INNOVATIONS  New ways of thinking about supply chain management.

A LEAN APPROACH to CROSS DOCKING

By Robert L. Cook, Brian Gibson, and Douglas MacCurdy

Robert L. Cook is professor of marketing and logistics at Central Michigan University. Brian Gibson is an associate professor of logistics at Auburn University. Douglas MacCurdy is the president of Transfreight LLC.
Lean production requires a lean supply chain. But how can you reduce waste and increase speed in your supply chain? One answer is to replace traditional warehouses with cross-dock facilities.

The unrelenting pressure of global competition in the marketplace has spurred many manufacturers to adopt a lean production philosophy—and a lean supply chain that supports that philosophy. A critical element in the design of such supply chains is an effective cross-docking operation.

Cross docking is defined as: the packing of products on incoming shipments so that they can be easily sorted at intermediate warehouses or for outgoing shipments based on final destination. The items are carried from the incoming-vehicle docking point to the outgoing-vehicle docking point without being stored in inventory at the warehouse. When cross docking replaces warehousing a number of benefits follow. These typically include: reductions in inventory investment, storage-space requirements, handling costs, and order-cycle times as well as faster inventory turnover and accelerated cash flow. The benefits of cross docking therefore are well-aligned with the goals of lean supply chain management: smaller volumes of more visible inventories that are delivered faster and more frequently.

To maximize the benefits, however, the principles of lean must also be applied to the design and implementation of the cross-dock operation itself. This article explains how lean production principles—also known as the Toyota Production System (TPS)—can be applied to create a cross dock that supports the lean philosophy. A practical example from the Eastman Kodak Company shows how applying TPS to a cross-dock facility can have a powerful impact not only on the supply chain’s efficiency but also its effectiveness.

The Toyota House and the Supply Chain

The Toyota Production System consists of mutually reinforcing principles, culture, and operational structure. To emphasize that it is a system of production, Toyota depicts TPS as a house.

Exhibit 1 shows how this “Toyota House” can be applied to the supply chain. The goal, or “roof,” of the supply chain is timely, consistent, level delivery of materials to production. It is achieved by reducing material order-cycle times, eliminating supply chain waste, and improving supply chain processes. The roof is supported by two pillars: just-in-time and quality. The just-in-time (JIT) pillar represents delivery of the right material in the right quantity at the right time to the right place. The quality pillar represents zero-defect pick-up, sorting, delivery, and operational support data. At the center of the house is a culture that demands excellence and employees who are flexible, capable, reliable, and motivated. Finally, the foundation of the house—operational stability—is built by standardizing supply chain processes and reducing the variability in these processes. This house provides a framework for introducing lean to the cross dock.

A Just-In-Time Cross Dock

In a lean system, a cross dock should focus on facilitating JIT delivery to the production sites. To accomplish this, the TPS principles of kanban, milk runs, and heijunka must be integrated into the operational design of the facility.

In a kanban or “pull” system, an electronic or physical signal (such as a card) is used to indicate that a product should be made or moved. To support JIT production, the kanban system must extend back to suppliers. In such a system, multiple production sites are pulling small lot sizes in standard containers from multiple suppliers. Integrating a lean cross dock into such a system can produce significant advantages. A lean cross dock would orchestrate pick-up, sorting, repacking, and delivery of the vast number of kanbans while reducing material order-cycle time. For example, in one week of operation, an 81,000-square-foot cross dock could process over 8,000 orders representing shipments from 100 suppliers to 34 production sites. The weekly inventory throughput

EXHIBIT 1

The Toyota House Applied to Supply Chain

<table>
<thead>
<tr>
<th>Goal</th>
<th>Just-in-Time</th>
<th>Culture</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timely, consistent, level delivery of all materials to production by reducing material cycle time, eliminating supply chain waste, and improving supply chain processes</td>
<td>Right Material, Right Quantity, Right Time, Right Place</td>
<td>Flexible Employees, Capable Employees, Reliable Employees, Motivated Employees</td>
<td>Zero-Defect Pickup, Zero-Defect Sorting, Zero-Defect Delivery, Zero-Defect Data</td>
</tr>
<tr>
<td>Kanban, Milk Runs, Heijunka</td>
<td>Teamwork, Empowerment, Respect for Worker</td>
<td>Visibility, Poka-Yoke, Kaizen</td>
<td></td>
</tr>
<tr>
<td>Preventive Maintenance</td>
<td>Operational Stability</td>
<td>Supplier Involvement</td>
<td></td>
</tr>
</tbody>
</table>
could equal 275 53-foot truckloads, but none of the inventory would be held at the cross dock longer than a few hours.

At the same time, a kanban system would improve operations at the cross dock. Since kanbans pull inventory as needed, inventory and storage-space requirements are minimized at the cross dock and production sites. In addition, the use of standard containers facilitates material handling, material transport, and line-side storage-space planning.

A lean cross dock also supports JIT production by using "milk runs" to pick up materials and deliver them just-in-time and in a consolidated manner. Under this method, trucks use regular pickup routes to build mixed loads from several suppliers and return to the cross-dock. Then moving from the cross dock, trucks use regular routes to deliver mixed loads to multiple production sites. Having a cross dock that utilizes milk runs enables planners to realize transportation consoli-

dation efficiencies. Milk runs also typically involve dedicated vehicles, which increases inbound-material visibility and control. These benefits, in turn, facilitate production scheduling efforts.

Finally, a lean cross dock follows the TPS principle of heijunka, which is the Japanese word for "to make level." In a cross dock, heijunka would involve leveling the load across operational hours in a manner that supports JIT operations. Heijunka is accomplished by scheduling and performing repeatable pickup and delivery routes at uniform time intervals throughout the day (for example, "pickup route 1" has scheduled departures of 8 a.m., 11 a.m., 2 p.m., and 5 p.m.). A master schedule ensures that the workload is leveled. All tasks have specific start and end times that are strictly met. The result is a level, uniform, rhythmic material flow through the cross dock as well as a level material-handling workload at manufacturing facilities, supplier locations, and the cross dock.

Quality Through Visibility
Supply chain quality is maintained and improved at a lean cross dock through visibility, pokayoke, and kaizen. Quality is achieved by making operations and problems visible through a four-step approach. First, all dock doors are labeled with a route number and times for unloading/loading. This allows anyone at any time to verify what truck is being serviced and ensures that trucks are serviced in the correct order within prescribed time limits. Second, a lean cross-dock floor is marked with kanban squares (the actual size of a truck floor), and overhead signs indicate delivery destination and times as well as truck height. This enables anyone to verify if shipments are being placed in the right lane at the right time and provides a visible check on truck cube utilization. Third, all containers entering a lean cross dock receive a ticket specifying contents, supplier, destination, and departure time. The ticket enables containers to be tracked internally. Fourth, dock employees use a box with designated slots for each ticket (or shipment) that is part of an outbound delivery. The box allows employees to quickly and visually verify that each shipment has been loaded on the truck. This visual control helps employees check loading accuracy.

Poka-yoke (or "mistake-proofing") is used to ensure zero-defect operations at a lean cross dock. The dock layout enhances fail-safe operations by designating docks on one side of the building for all incoming shipments and docks on the opposite side for all outgoing shipments. Companies can further ensure error-proofing by creating check sheets for both inbound and outbound cross-dock processes. In addition, cross-dock employees can use kanban squares as trial trailers. These kanban squares allow them to build loads prior to actual loading, which prevents them from having to unload and reload poorly loaded trailers.

There are many opportunities to practice kaizen or "continuous improvement" at a lean cross dock. Because each cross-dock process (pickup, delivery, loading, and repacking) has a documented set of procedures to follow and is performed repeatedly over a short time horizon, the potential for learning a process and improving it is high. In fact, employees are expected to suggest process improvements. To facilitate these improvement efforts, employees track and visually report key performance indicators, such as total order-cycle time, on-time pickup and delivery, truck cube utilization, expediting costs, inventory-carrying costs, and storage-space usage.

Culture of Excellence
In order to ensure a lean supply chain, companies need to build a culture that enables employees to achieve excellence. The TPS principles that drive this culture of excellence include teamwork, empowerment, and respect for each worker. At a lean cross dock, most tasks are assigned to teams of four to six members rather than individuals. Teams are flexible and can prevent workload bottlenecks. They also can provide multiple checks on work performed, thus, improving process quality.

Lean cross docks also create an environment of empowerment by enabling any cross-dock employee to stop and seek help to fix problems. Employee training encourages empowerment by providing the rationale for why processes are performed in a specified manner. This not only enhances employee understanding of operations but also facilitates operational improvements.

Respect for the worker starts with worker safety.
Employee safety is particularly critical at a cross dock because of the fast-paced, high-volume material flow. Respect for the worker is also communicated by seriously considering employee suggestions for improvement and reviewing them in a timely manner.

Operational Stability as the Base
Lean cross docks achieve operational stability by utilizing a number of TPS principles including standardized work, preventive maintenance, and supplier involvement. Standardized work is at the heart of lean cross-dock operational stability. For every process, the team knows what to do, how to do it the same way each time, where to do it, when to do it, how long it should take, and what the expected outcome is. Visually posting all process steps is one good technique for achieving standardization. Requiring a specific format, process, and procedure for all tasks enables employees to recognize operational error or variability instantly. Also, standardized work provides a benchmark that teams can use for process improvement.

Preventive maintenance of vehicles, material-handling equipment, and buildings also contributes to stability. By reducing process-disrupting breakdowns through preventive measures, the cross dock has less operational variability.

Operational stability not only requires internal commitment but also supplier involvement. For example, by jointly planning pick-up routes and sharing operational information with suppliers, the cross dock can further reduce operational variability. Timely, consistent, level delivery of materials to production is more likely when these types of techniques are applied.

Exhibit 2 summarizes how TPS principles are applied to a lean cross dock and the benefits of each application.

**Kodak’s Lean Cross-Dock Project**
Many companies have seen the important role that a cross dock can play in creating a lean supply chain. One excellent example is Eastman Kodak Company, which decided to replace a warehouse operation with a lean cross-dock operation.

Eastman Kodak Company is primarily engaged in developing, manufacturing, and marketing imaging products and services for consumers and commercial customers. In 2003, the company identified an opportunity to improve the inbound material flow from suppliers to its manufacturing facilities in Kodak Park, Rochester, New York. At that time, some of its inbound material was moving as less-than-truckload (LTL) shipments directly from suppliers to plants. Other materials moved as full truckload shipments from suppliers to a local area warehouse, where they were stored and then shipped by truck to the appropriate manufacturing facility.

A critical review revealed an inbound-material flow that was ineffective and inefficient. Five problems in particular were evident.

1) Each plant was managing material movement from common suppliers independently. As a result, material managers could not take advantage of transport-consolidation opportunities.

2) Because some suppliers selected the carriers and con-
Innovations

controlled inbound movement. Kodak had no control over these shipments. As a result, unscheduled material deliveries were being made at the warehouse and plants. This caused poor utilization of material-handling labor and floor space at all facilities.

3) Inventories were not visible in-transit, which made production scheduling much more challenging and, at times, negatively affected production operations.

4) Order-cycle times were long.

5) In some cases, suppliers held shipments until they had a full trailerload. Although this practice resulted in lower transport costs, it also increased leadtimes and inventories. Consequently, Kodak had high inventory levels at the warehouse and plants, which resulted in congested facilities and high inventory-carrying costs and storage costs.

Clearly, Kodak had an opportunity to develop a leaner inbound-material supply chain.

Kodak Sets Objectives

In pursuing that opportunity, Kodak used the expertise of Transfreight, a lean cross-dock specialist. Transfreight was formed in 1987 as a joint venture between TNT Logistics and Mitsui Trading Company to provide sole logistics support for all inbound part movement to Toyota’s North American assembly plants. The Kodak-Transfreight project team developed a pilot project that replaced an existing warehouse with a lean cross dock that utilized planned milk runs.

The project team began by educating employees about the application of TPS principles to a supply chain. Then, the team developed project objectives based on thorough discussions with Kodak managers in production, purchasing, and logistics. Viewed in the context of the TPS pillars, the specific objectives were:

**Just-In-Time**
- Decrease order-cycle time.
- Decrease plant inventory levels.
- Decrease plant storage-space requirements.

**Quality**
- Improve visibility from scheduled pickup at suppliers to delivery of materials at plants.
- Have visual control of shipments at cross dock.
- Continuously improve supply chain performance.

**Culture**
- Create employee-empowered, team-oriented problem solving.

Operational Stability
- Create a stable, repetitive material flow.
- Decrease inventory dwell time at cross dock.

Supply Chain Costs
- Decrease inbound-material supply chain cost.

**From Goals to Action: Cross-Dock Implementation**

Prior to the cross dock’s start-up, the Kodak-Transfreight project team took four preliminary actions. These efforts involved: (1) selecting a subset of suppliers and materials for the project, (2) choosing a cross-dock location, (3) developing appropriate information systems, and (4) reorganizing the company’s transportation systems to support lean cross-dock operations.

Three Kodak film and photo processing plants in Kodak Park agreed to participate in the pilot project. From the list of suppliers that shipped materials to all three plants, the project team selected three suppliers for the pilot: a paper supplier providing bags for photo-finishing paper, a coated-metal supplier providing metal parts for the photo film canister, and a plastics supplier furnishing containers for photo chemicals. The team chose these suppliers because they had a good relationship with Kodak, provided a relatively high and steady volume of materials to participating plants, and were in close proximity to these plants.

Next, the project team selected the cross-dock site. The team chose a warehouse facility in Kodak Park that fed materials to the plants involved in the project. This site had to be useful for the pilot project and viable as a long-term cross-dock site. It had to be capable of handling the material flow required to support many Kodak plants in Kodak Park. The site selected fit all these requirements.

A successful lean cross dock requires fast, accurate, and timely material order information. Accordingly, the project team developed a plan for how and when order information should be sent between the plants, suppliers, and the cross dock. In addition, the team ensured that the information technologies employed by all supply chain partners were compatible and capable of fully supporting a lean cross-dock operation.

Finally, to accommodate a lean cross dock, Kodak needed to change its transportation operations. First, the project team, with the aid of corporate purchasing, gained control of the inbound-materials transportation from the selected suppliers. Second, routes were designed and carriers selected for milk runs from suppliers to the cross dock and from the cross dock to plants. Third, the team developed a cross-dock layout and design. This involved the development of designated staging areas for shipments received from suppliers and plant-specific kanban squares for deliveries. Additionally, the cross dock incorporated kanban cards (tickets) for tracking shipments at the cross dock and signs to label cross-dock locations.
After completing the preliminary stages, the project team selected a start date and communicated procedures for ordering, pickup, and delivery as well as route plans to all parties. With these changes, Kodak was able to open up its cross-dock facility 20 weeks after the project inception.

**Going Lean Produces Results**

Kodak's move from a traditional warehouse to a lean cross-dock operation produced significant improvements in supply chain effectiveness and efficiency. Key performance indicators for each of the objectives provided evidence of the project’s success.

*Just-In-Time.* The lean cross-dock operation resulted in scheduled inbound-materials movement from suppliers to the cross dock and from the cross dock to plants. By controlling inbound-material flow, the project team was able to reduce the inbound-material order-cycle time from seven to two days, a 71-percent decrease.

Because Kodak is now pulling materials to production from suppliers as needed, inbound-material inventory levels at the plant decreased by up to 76 percent, from approximately a one-week supply to a one-day supply. One production department, for example, was able to remove 130 pallets of raw material during the first week of the project. Thanks to the shrinking plant inventory levels, the plant-floor space required for inventory storage also decreased by up to 50 percent. Finally, the more level, rhythmic (heijunka) delivery of materials reduced dock congestion at the plants.

*Quality.* The project team improved Kodak’s control of shipments both by replacing LTL shipments with scheduled, dedicated milk runs and by using kanban squares at the cross dock. The result: Kodak’s inbound-material shipment visibility improved from zero to 100-percent. Better shipment visibility, in turn, facilitated better problem identification and improvement. In addition, daily, regular routines and visibility checks (poka-yoke) made abnormal situations very obvious, which meant they could be addressed immediately. Finally, key performance indicators (KPIs) that focused on supply chain operations were tracked and used to make improvements.

During the project, Eastman Kodak Company drove continuous improvements in quality through kaizens at the cross-dock operations. These kaizens centered on cross-dock layout, schedules, standard work procedures, information quality, and safety. The kaizens resulted in a smoother flow of inbound materials as well as a more integrated supply chain from suppliers to Kodak plants.

*Culture.* The culture of supply chain process improvement at the company changed in two ways. First, cross-dock employees are now empowered to make improvements. Team members receive extensive training and actively participate in problem solving, which is designed to help them make a direct contribution to supply chain quality. Second, when the teams detect material-flow problems, they immediately take corrective action. In effect, the supply chain improvement process shifted from a management-led, large-scale, project-oriented approach to an employee-led, incremental, continuous approach.

**Operational Stability.** The company went from having few standardized work procedures at its warehouse operation to using multiple standards at its cross dock. As a result, material flow from supplier to cross dock to plant became repetitive and stable, thereby facilitating operational improvement and stability. For example, the project team worked with suppliers to schedule and improve milk-run routes. Thanks to these efforts, the inventory dwell time for the vast majority of the pallets flowing through the cross-dock decreased from more than 24 hours to less than 4 hours.

Notably, the company achieved these significant gains in supply chain effectiveness without increasing supply chain costs. In fact, costs actually decreased. Inventory-carrying costs declined because average inventory levels decreased at the cross dock and at each plant. Labor requirements to track inventory also decreased. In addition, plant storage space costs decreased as inventory storage-space requirements dropped. Furthermore, transport costs fell because consolidated milk runs had replaced LTL shipments. The milk runs also reduced product damage in-transit and shipment-unloading labor costs. The success of this pilot has spurred Eastman Kodak Company to expand the number of plants and suppliers involved in the lean cross-dock operation.

The results from this pilot show how utilizing a lean cross dock based on TPS principles can significantly improve the supply chain that supports lean-production operations. A lean cross dock helps create a leaner supply chain. And a leaner supply chain facilitates production planning through improved shipment control and visibility. A leaner supply chain also leads to faster order-cycle times, which result in decreased inventory levels and storage-space requirements. Even with this leaner material flow, carefully planned milk runs enable the manufacturer to achieve transportation economies of scale. The net result: As Kodak and others have demonstrated, lean cross docking helps companies improve both supply chain effectiveness and efficiency.

**Footnotes**


