acts as a container for inventory. By moving the containers around as parts are produced and consumed, the containers themselves become the trigger for replenishment. An empty kanban indicates to the work center or supplier that it is time to replace the parts that have been consumed from inventory.

Because the kanban act as containers, the number of kanban set up on the factory floor represents a specific quantity of parts that is either on hand (filled with material) or on order (empty and waiting to be filled). Therefore, in a pull system, determining the optimum number of kanban has a major impact on inventory performance, for example:

- If the number of kanban is too low, there will not be enough inventory to support the needs of the consuming work centers while the kanban are being replenished.
- If the number of kanban is too high, the factory is holding more inventory than it needs.

The main side effect of having too many kanban is inflated material buffers and consequently lower material velocity.

The primary function of the SAP xLPO kanban functionality is to monitor the projected demand and the capacity of the supplying work center. Based on these main constraints and the required safety stock buffers, the system determines the required number of kanban – known as the kanban loop size (KLS) – for every item. The system warns the user when the existing KLS is too small or too large compared to the calculated number.

Optimizing Kanban Loops

The optimization of kanban loops can be applied at any stage of the supply chain. For every supply chain or value stream, one key process is typically modeled as the pacemaker; the rest are modeled as supermarkets.

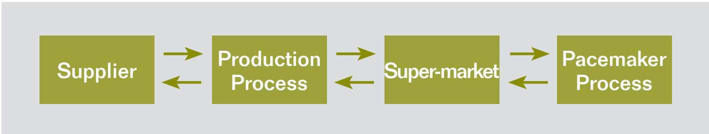


Figure 5: Material Pull and Kanban Loops Upstream from the Pacemaker

Instead of relying on representations of the various routes that products take from work center to work center through the factory, SAP xLPO gets the information it needs from only the following three inputs:

- Raw demand for the items controlled by the pacemaker process – Frequently, the pacemaker items are the factory's finished goods and this demand simply takes the form of the customer demand signal. (In some cases, the demand received by the pacemaker results from a leveled schedule further down the supply chain.)
- Bills of material – The demand for any item can be determined by traversing the bills of material and computing the demand for component parts based on the demand for their parents.
- List of items – This is a list of items that are built by each group of work centers known to the SAP xLPO composite application.

Replenishing Multiple Work Centers with Supermarkets

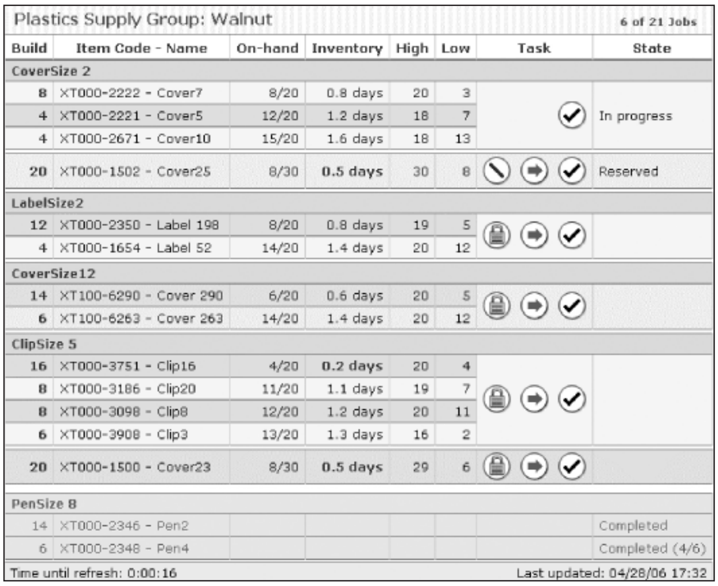
A supermarket kanban – sometimes referred to as a “production kanban” – models the production of items by multiple work centers. These work centers replenish the supermarket’s inventory. As the next set of work centers downstream consume materials, they take inventory from the supermarket shelves.

The supermarket process continually monitors the incoming demand and the overall capacity of the work centers under its management. The supermarket process can track thousands of items throughout the supply chain and highlights capacity problems to show the user which kanban loops need to be updated.

Importantly, because replenishment decisions are only confirmed after downstream work centers have actually consumed the material, there is no long-term production plan or schedule for signaled work centers in pull manufacturing. Instead of using a long-term schedule, signaled work centers have a to-do job list that provides them with the following information:

- A list of jobs to execute
- A sense of urgency or priority for every job
- Grouping and sequencing of jobs with similar attributes
- A measure of lateness and capacity problems

The system generates these lists and displays them at an appropriate terminal on the shop floor as shown in the following figure.


Plastics Supply Group: Walnut — 6 of 21 Jobs

Build	Item Code - Name	On-hand	Inventory	High	Low	Task	State
CoverSize 2							
8	XT000-2222 - Cover7	8/20	0.8 days	20	3		In progress
4	XT000-2221 - Cover5	12/20	1.2 days	18	7		
4	XT000-2671 - Cover10	15/20	1.6 days	18	13		
20	XT000-1502 - Cover25	8/30	0.5 days	30	8		Reserved
LabelSize2							
12	XT000-2350 - Label 198	8/20	0.8 days	19	5		
4	XT000-1654 - Label 52	14/20	1.4 days	20	12		
CoverSize12							
14	XT100-6290 - Cover 290	6/20	0.6 days	20	5		
6	XT100-6263 - Cover 263	14/20	1.4 days	20	12		
ClipSize 5							
16	XT000-3751 - Clip16	4/20	0.2 days	20	4		
8	XT000-3186 - Clip20	11/20	1.1 days	19	7		
8	XT000-3098 - Clip8	12/20	1.2 days	20	11		
6	XT000-3908 - Clip3	13/20	1.3 days	16	2		
20	XT000-1500 - Cover23	8/30	0.5 days	29	6		
PenSize 8							
14	XT000-2346 - Pen2						Completed
6	XT000-2348 - Pen4						Completed (4/6)

Time until refresh: 0:00:16 — Last updated: 04/28/06 17:32

Figure 6: Shop Floor Display for Schedule and Production Status Tracking

This to-do job list is updated in real time as the execution unfolds and can be viewed as a constant realignment of manufacturing activities. That feature, unique to material pull processes, is credited for the agility of lean plants.

Managing Complex Work Centers

When the constraints are severe, managing a signaled work center is not an easy exercise. Tooling, sequencing, and a long changeover time drastically impact the ability of the work center to rapidly replenish. Consequently, this increases the KLS and inventory buffers.

For many types of work centers, the available capacity is dictated by the placement of the tools used to produce specific items. A tool placed on one machine may produce at a certain rate, while the same tool on a different machine may produce the same items more quickly.

SAP xLPO supports the use of multicavities tools for molding processes. Based on demand, the application can assess the correct number of cycles a tool will be used. Also, users have complete control over tool placement and can transfer tools between work centers to make the best use of available production time.

Even with such complex work centers, SAP xLPO will properly calculate the kanban parameters.

Calculating Capacity

SAP xLPO calculates the available capacity of the supermarket work center by taking into account the following factors:

- Assignment of tool to work center
- Available operating time by work center
- Cycle time – The rate at which units are produced can vary by item and work center.
- Changeover times – Some of the available capacity of a work center is consumed in changeover from one item or tool to another. Because it impacts the minimum allowable production lot size, changeover time is a significant factor in capacity calculations for pull systems (see trigger level calculations).

Assessing Average Demand

The demand signals to the supermarket process generally come from the pacemaker planning function. The supermarket can also accept nonleveled demand signals in cases where demand comes from multiple external sources or is tied to the production schedules of work order–driven work centers.

Particularly in the case of nonleveled demand, it's important that the user can see both the average demand (used to calculate the recommended KLS) and the weekly demand for the period. Anomalies and instability in the weekly demand can affect the average demand. In keeping with the principles of transparency, the system gives users the information they need to accept, ignore, or adjust the recommended KLS.

Calculating Kanban Loop and Trigger Levels

Finally, based on demand and capacity, the system creates its recommendations for the KLS and the kanban trigger level. The trigger level is established by the number of empty containers that accumulate before the work center begins a run of an item.

In a typical factory, there will be several thousand loops represented in the system. For work centers whose pull signals come from leveled production plans, the loop sizes are very stable. The system's responsibility is to continually monitor the state of every loop and to call the user's attention only to those needing attention.

INTEGRATING SAP xLPO WITH SAP ERP

The integration of SAP xLPO with the SAP ERP application allows for mixed-mode manufacturing. In this scenario, part of a plant is managed by SAP xLPO based on lean processes; the other part is still managed by conventional push processes. However, the split must make sense. For example, work centers belonging to the same group must be managed by the same process. Manufacturing sites can progressively switch their processes to lean production.

Beyond the sharing of master data (for items, work centers, bills of material, and routings), the integration of SAP xLPO with SAP ERP is a well-defined process. In this process, demand flows from SAP ERP into SAP xLPO. SAP xLPO sends plans and schedules back to SAP ERP. In addition, SAP ERP transfers material movement tracking information and inventory adjustment transactions to SAP xLPO.

Integration Process

1. End-customer demand is transferred from SAP ERP to SAP xLPO.
2. The demand is propagated to all SAP xLPO constituents of the supply chain through the demand propagation engine and used to generate schedules and job lists at every work center group.
3. A production plan – leveled daily – is sent back to SAP ERP and used by the materials resource planning engine to compute suppliers' plans.
4. Detailed schedules are downloaded to the manufacturing execution system (MES).
5. Shop-floor tracking transactions (production, consumption/shipment) are sent from the MES to SAP ERP and optionally to SAP xLPO.
6. Shop-floor tracking transactions, together with SAP ERP–generated inventory adjustment transactions, are sent to SAP xLPO.

BENEFITS OF LEAN MANUFACTURING

Looking at the factory from the perspective of the bottom line, the substantial improved agility of SAP xLPO has the following impact on the production floor:

BENEFIT BUCKET	TYPICAL IMPROVEMENT	SAP® xApp™ LEAN PLANNING AND OPERATIONS COMPOSITE APPLICATION ENABLERS
Premium Freight Reduction	70%–90%	▪ Balanced inventory coverage across all items ▪ Rapid replanning to synchronize supply to demand
Unplanned Overtime Reduction	70%–90%	▪ Intelligent inventory buffer management ▪ Dynamic supermarket kanban sizing ▪ Date effectivity to reduce obsolescence
Customer Fill Rate Improvement	20%–40%	▪ Intelligent mix management ▪ Stable schedule to suppliers
Supply Synchronization	10%–20%	▪ Dynamic kanban loop sizing ▪ Stable schedule to suppliers
Inventory Reduction (Finished goods, WIP, and procured parts)	15%–30%	▪ Effective balancing and spreading across assets ▪ Intelligent build ahead to avoid ad hoc production
Planner Productivity and Knowledge Retention	50%	▪ Management by visibility to exceptions ▪ Rapid replanning to synchronize demand with production; Scenario analysis ▪ Repeatable and consistent operational workflows

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